PROCEEDINGS OF THE AUSTRALIAN CONFERENCE ON SCIENCE AND MATHEMATICS EDUCATION 2018
(23rd ANNUAL UNISERVE SCIENCE CONFERENCE)

26th– 28th SEPTEMBER 2018 FLINDERS UNIVERSITY

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TEACHING STUDENTS TO “THINK LIKE A PHYSICIST"

…and ending up with artists and scientists in a truly collaborative MakerSpace

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Students often leave school with an impression that physics is about nothing more than solving equations using a formulaic approach of substituting numbers they find in a text-book question. We sometime still observe this view all the way through to honours.

Science begins with inquisition and often child-like play. Models and theories of the world come after careful and curious observation. In 2012, we took over “Foundations of Physics” at ANU, a service course for students who had not previously studied physics, or simply wanted a taste. Borrowing ideas from studio and inquiry-based learning, along with our own intuition as experimental physicists, we developed a course from the ground up that brought the open-ended and uncertain nature of scientific discovery to the forefront.

The focus is around learning by doing, and teaching students to *“think like a physicist”* — a set of skills they could take with them into the rest of their degree and hopefully their life. Lectures were stripped back to minimal concepts with only 1 per week, and the core of the course focused around a weekly inquiry-based lab, that used carefully designed challenges to encourage experimental design, measurement, problem solving and conceptual learning. Working in groups, students are largely unguided with no lab “manual” to give them the recipe of what to do, but have access to a wealth of equipment, tools, and a team of agile teachers ready to probe and encourage their approaches. I will summarise what we have learned from the experience, with students often citing the course as changing their approach to learning for the remainder of their degree. We have explored a range of novel assessment techniques, most notably student-made video-summaries of labs and exams with full internet access.

The evolution of this course led us to realise the importance of physical making for learning, and the power that project-based learning has to create confident, life-long learners. Combined with a personal desire for more interdisciplinary environments, I wanted to create the first truly open and egalitarian MakerSpace on campus to support learning- and research-projects. In February of 2016, that vision was realised as the ANU MakerSpace. A physics initiative, but open to anyone on campus —staff or student alike— we now cater to over 650 users from all 7 ANU Colleges, as well as central areas. Artists have been purposely activated in the space, making up an equal-majority user-group with scientists and engineers. Half of our users are non-undergraduate, and include PhD students, professional, technical, and academic staff. In addition to supporting discipline-specific project-based learning, this novel community environment has lead to multi-disciplinary collaborations, including helping the Glass Workshop at the School of Art and Design fabricate the 2018 Australian of the Year Award Trophies, Empowering the Questacon Science Circus students with new skills, and enabling a music student to design, fabricate and model the physics of his own saxophone mouthpieces.

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STUDENT CHOICE OF ASSESSMENT TYPE TO DEMONSTRATE RESEARCH SKILLS IN PLANT SCIENCE

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KEYWORDS: research skill development, authentic assessment, inquiry-oriented learning

BACKGROUND AND AIM

The development of a student's ability to problem solve in real-life situations is integral to their success as a graduate. We therefore deliver an inquiry-oriented learning experience for students in the Bachelors of Applied Biology, Agricultural Sciences and Viticulture & Oenology in the second year unit *Foundations of Plant Science II.* Students work in small groups to complete an independent research project throughout one semester (12 weeks) under the informal guidance of an academic mentor. We have previously shown that scaffolding the experience with tutorials about the research process was important (Loveys et al., 2014) as was the student-mentor relationship (Able, Doerflinger, & Loveys, 2016). We also aim for authentic assessment tasks that allow students to demonstrate research skill development. Students increasingly view themselves as 'customers' and therefore expect to have greater input into how they are taught and assessed. Choice of assessment method can increase student engagement and develop greater self-awareness (O'Neill, 2017). However, students may also consider this to be an extra burden of responsibility unless they are provided with a 'low risk' environment as well as clearly-explained assessment options and equitable, authentic assessment that enables them to perform to their strengths (O'Neill, 2017). Interestingly, perception of ability to perform well using a particular assessment type is not always correlated with the actual learning outcome (Van de Watering et al., 2008). However, there is limited literature about the impact of student choice in the sciences. This study therefore aimed to determine how choice of assessment type is viewed by students and if this empowerment provides motivation for increased engagement and performance.

DESIGN AND METHODS

Students were given the choice of a consultancy report, poster or seminar to report their findings to peers, mentors and academics at a 'Plant Science Symposium'. Students (n=88) were surveyed using 5 point Likert scales and open-ended questions. An initial survey (in week 4 of the research project) explored perceptions of assessment choice while a follow-up survey and focus groups (afterwards) focused on whether, after having seen other groups' work and their own experience, whether they would change their assessment choice and why.

RESULTS AND CONCLUSIONS

The responses to the initial survey revealed that the majority were very comfortable (>90%) with the opportunity and felt that they could achieve best marks by choosing a format that allowed all group members to demonstrate or use their strengths. However, there were concerns about whether having different types of assessment would achieve an equitable workload or not. Interestingly, some groups chose an assessment option that would challenge them to learn a skill that they felt needed improvement (e.g. oral communication). After completion of the assessment, the majority (66%) of students would still choose the same task. Students that indicated they would choose another task felt their initial choice did not demonstrate their learning adequately.

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ONLINE TOOLS ADAPTED FROM INDUSTRY FOR TEACHING AGRICULTURAL SCIENCE AT UNIVERSITY

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

ABSTRACT
Agricultural professionals with contemporary knowledge and skills are critical to ensuring that new practices are adopted in farm businesses. However, only 8% of the agricultural workforce has a tertiary qualification compared with 25% of the broader population, with an estimated four jobs available for every tertiary agricultural graduate (Pratley & Acuna, 2015). Consequently, this raises two issues. Firstly, that the learning outcomes of graduates from Australian universities reflects the technology and data needs of contemporary farming practice. Secondly, that more students are encouraged to consider a future career in agriculture.

The SMARTfarm Learning Hub, ‘the Hub’, aims to address these issues by developing learning module that use authentic farm data in a real industry technology learning system (RITLS) (Trotter et al., 2016). The Hub is a collaboration between seven universities, each with a farm representing a varied range of agricultural enterprises and geographical locations.

Here we report on the development and delivery of an RITLS based on the online decision support platform Pasture.io. Using real-time data from dairy farms in north-west Tasmania, the tool can assist users to understand the complex nature of pasture management and dairy feed rations. The tool allows users to explore both tactical (short-term) and strategic (long-term) on-farm decisions. Supporting resources include a lesson plan, video and notes for both students and teachers for a 3-hour practical session, in the unit KLA211 Pasture and Animal Science to 64 students in semester 2, 2017.

The RITLS module was evaluated as part of an action research cycle (McTaggart, 1991), where most students (75%) regarded the practical to improve their knowledge of contemporary issues in agriculture. Similarly, a high number of respondents (79%) agreed or strongly agreed that the practical helped them to understand how to select and apply an appropriate tool to solve an agricultural problem.

The next steps for the project are to revise the practical for delivery in 2018 and, as appropriate, develop an assessable component aligned with the unit learning outcomes. Project partners have expressed an interest in using the Pasture.io practical in relevant courses.

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ACKNOWLEDGMENTS
Support for this publication has been provided by the Australian Government Department of Education and Training. The views expressed in this publication do not necessarily reflect the views of the Australian Government Department of Education and Training.

The authors would like to acknowledge the contribution of the following to the SmartFarm Learning Hub project: Richard Flavel (UNE), David Lamb (UNE), Rob Whannell (UNE), Fran Cowely (UNE), Jamie Barwick (UNE), Caroline Mohammed (UTAS), Marcus Hardie (UTAS), Richard Rawnsley (UTAS), David Swain (CQU), Lachlan Ingram (USYD), Brett Whelan (USYD), Matthew Tscharke (USQ), Troy Jensen (USQ), Ruth Nettle (UMelb), Brendan Cullen (UMelb), Derek Bailey (New Mexico State University).

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 4–5, ISBN Number 978-0-9871834-7-7

THE CHANGING NATURE OF MATHEMATICS SUPPORT

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KEYWORDS: mathematics support, diagnostic tests, support modes

BACKGROUND

This discussion considers the increasing use of mathematics diagnostic tests at a university in Sydney and how provision of support to students undertaking these tests is changing the nature of work undertaken by staff in the mathematics support unit. These changes also involve the inclusion of a broader range of disciplines than has traditionally been supported such as education, computing, sports science and nursing.

THE PROBLEM

Increasing numbers of students arrive at university to study subjects with quantitative components having not studied senior high school mathematics. Thus many students do not have the numeracy, mathematics and statistics skills required for their studies. Without prerequisites, students are entering these subjects unaware or unconcerned that they do not have the assumed mathematics background. One way of highlighting some of the background requirements of a subject has been to provide diagnostic tests. As a result, there has been an increase in the number of mathematics and numeracy diagnostic tests at our institution.

As members of a mathematics and statistics support unit we have increasingly been asked to assist in detailing the numeracy background assumed in subjects and in some cases assist in creating tests to highlight deficiencies. Some tests are designed to make students aware of the mathematics underpinning the subject. In other cases, where there is an option, the tests are used to determine the first mathematics subject the student should undertake.

Where these tests are used as diagnostic tests to highlight the assumed mathematics, students can see if they have demonstrated an understanding of the background knowledge. However, once highlighted, any weaknesses need to be addressed. Given that there is no time to address these topics in the teaching of the subject, students are required to take action themselves to develop these skills. Again, this leads to an increase in involvement by staff in the support unit through provision of face to face workshops or creation of tailored resources for students for delivery via a variety of modes.

Together with the increasing number of disciplines requiring mathematics support is the expectation and need to provide support online as well as face-to-face.

CONCLUSIONS

With the growing number of students without adequate numeracy and mathematics knowledge it has become increasingly important to identify the particular skills required and to ensure there are opportunities for each student to be able to improve the relevant background knowledge for their studies.

This increase in breadth of disciplines, number of underprepared students and required modes of delivery along with a need for more targeted support has greatly increased the demands on support staff.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 6, ISBN Number 978-0-9871834-7-7

DESIGNING CURRICULA AND ASSESSMENTS FOR QUALITY LEARNING IN THE SCHOOL OF EARTH AND ENVIRONMENTAL SCIENCES

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KEYWORDS: curriculum transformation, comprehensive review, assessment quality, constructive alignment, Higher Education Standards Framework

PROBLEM

During 2015 the School of Earth and Environmental Sciences (S.E.E.S.) at the University of Wollongong underwent a whole of school curriculum review, to rationalise and refresh each of its undergraduate courses to meet the future knowledge base and skill set required for its graduates. The courses in focus were: Bachelor of Science; Environment, Geology, Physical Geography and Environmental Geosciences. This change was in response to a number of drivers including the integration of the UOW Curriculum Model, revision of University Teaching & Assessment Policies in order to ensure alignment to the new Higher Education Standards Framework, and the comprehensive review cycle for all courses.

PLAN

Our intent was to design and provide courses fit for 21st century learning at appropriate levels of challenge, accounting for each student’s background learning and circumstances, and that take into account cognitive, affective and behavioural dimensions. This whole-of-school review took into account student feedback and involved collaborative discussion and extensive feedback from academic and professional staff teaching teams. The review led to the development to whole-of-school course learning outcomes, discontinuation of one major, renaming of another to more fully articulate its coverage and a review of the core subjects within each major. Skills were mapped across subjects to ensure appropriate student scaffolding and, where necessary, subjects were revised or deleted and new subjects introduced to fill obvious skill and knowledge gaps. Additionally, a set of four common core first year subjects EESC101/2/3/5, each covering different essential skills (e.g. academic writing; mapping; programming, key concepts, critical thinking, practical skills) were introduced to each of the majors. Each subject was scrutinised to ensure that subject learning outcomes aligned to the course learning outcomes, and that assessment in turn aligned to the subject learning outcomes. Formative feedback, scaffolding of assessment and iterative feedback cycles were introduced to each of the core first year subjects. A core third year level capstone subject was also introduced as the culmination of the skills and knowledge to be developed through the majors.

ACTION

The refreshed first year subjects were implemented in 2016, with the aim of benefiting students by providing an opportunity for them to incrementally develop the skill set and knowledge base required for success at university and to meet the needs of future employers. Following the introduction of the core first year experience, the whole structure was revisited in 2017 to identify subjects that required further modifications, and more importantly for informing how skills should now be scaffolded across the 200- and 300-level subjects. The curriculum re-designs and aligned assessment also ensures access to an equitable and enhanced learning experience for all students enrolled in the majors offered by the School. The transforming curriculum is the culmination of several action research cycles, but delivers: I. Distinctiveness, coherence and clarity of purpose across all SEES majors. II. Improved course quality assurance. III. Impact on student learning and student engagement.

REFLECTION

By conference time, the four core first year subjects will have been delivered successfully in three sessions (2015 to 2018) providing both quantitative and qualitative data to offer insights into the success of the curriculum reforms and whether quality learning has in fact occurred. In addition, we will be able to report on the ongoing changes that have occurred within the rest of the course, in particular the EESC320 Capstone that will evaluate if students have successfully attained the required Course Learning Outcomes.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 7–8, , ISBN Number 978-0-9871834-7-7

FEELING THE HEAT: EXPLORING EMOTIONAL ENGAGEMENT OF STUDENTS WITH EXPERIMENTS

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KEYWORDS: emotional engagement, colour, history of science

INTRODUCTION

Students' emotional engagement is one of the important factors to be considered in Physics Education research. Our study aims to investigate the role of colour, and the inclusion of a history of science context in generating students' emotional engagement (Stinner, 1993). We have tried to engage students emotionally with thermal physics through an experiment.

RESEARCH QUESTION

Do students emotionally engage in the experiment if colours and a history of science context are included in the experiment notes?

METHODOLOGY

We constructed an 'intervention' experiment on thermal physics. This was a guided inquiry experiment with clear instructions. Students were explicitly asked to discuss, analyze and interpret. We included a colourful story on the 'History of Heat' in the introduction of the experiment. The 'control' experiment on 'ultrasound waves' was written in a standard manner and was not modified. We designed a survey of 19 items based on Peixoto et al. (2015) and four open-ended questions. The surveys were given to the students of both the 'intervention' and 'control' groups.

DATA COLLECTION

This study was done over three weeks of laboratories for 1st year 1st semester regular undergraduate students at the University of Sydney. The data collected were 1) observational field notes 2) surveys 3) logbooks. Surveys were collected from 339 students, 190 for the 'intervention' and 149 for the 'control'.

RESULTS

Our preliminary results indicate that students were more emotionally engaged in the 'intervention' compared to the 'control'. Some quotes were:

> *"Fantastic! It affected me in a very positive way, enlightening not only me but my fellow peers in the field of thermal physics"*
> *"Excellent with description and picture"*
> "*Very easy to follow, fun and much clearer instruction"*

Comprehensive data analysis will be presented at the conference.

CONCLUSION

Our study shows that a simple change in the way experiments are presented to the students results in improved emotional engagement; students reported that the experiment was easier to understand and more enjoyable.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 9, ISBN Number 978-0-9871834-7-7

CONSTRUCTIVE ALIGNMENT: CREATING A QUANTITATIVE APPROACH TO REVIEW SCIENCE LEARNING OUTCOMES

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KEYWORDS: constructive alignment, graduate qualities, learning outcomes.

PROBLEM

Curriculum reviews are ubiquitous in Faculties of Science and related disciplines across Australia. In recent years the Threshold Learning Outcomes in Science, Biology, Biomedical Science, Chemistry, Physics, Psychology, Environment and Sustainability, have enabled us to backward-map what Science and Mathematics graduates should know and be able to do, whilst the implementation of graduate qualities allows us to do this at the institutional level. However, what sounds so refreshingly straightforward can be quite difficult to do in practice, especially in the non-professional degrees of science and mathematics, where students' future career pathways are uncertain and varied. Constructive alignment is key to outcomes-based curriculum reviews, and the learning outcomes of majors, streams and programs provide critical information on how students are building skills and knowledge across the curriculum.

PLAN

We describe here a quantitative analysis approach which was used to review learning outcomes in 44 majors within the faculty of science at a large and complex metropolitan university.

ACTION

First, we classified the active verbs of learning outcomes using the revised Bloom's taxonomy of Anderson and Krathwohl (2001), ranking them as 'low' (levels I and II), 'medium' (levels III and IV) or 'high' (levels V and VI). The learning outcomes sets for 17 majors had more than 50% of outcomes ranked 'low', no outcomes ranked 'high', or outcomes that were unable to be clearly defined. We then examined the alignment of learning outcomes with disciplinary-specific threshold learning outcomes (TLO) sets, and the new university-wide Graduate Qualities (GQs). In 21 majors, there were significant gaps in alignment, or evidence of inappropriate alignment, and over alignment. Based on our analyses, we constructed a set of tailored recommendations for each major, with over 50% of learning outcomes reviewed and re written in collaboration with academic leads.

REFLECTION

Creating the intended 21st century curriculum is a first step towards ensuring the experienced curriculum aligns with the goals of an institution. We applied both constructive alignment to map TLOs and GQs to major-level learning outcomes, and a quantitative approach to examining learning activities. We also identified gaps in alignment that could be filled with new or revised assessment tasks and will next review these assessments to ensure they are reflected authentically in the written major-level learning outcomes. Although the quantitative process described here is an efficient way to ensure constructive alignment, it misses how students experience the curriculum, which is a vital ingredient in the measure of success of any curriculum renewal.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 10, ISBN Number 978-0-9871834-7-7

SUPPORTING ACTIVE LEARNING THROUGH COLLABORATION AND PROBLEM SOLVING IN LARGE SUBJECTS

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KEYWORDS: peer-learning, active learning, problem-solving, large enrolments, online learning

PROBLEM

There is a growing appreciation for the benefits of active and authentic learning through application and student interaction. However, in the context of increasing undergraduate enrolments, the flexibility of learning and teaching activities is often constrained by the need to accommodate scale and efficiency. This results in large group teaching activities that are often highly transmissive, reducing interactions amongst staff and students and providing limited opportunities for the application of newly acquired knowledge and the development of key 21st Century skills. To provide large cohorts of students with authentic and interactive learning activities there are often multiple design factors that need to be considered.

PLAN

We have introduced small-group peer-based workshops to our large undergraduate genetics subjects, which cater to enrolments of 200-600 students. The workshops are designed to support peer-learning through collaborative data analysis and problem-solving. Initial evaluation of our workshops suggested that many students were not engaging with the pre-class preparation that involved independent revision and attempts at the workshop questions. Consequently, this limited group discussion and the potential learning opportunities afforded by the interactive workshops.

As is the case with many in-class active learning strategies, adequate student preparation is paramount to achieve the intended learning gains. We chose to encourage student preparation through the use of interactive online resources that included directed revision, data analysis, problem questions and opportunities for student collaboration using discussion boards (Brewer & Smith, 2011; Goldsworthy & Rankine, 2009; Liu & Taylor, 2014). This student preparation and interaction outside of class time would then enable more efficient and effective use of face-to-face discussion time in the group sessions. (Bell, Urhahne, Schanze, & Ploetzner, 2010; Goldsworthy & Rankine, 2009; Liu & Taylor, 2014; McKenzie, Perini, Rohlf, Toukhsati, Conduit, & Sanson, 2013).

ACTION

We have developed interactive and adaptive online resources using the Smart Sparrow platform (smartsparrow.com). This platform allows students to navigate through the materials and receive guided feedback based on their individual learning needs. Students use the online resources to progress through increasingly challenging data sets and problems prior to attending the workshop, with the most difficult questions to be solved collaboratively with their peers in class. Prompts are embedded throughout the material for students to contribute via LMS based discussion boards. Student use of the Smart Sparrow and LMS based resources and attendance at the fortnightly workshops has been monitored in semester 1, 2018. Student performance on concept and application based tests and relevant exam questions will be used to evaluate learning gains.

REFLECTION

Evaluation of the resources will include student use and perception of the resources and the association with learning outcomes and engagement. Particular questions to be addressed include:

- Does student use of the online resources and/or attendance at the peer-based workshops correlate with learning gains and overall subject performance?
- How do students perceive the resources and workshops in terms of engagement and learning benefits involving both conceptual understanding and problem solving/application?

Academic staff insights and further opportunities for improvement of the resources and workshops will also be discussed.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 11–12, ISBN Number 978-0-9871834-7-7

ARE SCIENCE ACADEMICS ON THE SAME PAGE AS SOCIETY FOR A NEW FUTURE OF WORK?

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KEYWORDS: curriculum, employability, career management, Work Integrated Learning

BACKGROUND

The vast majority of today's science graduates are being employed in positions that are non-traditional. This means that graduates are required to have knowledge and skills beyond those of their discipline. Both society and students are reflecting this by demanding that tertiary institutions identify, teach and articulate employability skills in degrees. At the beginning of this project, it was assumed that Western Sydney University B.Sc. programs taught employability skills. However, unlike graduate attributes, which are explicit in the curriculum via defined learning outcomes, most employability skill development is hidden and hence not clearly articulated. To address the needs of students and society, employability skills need to be explicit and students shown how to use them both in the workplace and for career management.

THE PROJECT

As a starting point to address this problem, we mapped Work Integrated Learning (WIL) throughout our science degrees using a developed rubric from Edwards *et al*. Current learning guides for individual units of study were analyzed for evidence of employability skills being taught and assessed. Unit co-ordinators were interviewed face to face using a structured survey having both directed and open ended questions. This included asking staff to identify the skills they value when recruiting a graduate in their workplace. Staff were also asked to identify other learning outcomes that require further development in our current degrees.

OUTCOMES

The power of conversation during the interviews was critical to this project. This revealed a range of employability activities that were not evident from the learning guides. In addition, this provided an opportunity to work with staff to make these activities explicit to students. When asking staff to identify skills important for their employment area, problem solving (47%) written communication (55%) and teamwork skills (55%) were the top three responses. This was in alignment with industry surveys. However, academics did not identify qualities such as leadership (4%), digital literacy (4%) or broader workplace skills such as punctuality (4%) or management skills (4%) highly. This was in contrast with industry, which, for example, valued demonstrated leadership capacity. When asked to identify deficiencies in our degrees, academics identified the need for further support for numeracy, literacy and work ethic development. In general they regarded this as "somebody else's problem".

DRIVING CURRICULUM CHANGE

Gathering this information provided the impetuous to tackle curriculum change, and this project provided a platform to minimize staff resistance. Crucial to the interview process was the opportunity to explore with staff the idea that employers of our students needed graduates with skills beyond the expectations of an entry-level position in their local workplace (e.g. a research technician). These small changes at the unit level are leading to larger changes that scaffold, assess and thus assure employability skills in our degree. This will be facilitated further by a new science degree with a structured core so these skills are no longer "some else's problem".

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 13, ISBN Number 978-0-9871834-7-7

STAFF AND STUDENT PERCEPTIONS OF FEEDBACK WITHIN BIOMEDICAL SCIENCE TEACHING

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KEYWORDS: feedback, assessment, students, teaching associates, biomedical science

BACKGROUND

Feedback is a vital aspect of the learning process, though it is notoriously difficult to implement effectively and efficiently. Feedback is often poorly rated on end of semester student experience surveys within our Bachelor of Biomedical Sciences course. While educators embed feedback practices within their units, low student ratings indicate a mismatch between staff and student perceptions of what constitutes quality feedback.

AIMS

The broad aim of this study was to produce a snapshot of feedback across the Bachelor of Biomedical Science degree at Monash University. Specifically, we aimed to ascertain students and staff perceptions of current feedback practices across the degree to identify potential misalignment between the views of these two cohorts.

DESIGN AND METHODS

Students (n = 1003, response rate ~60%) and Teaching Associates (n = 57, response rate ~25%) anonymously completed a survey in semester 1, 2018. Teaching Associates were surveyed as they conduct the bulk of feedback within the course. Each cohort completed a separate survey containing Likert-style items, and open-ended questions. A Mann-Whitney *U* test was used to compare the responses of students and Teaching

RESULTS

Staff and student perceptions of feedback differed in two main aspects. Teaching Associates were more likely than students to have a teacher-centric view of feedback ($p < 0.001$). Teaching Associates also gave higher ratings for feedback being coherent ($p = 0.001$) and actionable ($p = 0.001$) than did students.

First-year Biomedical Science students were more likely than students in later years to use comments from staff ($p < 0.010$) and feedback from prior work ($p < 0.001$) to improve the quality of their work. First-year students were also more likely to receive comments on their work from staff ($p < 0.05$) and other sources ($p < 0.05$) before submission of an assessment. All students, regardless of year level, reported that they were comfortable approaching staff to discuss feedback and were provided opportunities to do so.

CONCLUSIONS

Teaching associates have an inflated sense of their role and abilities to provide quality feedback, which is in conflict with student perceptions. These findings provide insight into a disconnect between staff and student perceptions feedback. In addition, first year students employ more desirable feedback habits than students in later years of the degree. This study has provided a foundation to further investigate the cause of these differences, and the development of strategies to improve feedback practice within the degree.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 14, ISBN Number 978-0-9871834-7-7

HOW DO STUDENTS DEAL WITH DIFFICULT PHYSIOLOGICAL KNOWLEDGE?

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KEYWORDS: self-regulated learning, physiology, academic resilience

BACKGROUND

Physiology is considered to be challenging for students to master due to the highly conceptual nature of the discipline and the substantial cognitive effort required (Michael, 2007). Students who experience such difficulties in understanding disciplinary knowledge face academic ‘hindrances’ (Ainscough, Stewart, Colthorpe, & Zimbardi, 2017). These hindrances, if unresolved, may result in disengagement with learning, decreased motivation and potential failure (Skinner & Pitzer, 2012). Students must choose appropriate learning strategies to overcome such difficulties and develop their knowledge, as such choices may influence both understanding and achievement (Hattie & Donoghue, 2016). This study aimed to elucidate how students respond when facing the challenge of learning a conceptually demanding discipline, the reasons students perceive physiology topics to be difficult and the relationships between students’ difficulties, learning behaviours and achievement.

METHODS

Undergraduate allied health students (n=231) studying physiology were asked which topics or modules they found difficult, the reasons they perceived those to be difficult, and how they overcame, or planned to overcome, their difficulties. Consenting students’ responses were subjected to inductive and deductive thematic analyses (Braun & Clarke, 2006) to identify (i) topics students had difficulty understanding; (ii) strategies students use to deal with difficulties and (iii) reasons for difficulties with those topics. In addition, the relationships between perceived difficulties and academic achievement were evaluated.

RESULTS

Students most often cited difficulties with the motor nervous system and respiratory physiology, and reported unfamiliarity and too many details as the most common reasons for difficulty. To aid their understanding, students commonly reported both reviewing the information they had and seeking further information, with more high-achieving students reporting reviewing records, and fewer reporting seeking social assistance than poor-achieving students. Surprisingly, the exam performance of students who cited difficulties with modules were equal, if not better, than those who did not.

CONCLUSIONS

The findings provide a unique student perspective on what they find difficult, provide insight into the reasons for those difficulties and the strategies students use in response to these academic hindrances. Importantly, the findings highlight that there is a disconnect between students’ reporting of difficulties and their examination performance on those modules. This suggests that students, in recognising their difficulties and the reasons for them, can implement effective learning strategies to overcome them, displaying resilience in the face of these challenges.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 15, ISBN Number 978-0-9871834-7-7

DEVELOPMENT AND VALIDATION OF A CHEMISTRY CRITICAL THINKING SKILLS TEST

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KEYWORDS: critical thinking, chemistry, assessment

PROBLEM

The importance of developing student critical thinking skills (CTS) at university can be seen through the inclusion of CTS as graduate attributes for universities and from research highlighting the value employers and students place on demonstrating CTS (Jones, Yates, & Kelder, 2011; Prinsley & Baranyai, 2015; Sarkar, Overton, Thompson, & Rayner, 2016). Commercially available critical thinking assessments are generic in context, however assessments using a context relevant to the student is believed to more accurately reflect the students' CTS (Garratt, Overton, Tomlinson, & Clow, 2000; Halpern, 1998).

AIM

This paper describes the development and evaluation of a chemistry critical thinking test (ChCTT), set in a chemistry context, and designed to be administer to undergraduate chemistry students at any level of study.

METHOD AND RESULTS

Development and evaluation occurred over three versions of the ChCTT through a variety of reliability and validity testing. The studies suggest that the final version of the ChCTT has good internal reliability, strong test-retest reliability, moderate convergent validity relative to a commercially available test, and is independent of previous academic achievement and university of study. Criterion validity testing revealed that third year students performed statistically significantly better on the ChCTT relative to first year students, and postgraduates and academics performed statistically significant better than third year students. Qualitative analysis provided evidence of social constructivist learning which suggests the ChCTT may be a valuable teaching tool.

CONCLUSION

The statistical and qualitative analysis indicates that the ChCTT is a suitable instrument for the chemistry education community to use to measure the development of undergraduate chemistry students' CTS or as a discussion tool to assist in the development of undergraduate chemistry students' CTS.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 16, ISBN Number 978-0-9871834-7-7

SYSTEMATIC REVIEW OF THE ASSOCIATION BETWEEN LECTURE ATTENDANCE AND ACADEMIC OUTCOMES FOR SCIENCE STUDENTS, AND THE EFFECT OF LECTURE RECORDINGS

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KEYWORDS: academic outcomes, biological science students, lecture attendance, lecture recordings, physical science students

BACKGROUND

A 2010 major meta-analysis showed that there was a positive relationship between lecture attendance and grades, and that attendance was a better predictor of grades than any other known predictors of academic performance including entry scores, study habits, and study skills (Credé et al., 2010). This meta-analysis did not consider individual disciplines, and was dominated by students studying psychology. Also, the use of lecture recordings was probably in its infancy in 2000-2010, and was not considered in the meta-analysis.

AIMS

The aims were to determine (i) whether there is an association between lecture attendance and academic outcomes for students studying the biological and physical sciences and (ii) whether any association was altered by the availability of lecture recordings.

METHOD

The method used was a literature review following the guidelines for systematic reviews, with the exception that the collection and analysis of papers was undertaken by one person i.e. not in duplicate, as suggested in the guidelines.

RESULTS

(i) For allied health and science students studying the biological sciences, there were 14 studies and 12 showed a positive association between lecture attendance and academic outcomes, whereas two did not. All eight studies of dental and medical students studying the biological sciences, and eight studies of students studying the physical sciences, showed a positive association between lecture attendance and academic outcomes.

(ii) Only six studies reported on whether lecture recordings were available or not, and only one study reported the effect lecture recordings had on lecture attendance and academic outcomes, and this study showed that using lecture recordings, instead of attending lectures, reduced academic outcomes (Fernandes et al., 2008).

CONCLUSIONS

(i) From the study of the association between lecture attendance and academic outcomes, there is strong evidence, supporting continuing with face-to-face lectures, and encouraging students to attend. (ii) Given that the only study of the effect of lecture recordings on academic outcomes showed a negative effect on academic outcomes, further studies are needed to confirm or refute this.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 17, ISBN Number 978-0-9871834-7-7

NO ASSOCIATION BETWEEN ATTENDING LECTURES OR ACCESSING RECORDINGS AND ACADEMIC OUTCOMES FOR MEDICAL LABORATORY SCIENCE STUDENTS

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KEYWORDS: academic outcomes, medical laboratory science students, attending lectures, accessing lecture recordings

BACKGROUND

A meta-analysis of science and non-science college students showed a positive association between lecture attendance and outcomes (Crede et al, 2010); however medical laboratory science students were not part of this analysis.

AIMS

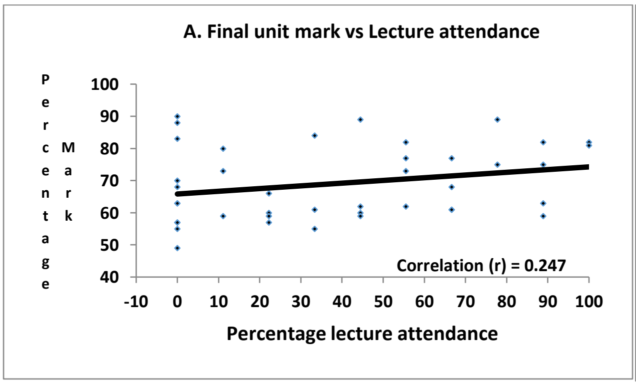
To determine (i) the relationship between lecture attendance and academic outcomes and (ii) the effect of using lecture recordings on academic outcomes, for medical laboratory science students.

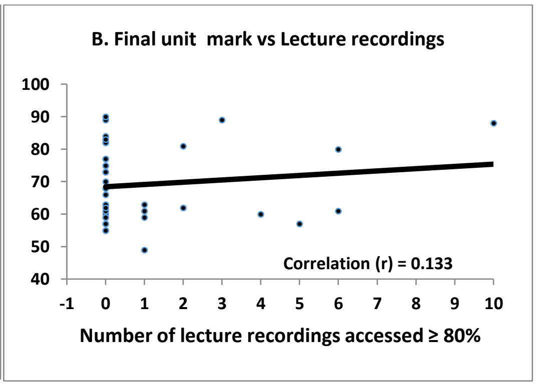
METHODS

In 2017, in a 3rd year unit for medical laboratory science students, 41 of 45 students consented to undertake the study. Attendance was documented in nine of 11 face-to-face lectures, and the number of lecture recordings used to ≥ 80% completion was collated. Regression analysis of final unit mark against lecture attendance or use of lecture recordings was undertaken and Pearson's correlation coefficient (r) determined.

RESULTS

There was no association between either lecture attendance (A) or accessing lecture recordings (B) and academic outcomes for medical laboratory science students:





CONCLUSIONS

In contrast to previous findings with other students, there was no association between lecture attendance and academic outcomes for medical laboratory students. The use of lecture recordings was also not associated with academic outcomes.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 18, ISBN Number 978-0-9871834-7-7

WIL-ing PARTICIPANTS: SUPPORTING SCIENCE STUDENTS' PARTICIPATION IN WORK-INTEGRATED LEARNING

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KEYWORDS: student experience, science, embedding WIL

Work-integrated learning (WIL) is key to developing graduate employability, but science students participate in WIL less than students in other STEM disciplines (Edwards, Perkins, Pearce, & Hong, 2015). We investigated science students' perceptions and engagement with WIL through focus groups and interviews at four Australian universities.

Science students perceived WIL as an opportunity to develop skills and networks, gain hands-on experience and experiment with different career options. They wanted more opportunities to participate in WIL, assigning greatest value to opportunities situated in the workplace and contextualised to their career ambitions. However, they discussed numerous barriers to participation, including time, money, confidence, and lack of visible opportunities. In particular, participation in optional or extra-curricular WIL often required the sacrifice of other opportunities like paid work, and not all students were able to do this.

Students recommended that all students should have an opportunity to participate in a WIL placement during their course and suggested embedding WIL opportunities into courses to increase participation. Other recommendations for increasing participation in WIL included communicating more and earlier about the specifics of WIL; and making it easier to find and access opportunities. In this presentation, we will compare the student experience with earlier research on the perceptions of staff involved in the design and delivery of WIL in science, and discuss how science faculties might use these insights to better engage students in WIL.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page19, ISBN Number 978-0-9871834-7-7

EXPERIENCES OF UNDERGRADUATE HEALTH SCIENCES STUDENTS IN A BIOCHEMISTRY UNIT: A BASIS FOR CONTEXT-BASED INSTRUCTION

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KEYWORDS: biochemistry, health science, nursing, pharmacy, psychology, medical laboratory science, experiences, context-based

ABSTRACT

There is an ongoing debate on the relevance of foundational biochemistry in the health sciences and medical education. The debate stems from the fact that much of the teaching of foundational sciences (such as biochemistry) has focused on the didactic delivery of challenging theories and concepts with very little emphasis on clinical applications. This has resulted in a *foundational-clinical gap* between biochemistry and the health sciences. In turn, it has led to the negative perceptions of biochemistry among health science and medical undergraduates and their educators (Scalise, Claesgens, Wilson, & Stacy, 2006; Afshar & Han, 2014). Notwithstanding, the inclusion of biochemistry into health science and medical curricula remains valid. As Gwee, Samarasekera and Chay-Hoon (2010) assert, since clinical practice of health professionals is based on scientific knowledge, biochemistry remain indispensable to their curricula. To address this *foundational-clinical gap*, the consensus is for biochemistry to be taught in the context of clinical practice (Bandierra, Boucher, Neville, Kuper, & Hodges, 2013; Chaney, Pelley, & Seifert, 2010; Gwee et al., 2010).

Biochemistry is a foundational unit for all health sciences students. Health sciences students are required to hurdle a unit of biochemistry or a health science unit with integrated biochemistry topics before proceeding to their clinical internships. Considering this, it is imperative to determine whether this debate and assertion is relevant in various health science disciplines namely nursing, pharmacy, psychology and medical laboratory science. Hence, this research aims to study the experiences of undergraduate health science students in a biochemistry unit. Specifically, this research will determine student perception on the relevance of biochemistry to their: (1) concurrent health science units and (2) future clinical practice.

This study will utilize phenomenography. Phenomenography according to Marton (1986) "is a research method adapted to mapping the qualitatively different ways in which people experience, conceptualize, perceive, and understand various aspects of and phenomena in the world around them."

Twenty health science students (consisting of five nursing, three pharmacy, six psychology and six medical laboratory science students) will be divided across seven groups. A focus group discussion (FGD) will be conducted using an expert-validated protocol. Emergent themes will then be identified from the interview transcripts. *The results of this study, in conjunction with the opinions of educators and clinical practitioners on the relevance of biochemistry, will be the basis in the development of context-based undergraduate biochemistry for health sciences (CUBHS) learning resources and activities.*

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 20–21, ISBN Number 978-0-9871834-7-7

A NEW AGE OF TEACHING: TEACHER FOCUSSED, FUTURE FOCUSSED

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KEYWORDS: teaching focussed, student engagement, 21st Century teaching, futurism

AIMS

Can development of teaching-focussed academics ensure improvement to student success and engagement that is required for 21st Century teaching quality? This paper explores the challenges for teaching-focussed academics using a personal case study.

CONTEXT

Teaching focused academic staff have a critical role to play in science, technology, engineering and mathematics (STEM) education as universities make changes due to 21st Century needs. Since 2009 the increase in these roles in Australia continues to grow due to various reasons including the massification of university, uncertainty of research funding, a need for quality teaching in higher education and differing academic roles within the university system (Norton, Sonnemann, & Cherastidtham, 2013; Probert, 2013). Different types of academic appointments have very different allocations for teaching and scholarship.

MAIN ARGUMENT

Contemporary teaching is complex. There is a need to adapt and change to students diverse needs. Teacher training and staff development and support is needed to overcome challenges of the modern student and technology change to ensure student success, engagement and attrition. There are opportunities for interdisciplinary collaboration amongst STEM teaching staff and other teaching focussed staff to improve overall teaching practices as new teaching methods for future learning require different skills in contrast to a disciplinary content focus.

Expectations of teaching-focussed academics encompass much more than discipline knowledge and require such skills including; content creator, video editor, online presenter, designer and developer using technology and data analyst. Specific training and development of academic staff in learning design and resource development is important to help develop the skills needed to effectively teach in this space with STEM educators can also learn from other teaching focussed academics to broaden and develop generalist skills that can be used in a multi- and interdisciplinary way.

High demands of teaching a student needs limit the capacity of teaching focussed academics to contribute to scholarship of teaching and learning (SoTL) although scholarship is critical to development of teaching expertise (Fanghanel, Pritchard, Potter, & Wisker, 2016). Development of personal learning networks (PLN) amongst teaching focussed staff will be crucial to support strong pedagogical development and enhanced teaching quality. Utilisation of networked learning environments using technology and social media is able to help with support and fostering growth of a networked educator though sharing of both best practices and failures. Through PLN collaborative scholarship outputs have increased in addition to further educational development and praxis.

CONCLUSIONS

Personal learning networks and collaborative SoTL can assist teaching-focussed academics by connecting them to institutional and wider networked support. Both practices build on teaching practice to support future career progression.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 22–23, ISBN Number 978-0-9871834-7-7

INVESTIGATING THE LONGITUDINAL EFFECT OF LARGE SCALE IMPLEMENTATION OF INQUIRY AND INDUSTRY BASED LABORATORIES ON STUDENTS

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KEYWORDS: student perspective, quantitative/qualitative, context-based, employability

ABSTRACT

Since 2016, the Transforming Laboratory Learning (TLL) program at Monash University has sought to increase the amount of inquiry- and context- based learning undertaken by students in the laboratory program delivered by the school of chemistry. Furthermore, an Education Developer was specifically hired to incorporate industry based techniques and contexts currently encountered in a range of chemistry industries including, but not limited to, pharmaceuticals, skin-care, dairy and gas absorption/transport.

This effect of this program on student perceptions of the overall purpose of teaching laboratories and their expectations of how they will act and feel during laboratory activities is being monitored through the use of the Meaningful Learning in the Laboratory Instrument survey[1] alongside a single open question. The baseline data (i.e. prior to the TLL program) has been published[2,3] and showed students held narrow views of the aims of these teaching laboratories but they held positive beliefs around their expectations of their own actions. The perspective of students towards the new laboratories has also been published[4] and indicates that the individual experiences are succeeding at broadening the students' views on skill development.

This presentation will focus on the changes noted after monitoring the views of students in 2017 and 2018. These changes will be directly compared to the baseline data and the effect of TLL on the student viewpoints discussed. Additional detail will be included such as the results of a reflective survey given to students completing their third year as well as comments raised during focus groups.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 24, ISBN Number 978-0-9871834-7-7

AUGMENTED REALITY IN SCIENCE COMMUNICATION

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KEYWORDS: augmented reality, posters, science communication, physics

INTRODUCTION

Within the Physics Discipline at the University of Newcastle, several core courses were selected to include student awareness and proficiency in science communication techniques in alignment with Australian Quality Framework (AQF). In the last two years this has evolved to include new technologies, such as augmented reality which doesn't have the equity issues that virtual reality brings with it, like people who wear glasses. Previous incarnations of augmented reality technology relied on QR codes to activate the external information, looked out of place on science posters, and could not be utilized on existing posters, signs or even murals and artwork. Second year students in Physics are tasked with producing a conference poster from a list of Electromagnetic devices used in everyday life or industry. Their presentation must include augmented reality that provides two outcomes.

1. Must use animation and be on topic
2. Must allow the observer to gain extra knowledge and contain links for further information.

The software used to implement the augmented reality without the need for QR codes is called Aurasma. The visualization is utilized through the Aurasma app and developed through the Aurasma Studio which is both free to use.

OUTCOMES

All students commented on how much "fun" the poster was to make with the addition of augmented reality. The poster assessment has been running for the last 6 years. Student Feedback on the poster assessment increased from an average of 3.5 (over three years) to 4.5 (over two years) out of 5. The posters were assessed by other academics during a mock conference poster presentation session. The average marks for the posters statistically increased by more than 5% (n=27, t=2.13, p=0.05). The academics also commented on how enthusiastic the students appeared at the presentation.

One of the students quoted "When I first read that we were adding augmented reality to the poster assessment, I was very uneasy about it, because I thought it was going to be very difficult since I hadn't done anything like it before. Instead, the augmented stuff we added made me more keen research the information and make the poster as good as possible. Lots of fun!!!!"

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 25, ISBN Number 978-0-9871834-7-7

ROLLING OVER 1^{ST} YEAR PHYSICS LABS

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KEYWORDS: 1^{st} year physics, laboratory, workshop

INTRODUCTION

In 2016 the course cohort for Advanced Physics I at the University of Newcastle was changed to mechatronic and mechanics engineers on top of Electrical Engineers, Science students and Physics Teachers. The topics in the course include Big Issues in Physics, Mechanics, Thermal Physics, Electricity and Oscillations and Waves. While most of the subjects produced insignificant changes to the final exam marks, topics such as Mechanics (rotation) were done much worse. Average scored dropped from approximately 34% to 28%. Furthermore a study done on the significance of attending Face to face lectures and tutorials showed that there was no statistical difference in this mechanics topic while other topics such as Thermal Physics showed up to 16% difference in the attending versus not attending averages. (Furst & Holdsworth, 2014)

A WAY FORWARD

The situation revealed that it did not matter if students came to lectures and tutorials or not, the understanding of problem strategies (i.e. summing forces together or conservation of energy) and applying this to rotational motion was very poor. Our response was to develop a workshop, similar to a lab with a twist that focused on systematically modelling of two simple rotational systems.

1. The Atwood's pulley where students develop a model using Newton's Laws of motion for the acceleration of the masses attached to the system.
2. Rolling different shapes down an incline and modeling the velocity using conservation of mechanical energy.

The workshop consisted of 5 sections. An introductory theoretical section, two theoretical sections based on the above systems and two experimental sections at the end of each of these. Students are tasked with experimentally determining their theoretically modelled parameter using a laptop camera and the open source Tracker software.

OUTCOMES

The approach to this workshop was very different than any other lab or workshop previous delivered at The University of Newcastle. The lab demonstrators were now required to monitor the students' progress much more vigilantly. Students were refused to progress past a section without it being done 100% correctly and demonstrators signing off that this has been achieved. This restriction proved vital as students built on what they had previously learned and habits from high school dominate the incorrect nature of their approach to problem solving. This approach forced students to react to the immediate feedback and required them to either deepen their understanding or more predominantly develop the correct step-by-step approach for the first time. The workshop is marked prior to student's leaving the lab so that they can take it with them. This is only possible since the only section that requires demonstrators to actually mark is the last section students obtained. All previous sections students receive 100%. Any student that finished the lab will obtain 100%. The students had a very positive response to this approach with the average mark for the workshop being 95%. Typical traditional lab marks are typically around 86-87%.

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THE LIVING DATA PROJECT: COLLECTING, VISUALISING AND COMMUNICATING SCIENCE

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KEYWORDS: data visualisation, creative code, digital literacies

PROBLEM

Students come to university to discover and create new knowledge, solve global challenges, and learn skills to help them face a future awash with data. Equipping science students to adapt to new models of engagement with the public (Pouliot & Godbout, 2014) and the transdisciplinary workforce that will use big data (Scott, 2016) requires innovative learning experiences that foster creative and logical thinking. The university experience needs a holistic approach to working data, introduces students to code and supports the creative thinking, problem solving and inventiveness that is needed in industry (Burleigh, 2015).

PLAN

To do this, the Living Data Project placed a cohort of 1500 human biology students in a real research project from the first semester at university. Students tracked their activity and nutrition for a week, using the Axivity AX3 tracker and Intake24 online dietary recall platform, developed by the Open Lab (Newcastle University, UK). They visualised their own data, developing code and data literacies that will be required to be leaders in a digital world, while also learning effective communication skills that will amplify the impact of their disciplinary expertise and help them communicate with the public (Rull, 2014).

ACTION

We developed three workshops, each delivered in 29 sessions over two-week periods to classes of 60 students. These introduced Processing, a widely used creative code platform, as well as narrative structure for effective communication through audiovisual media. The objective was not for students to become expert software developers or filmmakers. Rather, we gave them an introduction to what is possible with code and how to structure communication to engage their audience. Students created abstract and emergent visualisations (See Figure 1), exploring the relationship between data, code and their own creative choices (Seevinck, 2015). The activity and nutrition data students collected will also be published as an open dataset available for research and expanded each year the workshops run, becoming longitudinal snapshot of young adult activity and nutrition.

REFLECTION

The Living Data Project was received positively by students, as noted by one student during a focus group:

> *“I think it was good to be exposed to [data collection and visualisaiton] from the beginning, because that's very important in the future.”*

The quality of work students produced, particularly in relation to the visual presentation of the data visualisations, far exceeded our expectations. We saw deep student engagement with a novel activity that successfully integrated science with data, art and communication.

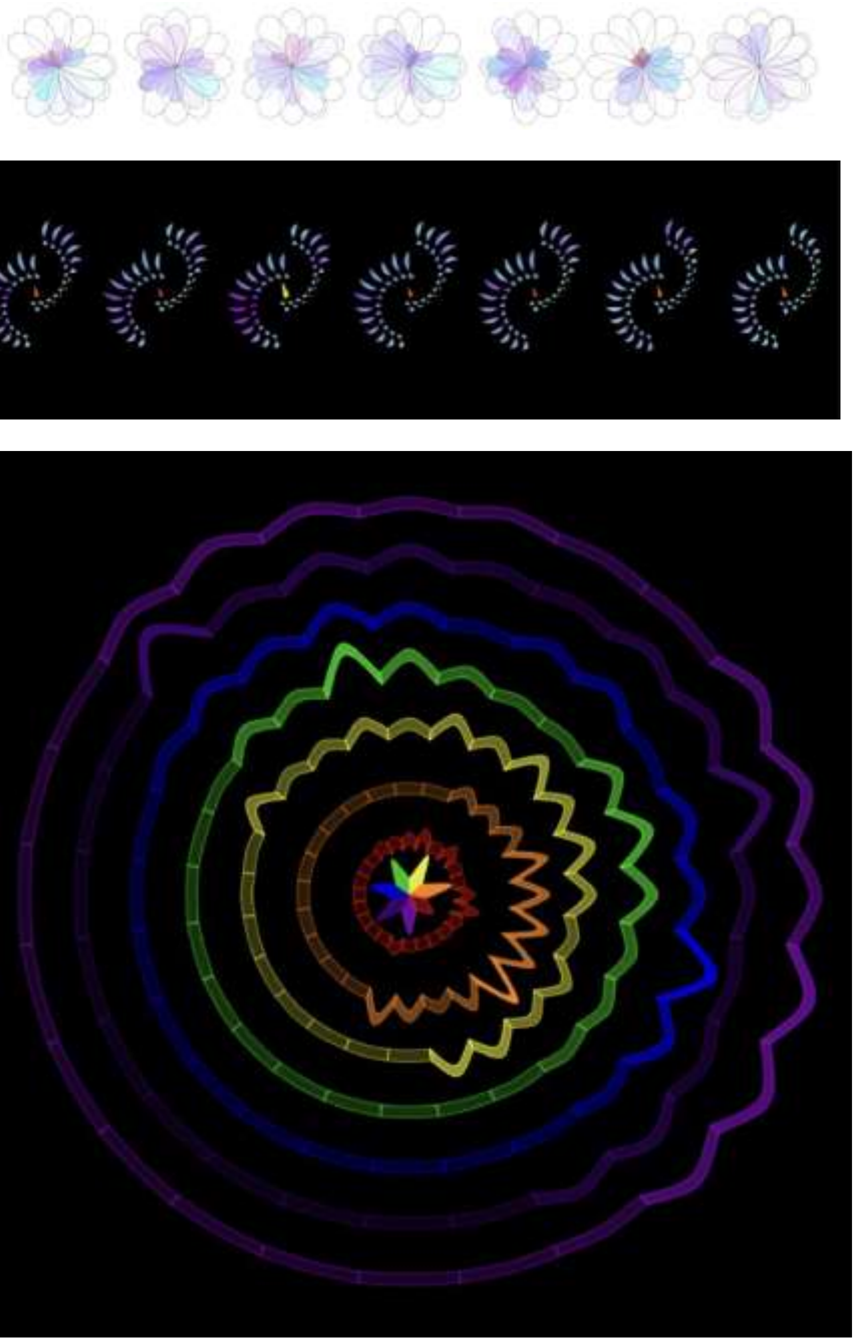

Figure 1: Three example visualisations created in processing

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pags27–28 , ISBN Number 978-0-9871834-7-7

CURRICULUM DESIGN TO BUILD CAPACITY OF INDUSTRY PROFESSIONALS: A MASTERCLASS IN HORTICULTURE

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KEYWORDS: online delivery, work integrated learning

ABSTRACT

The Masterclass in Horticultural Business is a new national program requested by and tailor made for Australian business managers and entrepreneurs in horticulture. The University of Tasmania has developed the Masterclass in collaboration with the internationally recognised higher education providers, Wageningen University and Research (Netherlands) and Lincoln University (New Zealand).

Building human resource capacity and leadership in production horticulture is of fundamental importance to the ongoing success and growth of the $9 billion industry in Australia (Horticulture Innovation Australia, 2015). The horticultural workforce, however, is less engaged with formal training and education compared with the broader agricultural sector. The Masterclass, delivered as a new pre-tertiary qualification (Diploma in Horticultural Business), combines a strong understanding of horticulture production and business practices. While this program aligns with professionally orientated qualifications, elements of the curriculum design are potentially transferrable to other science-based curricula.

First offered in 2017, the program has attracted a range of industry professionals in horticulture from across Australia. The design of the Masterclass for a national cohort of students necessitated online delivery that is highly professional, flexible and relevant to people working in the horticulture industry to foster innovative and creative thinking among students. As a new program, we have implemented an action research approach to evaluate the curriculum and student attainment of learning outcomes based on participant's reflections in questionnaires (HREC 16252).

Intensive face-to-face workshops and field visits, are provided for students in parallel with Work Integrated Learning (Patrick et al., 2008). Module topics and assignments promote interaction of the participants with their staff (if they are business owners) or employers (if they work for a business owner). In this way, the students are applying learnings to their workplace. The participants engage in an interactive workshop providing support on content, followed by tours of farms and businesses, with talks by keynote speakers. In their final assessment, the participants prepare and present a business plan to their peers, academics and leading industry representatives. Many participants have provided feedback that they intend to put their business plan into action, applying it to their own businesses. For example, participants describe an '*increased skills set… building confidence in those skills by implementing them back into the workplace'* and applying business strategies to implement change.

In summary, the high degree of industry engagement and endorsement as well as international collaboration in the design of the Masterclass is unique. This approach has the potential to be a "blue-print" for the development and delivery of new pre-degrees. It is already influencing curriculum design at the unit level in our Bachelor's degrees in Agriculture in terms of flexibility of delivery to meet the expectations of articulating students.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 29, ISBN Number 978-0-9871834-7-7

STRUCTURED MEDIA COMMUNICATION PROJECTS FOR STUDENTS OF THE LIFE SCIENCES

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KEYWORDS: science communication, digital literacy

PROBLEM

Science students can become influential leaders by learning to communicate effectively to diverse audiences. Broader skills in communication, collaboration and digital literacy are important for preparing students for lifelong learning in diverse future career pathways, and developing these skills is a growing trend in Australian higher education. However, sophisticated storytelling and media communication skills require dedicated practice, and a structured approach to learning storytelling principles, which are often lacking in biology teaching programs.

PLAN

We developed a media communication program with a structured approach to teaching storytelling concepts. The structure emphasizes student planning, development tools, peer feedback and iterative design. This approach was used for a media communications project for 3rd year biology students.

ACTION

Our student activity focused on enhancing digital literacy and science communication outcomes for 3rd year biological and medical science students.

Students developed sophisticated science communication and digital literacy skills by creating their own videos, which featured their own 3D cellular representations and other content of their design. We asked students to choose from a range of complex cancer topics and target audiences, and then design a video to suit their chosen options. Professional workflow tools such as storyboards and video treatments allowed the students to progressively develop and refine their drafts, with their work further modified and improved following feedback from their peers.

By guiding our students through a structured process of video development, feedback and revision, we aimed to instil in student's strategies that will allow them to deliver high-quality media on a consistent basis. We actively encouraged our students to explore different storytelling possibilities to make better-informed choices when designing their videos.

REFLECTION

Our students were thoroughly engaged with the activity. The development process allowed the students to curate their ideas and home in on storytelling motifs that enhanced their videos. Many students took the opportunity to express their creativity and represent cancer stories with visual metaphors and surprising storytelling devices.

This project accelerated the ability of the students to communicate complex cancer concepts to diverse audiences with proficiency and expanded their potential influence in the future. Strategies employed here may be applicable to other multimedia communications learning projects in the life sciences.

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DETERMINING AND DEVELOPING STUDENT SELF-ASSESSMENT CAPABILITIES

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KEYWORDS: self-assessment, success criteria, lifelong learning

BACKGROUND

A key component of lifelong learning is an individual's ability to undergo accurate self-assessment. Self-assessment has been defined as the range of actions and techniques through which students describe (i.e. assess) and possibly assign merit or worth (i.e. evaluate) to the qualities of their own academic work or learning processes (Pandero, Brown, & Strijbos, 2016). In the context of higher education, students trained in self-assessment improve their academic performance and self-regulation of learning (McDonald & Boud, 2003; Tarras, 2015). In spite of its benefits, self-assessment is poorly characterised in the literature, and the qualitative judgements tertiary students make about their own academic work remains undetermined (Boud & Falchikov, 2007).

METHODS

Participants in this study were 2nd year Physiotherapy (n=86) students studying functional anatomy. Students were given a typical functional anatomy short-answer question that required the integration of knowledge of multiple concepts to answer at a high standard. They then performed a quantitative and qualitative self-assessment of their answer. This initial self-assessment activity was followed by an interactive tutorial exploring success criteria through the marking of exemplars. Students marked individually then in small groups, and again after a instructor-led discussion on success criteria and expectations. The self-assessment task was then repeated later in semester. How, and to what degree, students performed self-assessment was determined via inductive thematic analysis (Braun & Clarke, 2006) of student's qualitative self-assessment. Accuracy of marking, both exemplars and self-assessment items, was determined by comparing student and instructor marks. The impact of the tasks were evaluated using students' perceptions and academic performance.

RESULTS

The most common self-assessment strategies used by students were checking for depth (88%) and breadth (66%) of the response with a strong correlation between these strategies ($r = 0.79$). Students varied in the level of self-assessment detail and a positive, but not significant, trend was evident between the level of depth and breadth against higher prior academic performance. However, students that identified the importance of integration of concepts in their self-assessment had significantly higher prior academic performance ($p<0.05$).

No relationship was found between prior academic performance and accuracy of students' marking of exemplars. However, student marks showed convergence toward marks by the instructor after small group discussions, and then even more so after instructor-led discussion. The majority of students (99%) found the tasks beneficial. Results from the second self-assessment task and final exams will be used to evaluate whether practice of marking exemplars improves quality and accuracy of student self-assessment and academic performance.

CONCLUSIONS

Students perceived the self-assessment and marking tasks to be valuable in their understanding of assessment requirements. Higher quality of self-assessment related to higher prior academic performance, and accuracy of exemplar marking improved after group discussion. These tasks may be particularly beneficial in improving the self-assessment skills of poorer performing students.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 31–32, ISBN Number 978-0-9871834-7-7

"THEY HELP YOU REALISE WHAT YOU'RE ACTUALLY GAINING": USING STATIC BADGES TO ENHANCE SKILL RECOGNITION AND VALUE AMONGST SCIENCE UNDERGRADUATES

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KEYWORDS: transferable skills, employability, badges, skill recognition, value, undergraduates

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). Analyses of global trends also indicate graduates will need many skills to adapt to an array of rapidly evolving factors that are impacting jobs and workplaces (World Economic Forum 2016). These skills include critical thinking, problem solving, creativity, communication, interpersonal, teamwork, numeracy, IT and others. Academics are building opportunities for undergraduates to develop such skills into the curriculum (Baker & Henson, 2010; Bennett, Richardson, & Mackinnon, 2015). However, past studies suggest students may not recognise skill development without prompting (Tomlinson, 2008; Whittle & Eaton, 2001).

Badging is an easily scalable tool that may enhance skill recognition, and, as called for in the literature, make explicit links between the curriculum and employability (Lowden, Hall, Elliot, & Lewin 2011; Saunders & Zuzel, 2010).

We have created a set of skills badges to highlight where undergraduates can build their employability and research skills in science units. Despite recent interest in badging, there is a lack of 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 & 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 curriculum-embedded skill development, has not been reported to date.

AIMS

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

DESCRIPTION OF INTERVENTION

Eleven transferable skills badges were developed and applied to student-facing online and hard copy course materials in six science units at Monash University and three at the University of Warwick. The icons were displayed on documents related to practicals, assignments, tutorial and workshop tasks identified by unit coordinators as providing students the opportunity to develop the relevant skills.

DESIGN AND METHODS

This mixed methods study involved administering surveys to students completing the relevant units both before and after adding badges and analyzing results for statistical differences. Focus groups were also carried out amongst students pre- and post-badging, providing detailed qualitative data on student views. Interviews were likewise conducted amongst teaching staff facilitating the badged units. The qualitative output was coded for themes, with comparison of themes arising before and after the inclusion of skills icons.

RESULTS

This presentation will provide a case study of the impact of badging two science units (one from Monash University and one from the University of Warwick). More than half of students found the badges helpful and quantitative analysis indicates they have the potential to increase student recognition of the development of some transferable skills. Qualitative analysis of student and staff feedback suggests several strategies for maximizing the impact of skills badging.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 33–34, ISBN Number 978-0-9871834-7-7

COLLECTIVE POLYMER LAB LEARNING: THE UoN APPROACH

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KEYWORDS: polymers, polymer lab

Polymers and Colloids is a Level 3000 10-credit point course at The University of Newcastle intended as a directed elective for BSc students. The Polymers section in this course is only 40% with 5 weeks (out of 12) 3-hour lab sessions associated with laboratory activities. There are 9 laboratory activities that have been developed for the course with each requiring 9-12 hours (3-4 weeks) to complete. The lab can comfortably fit 18 students at a time. Hence, it is only possible for each student to complete one activity. This paper will discuss the collective learning strategy employed by the author to ensure that learning outcomes for the course can still be satisfied despite limited lab time. Students, in groups of twos, are assigned different lab activities. At the completion of their project, (week 5) and prior to submitting a written report, students are asked to present their results to the entire class, paying particular attention to the background concepts and the link between the lecture and lab. The oral presentation also serves as a formative assessment and an opportunity to improve on their written report. In this collective learning environment, the role of the staff as a facilitator of learning is essential to its success. The staff has to be able to guide the students in evaluating and correlating results. Challenges that have been encountered will also be discussed but mostly centred on variable learning experiences and interests.

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DELIVERY OF SCIENCE PRACTICAL CLASSES IN AN INTENSIVE MODE: STAFF AND STUDENT PERCEPTIONS

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KEYWORDS: laboratory, practical class, teaching, intensive mode, block mode

PROBLEM

In a move to offer more flexible study options for an increasingly diverse student body, institutions are offering more subjects to students in an intensive mode delivery (IMD). This poses some challenges to the laboratory-based, practical classes within some science subjects. In the traditional mode, students may attend one practical class per week whereas with IMD, consecutive classes need to be run daily or at least 2-3 times per week to cover the equivalent content, skills and learning outcomes. There have been few studies investigating the design of IMD subjects in the sciences (Harvey, Power & Wilson, 2016) and those that exist describe the delivery of content and assessment design only. We found nothing that reported on IMD practical class design.

PLAN

The aim of this research project was to investigate the perspectives of teaching staff and students to inform the future design of IMD practical sessions. We surveyed practical teachers (n=13), subject coordinators (n=10), and students (n=185) studying in IMD science subjects with practical components during the 2017/2018 summer session. Three of the subject coordinators had designed and delivered for IMD before but none of the practical teachers had done so.

ACTION

The teaching staff commented on changes to their delivery and how they felt the subject went. Students commented on their learning experiences. We observed that each of the 10 science IMD subjects used a different pattern of delivery for the practical component. The duration of each IMD subject varied from two to four weeks. Daily patterns of face-to-face classes varied; some subjects delivered lectures and practical classes every day, some with classes on alternate days, and some in a 3-day block per week.

REFLECTION

Findings from the staff survey indicate that 56% of practical teachers and 60% of subject coordinators preferred teaching in IMD compared to traditional delivery for reasons including “getting to know the students better” and the students being “more motivated to grasp concepts in depth in order to move on to the next [days’] experiment”. Many students (70%) reported that they would study in IMD again and practical related reasons included increased interactions with staff and the teachers’ enthusiasm for the subject. Those students who did not have a positive IMD experience related it to (dis)organisation, lack of alignment between lectures and practical classes and timing between classes being too close. However some students thought this timing was beneficial since they could quickly put theory into practice.

These findings will be shared with subject coordinators via a custom workshop, for planning the next iteration of IMD. In the next cycle of action research, we will evaluate the changes made based on these findings from across the same subjects, to assess their efficacy. We will also investigate practical related assessments and student attainment.

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IMPROVING ESSAY WRITING IN LARGE CLASSES

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KEYWORDS: essay assessment, marking tool, formative feedback, large classes

BACKGROUND

Essay writing is difficult to assess: written explanations are time-consuming (Mingo et al, 2018) and costly (Lukhele et al, 1994) to mark, and constructive (Higgins et al, 2010; Nicol & Macfarlane-Dick, 2007), consistent (Hickson et al 2012; Tuckman 1991) and timely (Higgins et al 2010; Nicol & Macfarlane-Dick 2007) feedback is difficult to provide, especially in large classes. Consequently, many educators resort to machine-markable, multiple-choice assessment (Becker & Johnston 1999; Mingo et al 2018). However, written communication is a key skill many employers expect (e.g., Graduate Careers Australia, 2014) so students should be assessed on writing concise, logical explanations of technical issues.

AIMS

Our project aimed (1) to streamline the process of marking and delivering feedback for essays, and (2) to improve students' essay writing skills by providing formative feedback.

DEVELOPING A MARKING TOOL

We built a web application ('Wombat') to assist markers to assess essays, and to streamline the delivery of feedback. Using Wombat, markers viewed essays, and assigned marks and feedback (primarily by selecting pre-generated comments). Throughout this process, the time each marker spent assessing each essay was recorded. Wombat has additional, text-mining features to assist marking. Specifically, Wombat highlights sentences containing correct relevant information (i.e., content) and words that indicate structure (i.e., linking words). Essay questions were carefully constructed so we could define both correct content and the expected essay structure.

To test Wombat, we ran a controlled trial to investigate the utility of the highlighting. A group of 6 markers assessed essays from a previous year; half of the essays with highlighting, and half without. We surveyed markers to gain feedback on Wombat and the use of highlighting, and 5 of 6 markers reported they would like to use Wombat when marking in the future. We adjusted Wombat according to the markers' feedback for use during the marking of two "live" essays.

STUDENT ASSESSMENT AND PERFORMANCE

Students enrolled in a second-year science subject, *Animal Structure and Function* completed two essays, each with a 750-word limit. The first essay was optional whilst the second essay was compulsory and counted towards students' subject grade. Students wrote essays in a standardised, secure online environment (Cadmus), and were provided instructions for drafting and editing. Each essay was assessed on the accuracy of its content and the quality of its structure (i.e., organisation, logical flow, and referencing). For both essays, the structure was assessed in the same way, but the essay question (i.e., the required content) differed. Students received feedback and marks after each essay using Wombat, and completed surveys to provide feedback on the process.

All students who opted to write the first essay consulted the feedback and found it useful when writing the second essay. On average, these students felt more confident: in finding areas to improve, thinking of changes to make, in constructing logical arguments, posing the argument in the introduction, summarising the argument in the conclusion, and being able to advise others on how to improve an essay. For the second essay, 75 percent of students received higher scores for structure, suggesting most students' essay writing can be improved with practice and feedback of the kind we provided.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 37–38, ISBN Number 978-0-9871834-7-7

USING STUDENT SELF-REFLECTION TO IMPROVE LEARNING OUTCOMES AND ENSURE WORK-READY BIOLOGY GRADUATES

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KEYWORDS: self-assessment, assignment, feedback

BACKGROUND

Well-designed assignments and appropriate feedback ensure that students move beyond acquiring knowledge and skills into pathways toward lifelong learning. Yet, current feedback mostly focus on what students have done wrong or have not assimilated rather than how to improve and address knowledge gaps. Barriers to providing good practice in assessment and feedback include large class sizes, and lack of resources and knowledge of innovative work practices and technology.

AIMS

Here, we used a three-part study to investigate the ability of students to self-assess and their ability to improve their grades using standard rubrics across a Bachelor of Science degree.

DESIGN AND METHODS

Part 1 asked students to self-assess their assignment, which was compared to a lecturer's grade. Part 2 also compared self-assessed to lecturer's grade, but incorporated a test for self-assessment honesty by informing students that their assignment mark will be partly based on their ability to self-assess (against lecturer's grade). Part 3 compared assessment improvement when students were provided the opportunity to resubmit their assignment to improve their grade. Grade improvement was compared between students who received feedback based on rubric (general feedback) vs. detailed feedback.

RESULTS

Findings showed that although student's self-assessments were similar and correlated to lecturer's marks, the correlation was weak. The difference between lecturer's marks and student's self-assessments ranged from -24 to + 22, and ~30% of students self-assessed themselves to a different grade (more than 10 points). Students with good topic marks were slightly better at self-assessing than students with low topic marks, but the relationship between topic grade and self-assessment accuracy was not significant. Providing additional feedback did not increase students' grades. Students with similar or higher grades than average were more likely to re-submit assignments to improve their marks, especially if their mark for that assignment was lower than other marks in the topic, which would result in the assignment bringing their overall mark down.

CONCLUSIONS

These results suggests that students were not capable of self-assessment and resulted in differences of marks by more than a grade. However, when provided with the opportunity to re-submit assignments, students self-reflected and attempted to improve their marks, particularly when their assignment grade was lower than their overall grade. Detailed feedback did not substantially increase the ability of students to improve their grade, querying the need to provide extensive feedback.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 39, ISBN Number 978-0-9871834-7-7

AN ANALYSIS TO INVESTIGATE STUDENTS' DEFICIENCY IN TERTIARY MATHEMATICS AND STATISTICS

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KEYWORDS: mathematics support, text mining, topic analysis

BACKGROUND

The Mathematics Education Support Hub (MESH) provides mathematics and statistics support to all students in a variety of ways, including drop-in assistance for students in six campus libraries. MESH keeps records of each consultation including a detailed explanation of the student's query, the student's year of study, ID, discipline, the subject that the question is about, approximate duration of the consultation and on which campus the consultation occurred.

AIMS

The primary aim of the research presented is to analyse data collected from the drop-in support service to determine students' mathematics support needs during their degree. This will allow MESH to identify and build resources to assist students with the most common problem areas. A secondary aim is to help academics to improve the curriculum to enhance students' understanding in these areas for the relevant subjects.

DESCRIPTION OF INTERVENTION

We examined data on drop-in consultations with the MESH tutors in campus libraries. The data contain 4925 consultations that occurred in the last five years and include the tutor's explanation of the problem, the subject that generated the question and the year of study.

DESIGN AND METHODS

Current text mining techniques allow us to identify dominant themes in a large collection of documents (queries) rather than reading and interpreting thousands of queries to extract meaningful results. Text mining was used to create wordclouds, dendrograms (hierarchy of words), bigrams (how often word X is followed by word Y) and topics (groups of words that best represent the information in the collection). These techniques enable us to identify most common problem areas from consultation data and to analyse differences and similarities between years of study and between different subjects.

RESULTS

Our results show that some topics are common among mathematics and statistics topics regardless the year of study and the subject (e.g., probability, equation solving and differentiation). By creating a disaggregation of these topics into sub branches we obtain a better understanding of the scope of the questions for the first year and non-first year students separately. We also have examined the students' background knowledge of mathematics in order to relate the underlying reason for the student's questions to a mathematics deficiency or the design of the subject.

CONCLUSIONS

Interestingly, but not surprisingly, for the students who completed first year, the most common mathematics and statistics related problems were found to be based on fundamental mathematical and statistical concepts. This research suggests areas for curriculum improvement and more targeted support for first-year statistics and mathematics subjects, enabling students to improve their understanding and to create a more solid foundation for later years.

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PREPARING SCIENCE STUDENTS FOR THE WORKPLACE THROUGH EMPLOYER BASED PROJECTS

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KEYWORDS: workplace integrated learning, industry engagement, scalable WIL projects

AIMS

We have designed a Work Integrated learning (WIL) unit for all Bachelor of Science students with the intention to prepare graduates for the workplace through increased engagement with industry. Rather than student placements, our students gain experience though solving real problems provided by our industry partners. This approach will allow large cohorts of students to have a unique WIL experience which may act as a stepping stone to later placement opportunities.

Using a simulated workplace environment, we aim to 1) build and strengthen capabilities for WIL, especially in Science which has been traditionally lacking placement opportunities, 2) create a sustainable WIL model that delivers authentic work experience for students, and 3) enhance employability of our graduates, and reinforce skills and qualities gained through the experience.

OUTCOMES

A number of key outcomes to Science undergraduate students in their final year of study are expected, in addition to building the ongoing academic-industry partnerships across south-eastern Australia. Expected outcomes include:

i) The development of a WIL curriculum model (called Science Connect) connecting large numbers of students to a range of industry-driven projects where students work in small consulting teams supervised by an academic to produce a product/ service/ report for the business/ organisation across a 12 week semester.

ii) The delivery of the Science Connect program to students across a semester incorporating innovative pedagogy that immerses the students in a relevant science-related industry; is structured to enhance a teamwork environment that allows students to apply and transfer their collective knowledge to a real-world project with associated constraints and deadlines; and connects students to the process of articulating their skills to future employers.

iii) A showcase of the Science Connect project outputs to the relevant business partners as well as to the broader related industry through 1) a business-style presentation to the organisation; 2) an industry poster/ product expo at the university (including invited media); and 3) various conference presentations.

iv) Ultimately, we aim to demonstrate an effective and efficient model to deliver a unique and meaningful WIL experience for students that can be utilised by other teaching organisations.

A vital step to ensure the long term sustainability of the unit is for proposed projects to be reviewed by academic staff. This will ensure that expectations of the external organisation are moderated and ensure that a low level of time commitment is required from the industry partners.

Generic Bachelor of Science students typically struggle to see a pathway to employment, mainly due to a missing clear job profile. Through involvement in applied projects, it is expected that Bachelor of Science students will realise that developing generic skills in a science related field will allow them to be highly agile, and be able to adapt and succeed in a changing workforce.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 41, ISBN Number 978-0-9871834-7-7

MATHEMATICS SUPPORT – WHO NEEDS IT, WHY DO THEY NEED IT, AND HOW SHOULD WE DELIVER IT?

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

ABSTRACT

In the last decade, mathematics support centres have appeared all over the world and are now an integrated and essential part of a student's learning experience at many universities. They feed the growing appetite for secure mathematical understanding and skill required for a course or subject discipline, and add quality to student learning. Mathematics support centres have now become essential, even crucial, at universities for many and varied reasons. But there are different types of support, and diverse approaches. This presentation discusses this issue, highlighting *The Maths Skills Program* at La Trobe University as an example of a structured program which provides mathematics support for over 30 subjects in the disciplines of Chemistry, Physics, Biology, Statistics, Psychology Statistics, Mathematics, Biochemistry, Biotechnology, Nursing, Engineering and Exercise and Sports Biomechanics. This program 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). Data analysed over the eight years (16 iterations) of the program's delivery is discussed. The main findings are that the program helps students with their mathematical skills, maths confidence and subject grades.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 42, ISBN Number 978-0-9871834-7-7

BLENDED VS FACE-TO-FACE COMPARISON IN DELIVERING 1ST YEAR STATISTICS

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KEYWORDS: blended, face-to-face, teaching, statistics, psychology, socio economic status, ATAR

PROBLEM

Advancements in technology have revolutionized both the data analysis industry and traditional teaching techniques. Software packages have eased the programming task of data analysis. Due to the current economic situation as well as advancements in communication technology, universities and educational agencies now promote more student enrolments and the utilization of technology as a tool for teaching. University students often have to work part time to support themselves while they study. This results in difficulties attending some of their required face to face contact hours. When there is less face to face contact with students, the problem of student knowledge retention rises. In addition, the students' retention rate drops.

AIM & PLAN

The aim of this project was to compare the learning outcomes between first year psychology students at La Trobe University to see if using blended learning methods is more effective than face to face delivery of the subject. Comparisons were made between students' learning results for two consecutive years of the Statistics for Psychology subject; 2015 (face to face model) and 2016 (blended model). Ethics approval was obtained. Information retrieved from students' database and Learning Management Systems were then compiled and used in the analysis. Data about the student's age, gender, Australian Tertiary Admission Rank (ATAR) score, socio economic status (SES), basis for admission to the university and mathematical backgrounds were also retrieved and analyzed for both methods of delivery of this subject.

ACTION

The statistics subject for first year psychology students was delivered through a face to face model in 2015 (n=279) and blended model in 2016 (n=261). Five assignments, two computer tests and the final examination were kept unchanged in these two years. Results were retrieved and analyzed.

REFLECTION

Preliminary analysis indicated that there was no difference between students' final marks for the two delivery methods after fully adjusting for the relevant confounders ($p=0.0827$) (ATAR score, age, gender, SES which are all balanced between year 2015 and 2016). ATAR score had a significant positive effect on the final marks based on multiple linear regression ($p<0.001$) whereas, age, gender and SES have no major effects on the final marks. Subgroup analysis of the blended group showed that students with a higher socio-economic status performed slightly better in the blended delivery model as compared with lower socio-economic status, based on ANOVA analysis and subsequent pairwise comparisons. Teaching first year statistics to psychology students in blended form is still a work in progress. A summary of our findings will be presented according to tutor and student feedback.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 43, ISBN Number 978-0-9871834-7-7

A NEW MODEL FOR ASSESSING LABORATORY WORK

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KEYWORDS: education, laboratory, assessment

PROBLEM

The teaching of experimental physics in laboratories is central to any physics course. Through the teaching of experimental skills, students learn to produce scientific knowledge following scientific methods, by developing expertise in identifying and designing experiments, critical thinking and problem solving skills, the capability to analyze scientific findings and to communicate them effectively to the scientific community.

However, in articulating the big picture, we must not lose sight of the basics of experimental work: students taking actual measurements and using equipment, analyzing data, and interpreting and connecting with knowledge. This was articulated by Kirkup (2009) who says `Experimentation is at the heart of science... Many of the skills required to convert theory into reality and to explain measurements are learned through… a methodical and systematic approach to solving experimental problems and analyzing experimental data.' Richardson, Sharma and Khachan (2008) capture the development of these basics of experimentation as 'levels of sophistication'.

In our work, we have gone back to the basics and are incorporating these fundamental skills into our lab program, strategically utilising these to teach the broader skills such as critical thinking. Together with teaching the basics, we have developed and implemented tools to test whether students are actually acquiring them.

ACTION

We have introduced a new model for assessing student laboratory learning. Three learning outcomes are identified for each lab: an experimental approach, an analysis of the data acquired, and interpretation of the results in the light of theory. Over the semester, students practice this threefold approach to experimental work in each of eight separate experiments.

These skills are then assessed in three separate assessment tasks: an individual practical test, which tests the students' ability to perform an experimental investigation; a paper-based test which tests student's understanding of analysis and uncertainties, and a short lab report, which tests students' ability to interpret experimental data to address an experimental aim. The novelty of this approach is that we are assessing the *process* of experimental work, instead of the outcomes.

OUTCOMES

We introduced this model during semester 1 2018 in Junior Physics at the University of Sydney. We involved our lab tutors as partners in the development and implementation phases. This presentation will discuss our experience with the introduction of this new assessment model for experimental lab. Our initial results suggest that students are mastering the skills they need, and that this mastery is noticeably better once explicit assessment of the skills is introduced. We will discuss feedback from students and tutors, as well as how we can improve the schemes in future semesters.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 44, ISBN Number 978-0-9871834-7-7

INNOVATION TO IMPROVE LEARNING OUTCOMES: WHAT ARE WE MISSING?

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KEYWORDS: innovation, evaluation, learning outcomes, student satisfaction

BACKGROUND

Most evaluations of educational innovation focus on student satisfaction. Effects on learning outcomes are infrequently reported, and where they have been, they are often unchanged (Lee 2011) or mixed (Mahler et al., 2011). Here, I reflect on studies of innovation published with colleagues and suggest that the mismatch between student satisfaction and learning outcomes can be explained by confounding variables affecting the internal validity of the studies that are primarily related to constructive alignment (Biggs & Tang 2011) and observer effects (Pigott et el., 2013).

AIMS

Reflect on the reasons for the mismatch between student satisfaction and learning outcomes in studies of educational innovations published with colleagues.

DESIGN AND METHODS

Student satisfaction and learning outcomes were compared in published studies of learning innovations carried out at the University of Adelaide between 2010 and 2017 (Table 1). These were an interactive, in-house, clinically-relevant on-line anatomy tool; use of an online ‘Prezi’ presentation to integrate cranial nerve structure and function; a flipped classroom approach to anatomy practicals and to pathophysiology; and the use of ultrasound simulators in anatomy. Learning outcomes were compared with previous year’s marks, except study 6 (Table 1) where they were compared before- and after- the deployment of the educational intervention in a single learning session. Student feedback about the innovations was obtained near the end of the courses.

RESULTS

Student feedback was very good for all innovations, as evidenced by unanimously positive free comments and focus group comments for study 1 and 76-91% broad agreement on overall satisfaction for the remaining studies. Only 2 studies showed any statistically significant effect on learning outcomes (t-test, $p<0.05$): study 7, where positive changes were associated with clear constructive alignment, and study 8, where negative changes were associated with content that had poor alignment to some assessment elements. Many other factors able to influence outcomes were also noted.

Table 1: Learning outcomes before and after intervention

Study	Innovation	No. students (degree and study year)	Survey response rate	Students satisfied?	Learning outcomes affected?	Reference
1	On-line anatomy tool	195 (Medicine,3)	40%	Yes	No	Johnson et al., (2013)
2	Neuroanatomy tool (bolt on)	50 (Health Science, 2)	89%	Yes	No	Collins-Praino et al., (2015)
3	Neuroanatomy tool (integrated)	50 (Health Science, 2)	23%	Yes	No	Collins-Praino et al., (2017)
4	Reorganized practicals	148 (Medicine,1)	53%	Yes	No	Johnson (2016)

5	Reorganized practicals	136 (Medicine, 2)	60%	Yes	No	Johnson (2016)
6	Ultrasound simulators	59 (Medicine,1)	72%	Yes	No	Massey-Westropp et al., (2015)
7	Flipped course	167 (Nursing, 2)	69%	Yes	Increased	Gladman & Johnson (2017)
8	Reorganized practicals	146 (Medicine,3)	47%	Yes	Decreased	Johnson (2016)

CONCLUSIONS

Multiple variables affect student satisfaction and learning outcomes, not least year-to-year cohort variability, the measures employed and how- and from which view point (student, teacher, institution)- they are defined. It is unlikely therefore that there is a simple link between these measures and the innovations reviewed here, which in any case need to be considered more broadly in the context of overall student success (Cole, 2018). The present review indicates that when innovation involved close alignment, it had a positive effect on learning outcomes, but when this was poor it generally had little-, or occasionally a negative- effects. The review also suggests that innovation introduces unanticipated new learnings that are not assessed. To reduce this variable, we could anticipate and assess these new learnings before implementing the innovation. This would allow 'before' and 'after' comparisons that would inform subsequent course design, allowing better assessment of the learning activities that are supported by the innovation.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 45–46, ISBN Number 978-0-9871834-7-7

A PROJECT ON COMMUNICATING DISEASE TO NON-SCIENTISTS: DO THIRD YEAR HUMAN PATHOPHYSIOLOGY STUDENTS THINK THIS IS AN IMPORTANT TASK AND WHAT WAS THE NATURE OF THE STUDENT EXPERIENCE?

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KEYWORDS: threshold learning outcome, science communication, authentic assessment

Expert educators in science argue that science graduates should be "effective communicators of science by communicating scientific results, information, or arguments to a range of audiences, for a range of purposes, and using a variety of modes" (Colthorpe et al., 2013). To address this learning outcome we designed and delivered a project in a 3rd year human pathophysiology subject called *Communicating Disease*. Students chose a disease and a non-scientific target audience, and created a communication piece designed to educate this audience on the pathophysiology of the disease. Students chose one of six communication modes: video, website, audio podcast, magazine article, game, or story book. Students also submitted a 1000-word report in which they explained the pathophysiology of the disease for a scientific audience, explained the relevance of the disease, and justified why the target audience should be educated on the disease. In the final week of semester, students presented their communication piece to peers and staff. To support students through completion of the project they were provided with student forums, a range of resources on communicating science to non-scientists, and a detailed student guide which included a weekly schedule, a report template, detailed assessment instructions and a rubric marking scheme.

At the completion of the project we conducted a survey comprised of Likert-scale and open-ended questions to determine student perceptions. Forty-eight students completed the survey which is a response rate of 84%. Results from Likert-scale questions showed that a majority of students: 1) believe it is important for science students to become effective communicators of science; 2) thought the project helped them to improve their ability to communicate to a non-scientific audience; 3) thought the project was well-scaffolded; 4) gave their best possible effort; and 5) found the project somewhat challenging, and experienced a sense of achievement. Thematic analysis on open-ended questions revealed that: 1) the most commonly identified new skill developed was the ability to communicate science to a non-scientific audience (46% of comments); 2) the most commonly identified strength of the project was that it was fun, interesting and engaging, and fostered creativity and the development of a range of skills (35% of comments); and, 3) student advice to the next cohort was to start early, plan, and follow the weekly schedule (52% of comments). From the staff perspective, most students developed highly creative communication pieces. More variable was how successfully students were able to simplify the pathophysiology of the disease for the lay audience, with some students focusing on symptoms and treatment rather than explaining scientific concepts.

In conclusion, 3rd year human pathophysiology students believe it is important for science students to become effective communicators of science. Students are of the opinion that the communicating disease project helped them to learn this skill, and in doing so they gave their best effort to the project and experienced a sense of challenge and achievement. This project could be adapted and used in a range of science disciplines to foster the development of communication skills in science students.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 47, ISBN Number 978-0-9871834-7-7

THE HEALTH SCIENCE TOOLKIT: A CONFIDENT START TO UNIVERSITY

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KEYWORDS: health science, basic scientific concepts, human biology

PROBLEM

Students entering Health Science programs find their first-year learning experiences difficult for several reasons (Hoyne, 2016; Sturges & Maurer, 2013), one being students' lack of basic scientific concepts that underpin human biology (Thalluri, 2016). This issue is also encountered at our university for students accepted into nursing and rehabilitation sciences. There is a need therefore to bring these students up to speed with the necessary scientific concepts quickly and effectively.

ACTION

A four-day bridging unit, "Health Science Toolkit – The Ingredients of Life" was developed by modifying a similar program designed by Thalluri (2016). Toolkit was organized into 10 modules; after an overview of the human body, it dealt with basic concepts of chemistry and biology first, followed by the application of these concepts to structure and function of body systems. The theme of homeostasis was integrated throughout the modules. Each day was designed around student-centred activities including lectorials, workshops, campus tours and lunches.

OUTCOME

The inaugural session of Toolkit was implemented just before the start of Semester 1, 2018 on Townsville and Cairns campuses simultaneously, and attracted 30 participants.

Analysis of Likert scale pre and post surveys show that the most cited reason for attending was to attain knowledge in the biological sciences, followed by the need to be confident in starting university. At the end of Toolkit, the number of students anxious about starting first year was reduced, coinciding with an increased number of students who felt more at ease with engaging with content and academic staff, reiterating the findings of Thalluri (2016). Notably, more students regarded the concepts behind human biology, scientific terminology and homeostasis less challenging at the end of Toolkit.

In addition, responses to open-ended questions suggest participants found Toolkit beneficial because of the 'hands on' activities and supportive academic and technical staff. Responses to an electronic survey sent out to participants at the end of their first semester reiterate these perceptions and indicate, unlike Thalluri's findings (2016), that "Chemistry of Life/Water Biology" was the most useful module.

REFLECTION

We believe that Toolkit has given participants the confidence in their ability to learn and then apply basic scientific concepts to more complex ones. Given the increasing number of students who enroll into Health Science programs and who are at risk of poor educational outcomes, implementation of programs like ours would not only ease transition to university, but also reduce attrition. Integrating such enabling programs into Health Science degree programs are likely to become commonplace at Australian universities, and could possibly benefit from a review of how learning and teaching resources are currently utilized.

We note that uptake of Toolkit was lower than expected, and for future iterations of Toolkit, improved marketing support could potentially capture much larger numbers. However, Toolkit has now been adapted for a 13-week AQF level 5 Diploma to be delivered in semester 2, 2018, illustrating that it was a successful proof of principle for development of the diploma subject.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 48-49, ISBN Number 978-0-9871834-7-7

GENDER BIAS IN NSW HSC PHYSICS: PAST, PRESENT AND FUTURE

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KEYWORDS: physics, gender, teaching materials

INTRODUCTION

The low proportion of females studying and working in physics has been an expressed concern of a variety of academic societies, government bodies and educational institutions for decades and it has been the subject of a very substantial body of research. This research has revealed a multitude of complex, dynamic and interacting factors and much progress has been made in improving teaching pedagogy and resources to remove gender biases at all levels of education (Blickenstaff, 2005; Cheryan, Ziegler, Montoya, & Jiang, 2017; Eddy & Brownell, 2016). The research has also been used to design a variety of programs and interventions that aim to increase female participation rates. However, despite these efforts, the “problem” of women in physics has shown itself to be remarkably intractable. The international participation rates for girls and women in physics hovers at around 20% at all levels of education and has not improved for the past two decades. In fact, the proportion of students taking physics in the NSW HSC who are female has been falling.

An important aspect that has come out of the research into the gender imbalance in physics has been the importance of identity (Eccles, 2009). A student has to feel that their personal identity aligns with the perceived identity of practitioners in physics. The history of physics is a history from which the images of female practitioners of physics have been largely absent. Teaching materials have been found to show few female figures (Kerkhoven, Russo, Land-Zandstra, Saxena, & Rodenburg, 2016; Lacin-Simsek, 2011; Larsen, 1995; Rawson & M., 2014; Taylor, 1979; Walford, 1981). This research project examined the extent to which the image of physics presented to students today remains to be one dominated by men and masculine interests. This was achieved by analysing the syllabus, exams and teaching resources of the NSW HSC physics course.

METHODS

The HSC Physics final exams for the period 1996-2017 were examined for gendered content. Every question in the exams was evaluated and was taken to be gendered if it referred to stereotypically masculine or feminine interests, or referred to an individual person who was male or female. The 1995-2001, 2002-2017 and the 2018+ HSC syllabi were similarly examined. Every item in the syllabi were evaluated for reference to stereotypical interests or reference to male or female individuals. In this way it was possible to determine whether the gendered nature of the exams was a reflection of the associated syllabus or appeared during the construction of the exams. Finally, the images, questions and examples present in widely used textbooks were analysed for their gendered content. Textbooks associated with both the 2002-2017 and the 2018 syllabi have been examined.

FINDINGS

The ratio of masculine to feminine items in the exams was approximately three to one. This gender bias predominantly arose from questions containing mention of historical figures. In the 20 year period covered there were over 50 reference to male historical physicists and not a single reference to a female physicist. The 2002-2017 syllabus contains 22 references to male historical physicists and not a single reference to female physicist. The gender bias has improved in the new syllabus with only 7 references to male physicists, but still no reference to female physicists. None of the syllabi include explicit discussion of the gender imbalance in physics, which some research has been demonstrated to be the most effective strategy for encouraging female participation (Hazari et al., 2013).The textbooks show a similar gender bias, but with the recent text being markedly improved over the older book.

Although it is not suggested that the findings of this research are responsible for the gender disparity in physics, a focus on the history of physics in the syllabus, exams and teaching resources may inadvertently present an image of physics to that make it difficult for girls to identify with the subject. Particularly if the reasons for such disparity are not explicitly discussed and addressed.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 50–51, ISBN Number 978-0-9871834-7-7

DISPARATE DEVELOPMENT OF STUDENT UNDERSTANDING AND EXECUTION OF THE CONVENTIONS OF SCIENTIFIC WRITING

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KEYWORDS: scientific writing; conventions; informative writing; persuasive writing

BACKGROUND

Scientific writing tasks are designed to promote development of effective communication, reasoning and thinking skills (Zimbardi, Loyle-Langholz, Kibedi, & Colthorpe 2015; Colthorpe, Mehari Abraha, Zimbardi, Ainscough, Spiers, Chen, & Lavidis 2017). In facilitating students' mastery of scientific writing, they are often directed to literature as a model (Porter, Wolbach, Purzycki, Bowman, Agbada, & Mostrom 2010) however, novice students may lack the awareness and appreciation for the written conventions or how these are applied in the literature (Gillen, 2006; Snow, 2010). Further, scientific writing varies in complexity, particularly across informative (Methods and Results) and persuasive (Introduction and Discussion) sections. To recognise these nuances a well-developed understanding of conventions is required; therefore students need support to develop and then apply this understanding to their writing.

METHODS

In a 2nd year Physiology course, we directed students to the online science communication tool 'CLIPS' (Hardy, Pedwell, Kuchel, Colthorpe, & Rowland 2017) to support their preparation of a laboratory report. Through meta-learning tasks, students (n=376) were asked at the start and end of semester what information from CLIPS was useful for writing their report and why, and about their understanding of the purpose and approach to the Introduction and Discussion. Responses were analysed to assay recognition of scientific conventions, and development of students' understanding of complex writing. Academic performance, both overall and in each report marking criteria, was compared to the previous year.

RESULTS

At both the start and end of semester, students most commonly reported the usefulness of the Writing (44% and 37% of responses, respectively) and Displaying Data modules in CLIPS (33% and 48%). Students' initial responses showed they could identify key elements for presenting data and text construction but described these somewhat superficially. By the end of the semester, responses about conventions for figure legends, graph formatting and use of statistics increased up to four-fold, and students were recognising the nuances of variation in these conventions. Responses highlighting structure and purpose of report sections also increased and reflected a more sophisticated articulation of components required for effective, evidence-based reasoning. In 2017, the mean report score was significantly higher than 2016, with fewer failing and more in the higher performing bands. Within criteria, the median achieved in informative sections increased by one grade band to 80%. There was no improvement between years however, in median performance across persuasive sections, although the standard achieved for the Introduction by the lower quartile increased from 40% to 60%.

CONCLUSIONS

By the end of the semester, students appeared to have developed a deeper appreciation of scientific conventions and their purpose for enhancing communication, demonstrating particularly better recognition and application of scientific conventions for informative writing. Despite a seeming increase in awareness and understanding of the requirements for persuasive writing however, students lacked the higher-order skills to effectively execute this awareness within their writing. The longitudinal development of students' understanding and demonstration of effective persuasive writing in science, is currently being explored.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 52–53, ISBN Number 978-0-9871834-7-7

HOW CAN WE FOSTER CREATIVITY IN SCIENCE EDUCATION?

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KEYWORDS: creativity, explicit, curriculum redesign

BACKGROUND

Biomedical Science (BMS) Students at Monash University are high achieving students, often aiming for postgraduate medical courses. As many students will not achieve this, it is important that the curriculum develops skills to enhance workplace readiness. The Australian workplace is changing and there is an increasing demand for employees with "enterprise" skills. Creativity is an "enterprise" skill included in the Monash Graduate Attributes - *"Monash University prepares its graduates to be a ... creative scholar*". However, a previous study, by the authors, identified that creativity was not explicitly discussed in the curriculum, students did not fully understand "creativity" and perceived a lack of creative opportunities in the course.

AIMS

To determine the impact of curriculum redesign to introduce the concept of creativity, evidence that creativity is a skill valued by employers and that science is a creative endeavor. To examine if developing students' understanding of creativity enables them to see opportunities to develop their creative abilities and demonstrate this to employers.

DESCRIPTION OF INTERVENTION

The intervention included the development/implementation of a workshop "Identifying creativity in science" in 2nd year of the BMS degree. The workshop explicitly introduced definitions of creativity and the creative process and its relevance to science and employability. Bloom's taxonomy and the Double Diamond model were introduced to demonstrate that create is the pinnacle skill on the taxonomy and to help conceptualize the creative process. Other existing workshops were modified and Bloom's taxonomy and the "Diamond model" were used extensively to explicitly signpost creative learning opportunities and raise students' awareness of creativity

DESIGN AND METHODS

The redesigned curriculum was implemented in semester 1/2018 in a 2nd year unit (503 students). Students completed online surveys, pre- and post- the new workshop (week 1) and post-week 4. Likert scale and open-ended questions regarding students' conceptions of creativity, self-evaluation of creativity, and perception of creativity in the unit were included. Quantitative data was analysed by two-tailed Wilcoxon matched pairs signed-ranks test to determine if there was statistical differences between student's responses prior and after the workshop(s). Qualitative data (open-ended questions) were thematically analysed.

RESULTS

Data from student surveys pre- and post-week 1 workshop demonstrated participation in the workshop had a positive impact on conceptions of creativity and broadened the understanding of creativity. Significant differences were observed pre- and post-workshop. Over 90% of students indicated that the workshop broaden their understanding of creativity and many indicated that it helped them see that creativity is applicable in different areas in life and is important in the sciences.

CONCLUSIONS

The data from the student surveys supports the introduction of explicitly defining and discussing creativity to increase students' conceptions and perceptions of creativity. It raised students' awareness of their own creativity, the importance of creativity in science and their ability to communicate their creativity. This model of workshops and curriculum redesign may be a suitable model of curriculum design to be used to raise students' perceptions and awareness of other 'enterprise' skills, thus increasing workplace readiness.

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PRECURSOR OR PRODUCT: THE BLENDED LEARNING ENVIRONMENT IN A CHEMISTRY MAJOR

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KEYWORDS: blended learning, demographics, performance, assessment, chemistry

AIMS

Diverse learning platforms facilitate accessibility of content for non-traditional students and compensate for geographical limitations that universities might experience. In utilizing diverse learning platforms, it is critical to ensure effective and equitable teaching and learning outcomes across different student demographics. Based on the foundation and first year chemistry offerings at the University of New England (UNE), we aim to develop a theoretical construct for the basis of a long term quantitative study on student performance across multiple learning platforms.

SOURCES OF EVIDENCE

Pressure to speed up the evolution of blended learning in many courses comes from management, students, industry, and certain cohorts of academics. Students suggest all content and activities should be available online. Management emphasizes reaching a broader audience, and doing so economically. Industry wants novice and veteran chemists to revisit some fundamental concepts and lab skills. Educators want to embrace effective teaching strategies for every student population.

It is well established in the education literature that "diverse student groups bring with them a rich prior experiences and knowledge about science as well as their own ways of knowing, thinking, and communicating that influences their learning" (Walls, 2016). In a recent review (Cooper, 2018), several studies were highlighted as reporting demographic disadvantages to online learning, and other research (DeKorver, 2016) also suggests demographics and student goals correlate with assessment outcomes; which demonstrates that not every iteration within the blended learning spectrum is equal.

The learning platforms utilised to teach chemistry at UNE are diverse. Foundation and first-year chemistry content is presented in several combinations of the following: conventional lectures throughout the term, online lectures throughout the term, conventional laboratory experiments throughout the term, expedited laboratory experiments during one 'intensive' week, flipped classroom 'workshops' on campus, evening 'tutorials' on campus, and evening online 'Q&A' sessions. All students participate in a combination of the aforementioned learning platforms. Despite on-campus and online students being given the same content and assessments, student performance remains different.

MAIN ARGUMENT

Where do the learning platforms used in chemistry fit into the blended learning landscape? Are we currently a precursor or product of the blended learning format? We are at a pivotal point in education with the advent, flexibility, and economics of online study, and so we must re-evaluate the relative effectiveness of our learning platforms and our traditional methods to assess student learning, particularly in relation to diversity of learning platforms. As discussed, student demographics and individual learning goals are critical factors in performance; and if the design and range of learning platforms is satisfactory, they should be shown to support underperforming cohorts.

CONCLUSIONS

This work will elucidate the key components of first-year chemistry learning platforms and highlight any underrepresented student populations who will require the next step in evolution within blended learning. This information will be an important consideration in the design of future teaching and learning strategies. The results of this study will be applicable to other fields of science traditionally taught through a combination of lectures and activities in a laboratory (e.g., biology, physics) or field settings (e.g., ecology, geology, environmental sciences).

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 56–57, ISBN Number 978-0-9871834-7-7

MODERN CHEMISTRY: CHALLENGE-BASED CURRICULUM DESIGN

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KEYWORDS: challenge, flipped classroom, laboratory experience

In science courses in general, but especially in 1st year chemistry classes, the amount of content that is delivered is often overwhelming and too complex for the student to easily cope with. Students not only have to gain knowledge in a variety of different field, they also have to learn new laboratory skills and analytical techniques. In addition to the academic content, it is often difficult for students to connect the fundamental concepts covered to any 'real-life' scenario or application. The view of the 'big picture' is often lacking, even if the lecturer tries to convey this in a lecture, which is in most cases still the most common form of teaching.

There have been different approaches on how to make 'dry' scientific concepts more interesting and how enhance student engagement, ranging from problem based learning approaches, case studies or flipped classroom models.

We have recently turned a fairly classic 1st year chemistry course into something, where students are gaining knowledge and understanding purely through completion of a range of challenges. We have removed all lectures, tutorials and the final exam, and every interaction with the student happens in the laboratory. Throughout the semester, students will attempt to complete a range of challenges, both theoretical and practical, find relevant information, propose approaches to solving the challenges, and discuss these and subsequent outcomes with academic staff. Non-graded passes are awarded for completed challenges, and the students complete the course by completing a set number of challenges.

The approach fosters and promotes self-directed and peer-assisted learning over classical accumulation of knowledge. Which the curriculum is certainly less broad in terms of topics covered, students get a deeper understanding in a selected number of areas. Additionally, students are encouraged to become more independent learners.

Initially, resistance among staff and students was relatively high, with the latter quickly recognizing the added skills they could gain from the course. While student workload is relatively high, we could observe in general a very high engagement of the students, and their effort often went beyond what was expected.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 58, ISBN Number 978-0-9871834-7-7

JINDAOLA, AN ABORIGINAL WAY: EMBEDDING KNOWLEDGES AND PERSPECTIVES ACROSS THE CURRICULUM

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KEYWORDS: Aboriginal, Indigenous, knowledge, Jindaola

PROBLEM

While much research concerning Aboriginal people has been conducted since the British invasion of the late 1770's, much of this had been done without permission, consultation or involvement with Aboriginal people. This project aims to shift the University of Wollongong (UOW) approach from learning about Aboriginal culture to learning and valuing Aboriginal ways of knowing, being and doing, empowering traditional knowledge-holders as teachers. Respectful, reciprocal relationships with custodians of local Aboriginal knowledges are fundamental to the successful integration of these knowledges into our curricula. We aim to re-orientate from a deficit model to a knowledge-exchange model when considering Aboriginal knowledge, where there is a respectful reciprocal relationship between UOW academics, local Aboriginal organisations, elders and traditional knowledge holders and students. Through this approach, we demonstrate that Aboriginal knowledges have intrinsic value and should be studied alongside, not as an alternative to, or in opposition to, 'Western' scientific knowledge.

PLAN

Jindaola is a project within the University of Wollongong (UOW) in partnership with local Traditional Owners from the Yuin nation that seeks to enrich the experience of all students at the University by embedding Aboriginal knowledge in the curriculum. *Jindaola* is the Yuin term for goanna and represents a philosophy of practice, based upon the principles of respect, responsibility and reciprocity. It is a reciprocal learning/teaching process for staff involved, who are on their own journey of personal development, learning the Aboriginal way of sharing knowledge as they embed these knowledges in the curriculum. This qualitative study uses Indigenous research methodology embedded in an overarching framework of Participatory Action Research (PAR). The Indigenous research methodology broadly uses the framework of Martin and Mirraboopa (2003) who describe Indigenous Ways of Knowing, Ways of Being and Ways of Doing and their interrelationship's.

ACTION

This study reports on two components of Jindaola specifically: 1. The process of academic development of the non-Aboriginal staff involved in the initiative and 2. The development of an educational intervention aimed at increasing science student's awareness of local Aboriginal knowledge and culture. The curriculum innovations to be discussed will be applied to a 1st year generalist molecular biology subject with 700 students in Spring 2018 and are components of a larger project that aims to better reflect the breadth and depth of knowledge in our society through embedding Aboriginal ways of knowing, being and doing in university curriculum.

REFLECTION

Our strong recommendations are 1. Aboriginal staff must lead the change process and provide education to non-Aboriginal staff on how to conduct community consultation respectfully, responsibly and with reciprocity 2. Non Aboriginal academic staff must be re-oriented to view Aboriginal knowledges without a colonial lens and so non-Aboriginal academic staff members must spend meaningful time with Aboriginal staff and or community members to develop a deep, rather than a surface, appreciation and respect for the depth and complexity of Aboriginal knowledges before any curriculum modifications can be developed and implemented.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 59–60, ISBN Number 978-0-9871834-7-7

ASSESSMENT OF STUDENT REASONING THROUGH ONLINE SYNCHRONOUS CONCEPT CHATS

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KEYWORDS: MOOCchat, cognitive conflict, critical reasoning, online discourse, rubric

ABSTRACT

Challenging students to engage actively in thinking about their thinking in chemistry concepts requires increasingly creative strategies and, as incentive, summative course marks. We are exploring new ways to adapt an online synchronous discussion tool (MOOCchat) to achieve this goal in large first year chemistry cohorts. Individually, students are first asked to view a YouTube video and apply critical thinking to analyse and identify the underlying concepts then to submit their explanation. The collaborative tool assembles students into groups, based on their confidence in their explanation, and they are then required to engage in a collaborative discussion to develop the best explanation by comparing their individual propositions. Once the group agrees on a consensus explanation, the student moves on to individually reflect on how this consensus explanation differs to their original thinking. We have trialled two separate scenarios to date using videos related to concepts of the first law of thermodynamics and saturated salt solutions.

This activity has now been trialled in three separate semesters, applying a different assessment structure in each, in an attempt to engage students and gain evidence of deeper critical reasoning. In collaboration with the eLIPSE (UQ based) and ELLIPS (US NSF) teams, we have developed and embedded assessment criteria that evaluate a student’s process skills based on their individual contributions to the group chat and post-chat reflection. The criteria include: evaluating, interpreting, analyzing, making arguments, expressing and responding. In this presentation, we will provide insights and evidence of students thinking about their own thinking, gained through analysis of the data collected during the evaluation of this assessment. We will also share students perceptions of this learning activity in regard to its usefulness in their learning (or not) collected through online questionnaires and interviews.

ELLIPS, Enhancing Learning by Improving Process Skills in STEM, http://elipss.com/index.html
eLIPSE, Centre for eLearning Innovations and Partnerships in Science & Engineering, https://www.elipse.uq.edu.au/

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 61, ISBN Number 978-0-9871834-7-7

RIDDLES AND REFLECTION: THE QUESTION MATTERS

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KEYWORDS: reflection, riddles, veritasium

REFLECTION

"Reflection enables us to correct distortions in our beliefs and errors in problem-solving" (Mezirow, 1990). The importance of reflection in education has been noted as far back as 1910 in John Dewey's book "How we think". According to Dewey, there are 6 phases of reflection.1. an experience; 2. spontaneous interpretation of the experience; 3. naming the problem or the question that arises out of the experience; 4. generating possible explanations for the problem or question posed; 5. ramifying the explanations into full-blown hypotheses; 6. experimenting or testing the selected hypothesis. (Rogers, 2002). These phases closely follow the scientific method – this kind of thinking is Reflection is also an integral part of metacognition including self-regulation in learners (Ertmer and Newby, 1996, Bewes and Sharma 2011).

INTERVENTION

This research is based on two videos uploaded by popular science communication YouTube channel 'Veritasium'. Video one contained four riddles, and video two the solutions to those riddles. The riddles broadly follow the phases of reflection outlined by Dewey (1935). An experience is shown, there is a pause for the viewers to process the experience, the question is posed, and the viewers are requested to generate/ramify the possible explanations. After watching video two – containing the solutions to the riddle, the viewers are encouraged to fill out a survey. The survey consisted of the same set of questions, duplicated for each of the riddles. For riddle one, the survey posed "After watching the solutions video, did your answer to question (riddle) 1 change?" Respondents could only select one of the following options, "Yes", "No" and "My answer was correct." This process was repeated twice – once for a sample of the general public (n=2200), gathered from "Veritasium" viewers, and once more from the first year physic students at the university of Sydney (n=630).

DATA AND RESULTS

The answers were coded qualitatively, and fell into distinct categories, which match Mezirow's (1998) taxonomy of critical reflection. The categories were "Almost", "Alternative Solution", "Fault", and "Self". "Almost" "Alternative" and "Fault" all match Narrative Critical Reflection on Assumptions (CRA), outlined by Mezirow, and "Self" matches Narrative Critical Self Reflection on Assumptions (CRSA). The question had a profound impact on the types of reflection triggered. The question affecting the type of reflection is useful information to know for creating educational content and assessment. The detailed results will be presented at the conference.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 62, ISBN Number 978-0-9871834-7-7

APPLYING DISPOSITIONAL LEARNING ANALYTICS TO CLUSTER LEARNERS BY BEHAVIOURS AND PERFORMANCE

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KEYWORDS: self-regulated learning, learning analytics, cluster analysis

BACKGROUND

Learning analytics uses the digital trace left by students as they engage with online learning activities to improve learning and teaching (Arroway, Morgan, O'Keefe, & Yanosky 2016), but this trace represents only part of the story. The new field of 'dispositional learning analytics' combines learning analytics data with learner dispositions (such as self-regulation) to better understand how students approach learning and engage with learning activities (Shum & Crick, 2012). In this study we used dispositional learning analytics and cluster analysis to group students based on their patterns of engagement with meta-learning tasks, self-regulated learning behaviours, and academic achievement to evaluate if this method could be used to identify at-risk students.

METHODS

Participants (n= 200) were students studying a first year anatomy and physiology course. As part of course assessment, students completed four online meta-learning tasks consisting of open-ended questions designed to encourage students to reflect on their learning (Colthorpe, Sharifirad, Ainscough, Anderson, & Zimbardi 2017). Learning analytics data was collected from the tasks, including word count, submission time and task completion rate. Students' self-regulated learning behaviours were determined by thematically analysing responses. This data was then used to cluster students using a two-step cluster analysis.

RESULTS

Three clusters were identified: high, medium and low self-regulated learners. High self-regulated learners reported using the most exam preparation strategies, and the most new strategies. They had the highest academic performance (71.39%±2.30), wrote the most detailed responses for the meta-learning tasks, and had a high task completion rate. Low self-regulated learners reported the lowest number of learning strategies, had the lowest word count for their responses, and the lowest completion rate. Medium self-regulated learners reported more strategies and had higher engagement with meta-learning tasks than low self-regulated learners, but had similar exam results (medium = 64.63%±1.71; low = 64.43%±1.98). High and medium self-regulated learners relied most heavily on self-evaluation and transforming records strategies, whereas low self-regulated learners relied on reviewing records.

CONCLUSIONS

The cluster analysis identified groups of students based on differences in self-regulated learning and engagement with meta-learning tasks; however, the procedure was less successful at differentiating between students based on academic achievement. Although this approach demonstrates how dispositional learning analytics can be used to characterise students learning behaviour, further analysis is required to identify students at risk of academic failure.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 63, ISBN Number 978-0-9871834-7-7

ASSESSMENT DESIGN FOR A COURSE/UNIT: DATA DRIVEN DECISION MAKING VS. ACADEMIC VIEWS

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KEYWORDS: assessment design; learning analytics; concept mapping

BACKGROUND, AIMS AND METHODS

'Emerging models of assessment' is a key consideration, generally in higher education, but in particular within the current *Future Learning, Future Teaching* theme of this conference. The recent hype in the field of learning analytics adds a new dimension to curriculum design, especially one that involves data-driven decision-making when it comes to course/unit design. Learning analytics refers to 'the measurement, collection, analysis and reporting of data about the progress of learners and the contexts in which learning takes place' (Sclater et al., 2016), which can then be used to optimise learning environments. However, a dilemma arises when such data conflicts with the long-existing views of experienced academics, in relation to appropriate course design.

For years, we believed that one of the practicals in our large first year biology course (enrolments up to 1000 students per semester) is relatively more important than most of our other intra-semester assessment tasks, as this practical involves a complex concept-mapping exercise that drives deeper thinking amongst students. This activity, we believed, will significantly help students do better in the exam, especially with integrative Short Answer Questions (SAQs). Furthermore, given the extensive work that goes into this practical report, particularly in comparison to other practical reports, we noted that some students weren't giving all the effort that they could for this practical. As this is in turn going to affect their exam performance and course grade, we wondered if this practical deserves more weightage in course assessment.

In light of this situation, we analysed the marks that students received for each assessment task in the course in semester 2, 2017 (n=837), and correlated that data with their performance in SAQs and their final course grade, with a particular interest towards any correlations between the various practical report marks to SAQ performance and course grade.

RESULTS AND DISCUSSION

As expected, students who performed well in the concept mapping practical also did well in the final exam and received better grades. This correlation between concept mapping mark and performance in the SAQs was visible throughout the spectrum of marks, however, it was significant from 60% marks for the practical, and above. Similarly, a clear discrimination also existed in final course grades between students receiving less than 60% of marks in the concept mapping practical vs. those that received 60% and higher.

However, interestingly, and in complete contradiction to our expected views, the concept mapping practical had similar correlations to all other intra-semester assessment tasks in the course, especially the remaining practicals, to performance in SAQs or the final course grade. The Pearson correlation score for concept mapping exercise to performance in the SAQs and final course grade was 0.42 and 0.46 respectively, while the other practicals had similar correlation scores, ranging between 0.39-0.44 and 0.41-0.55 respectively. This data-generation process was extremely beneficial to our decision-making as we now, with confidence, are able to leave the course assessment structure as it is, while still emphasising to students the benefit of generating concept maps for their learning in general.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 64, ISBN Number 978-0-9871834-7-7

PARTNERS IN PROTEIN SCIENCE: STUDENTS AS CO-CREATORS IN CURRICULUM CONTENT AND ASSESSMENT

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KEYWORDS: engagement, curriculum design, student as partners

PROBLEM

In recent times there has been a noticeable reduction in student engagement in higher education, particularly in traditional lectures, and regardless of whether they incorporate active learning components or performed in a flipped classroom setting. We have also observed a reluctance of students to participate in small problem-based classes or tutorials. Students have suggested that this is due to fear of failure or ridicule from fellow students, and explains why engagement strategies involving anonymity, such as clickers, remain popular with students. As educators we understand the benefits of active learning but the question we need to answer is, how do we encourage students to participate?

PLAN

While institutions grapple with improving student engagement and defining exactly what is meant by the term “engagement”, there is an increasing trend to build partnerships between students and academics, with both parties contributing to the teaching and learning in higher education. The “Students as Partners” (SaP) approach encompasses students working with academics and providing opportunities to contribute to all aspects of teaching and learning (Healy et al., 2014). This approach is supported by the growing number of publications reporting the positive outcomes of involving SaP, which included: increased engagement, improved relationships, enhancement in student learning and a sense of being part a community (Cook-Sather et al., 2014; Mercer-Mapstone et al., 2017). In light of these findings, we decided to adopt a students as partners approach to a second year biochemistry course to improve engagement by allowing student to contribute to both aspects of the course curricula and assessment.

ACTION

In order to enhance the engagement in Protein Science, a second year biochemistry course we initiated a SaP approach allowing student to contribute to part of the curricula and the assessment. We felt that giving the students a say in what was taught and allowing them to design assessment would encourage them be more engaged or have a vested interest in the course. Our SaP strategy was three-fold: 1. Provide student with a choice of topics for part of the course; 2. Create an opportunity for students to design multiple choice questions, with scaffolding, which form part of the assessment; and 3. Provide a forum for student reflection on evaluation of their partnership experiences.

REFLECTION

We were surprised at the level of engagement of the SaP in the course and in particular with the reflections provided by students. Of the students who participated in the SaP task, 86.4% rated the partnership experience for the curricula and assessment design as being useful (52%) or very useful (34.4%), and 80.5% indicated that they were engaged (32%) or more engaged (48.5%) as a result of being involved in the course design and assessment. Student reflections provided direct insight into student’s perceptions of the partnership, and endless information about student learning, metacognition, motivation and knowledge construction. The majority of the reflections on the choice of topic related to their future courses or degree programs or topics that they thought would be interesting, for example, “I believe these topics could be of use in my future as a researcher”, and “I chose Protein Therapeutics because I find it fascinating how proteins can be used to treat medical conditions'. Another student stated that, "I liked that I got to study a topic I chose for once". With respect to designing multiple choice questions for assessment, students overwhelmingly commented on the difficulty of this task, such as "It was a lot more difficult than I anticipated". While many suggested that this supported their learning, for example, "it forced me to have an understanding of the content to create questions in which I could ultimately test myself on, further improving my knowledge". A final student comments is a testament to our successful foray into SaP, "Choosing a topic meant an increase in engagement and interest, and choosing questions for assessment meant I had to filter through what I know, didn't know and what gaps I had in my knowledge".

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 65–66, ISBN Number 978-0-9871834-7-7

INVESTIGATING THE EFFECTS OF OBJECT BASED LEARNING ACTIVITIES- A PILOT STUDY IN POLYMER CHEMISTRY

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KEYWORDS: object-based learning, observation, polymer chemistry, polymer properties, active learning

ABSTRACT

This paper investigates the effectiveness of a student-centred learning activity- Object Based Learning (OBL) when implemented in an upper level (3rd year) polymer chemistry topic. There is now a major drive in many tertiary institutions in Australia and worldwide towards using student-centred approaches to teach wherever possible. Student centred active learning is a pedagogical process whereby students are directly involved in the learning process, i.e. they are engaged in the material to be studied through various meaningful activities [1]. Object-based learning approach is one of the student-centred approaches that combines active learning, group work and peer learning and it makes use of the objects as thinking tools to provide hands-on and minds-on engagement with the object of study in order to facilitate deep learning [2]. The primary aims of this project are to develop OBL approach in Polymer Chemistry to improve student learning outcomes and engagement, and to enrich student experience. OBL activities that cover different ideas and concepts in Polymer Chemistry will be created to engage students and to provide them with opportunities for problem solving and application of content. Four OBL workshops that include innovative activities will run during the second semester of this year to challenge students in their learning, surpassing their expectations of using objects, fostering work-ready skills-teamwork and communication, transferring learning into specific disciplinary content. The key research questions to evaluate the effectiveness of this new teaching method are: Does OBL activities improve student learning in Polymer Chemistry?; What are the students' responses to OBL activity as an inclusive and motivational tool in a polymer chemistry topic?; Does offering OBL activities enhance student engagement? These research questions will be addressed respectively by surveys, testing students' exam scores between two methods (using standard methods of teaching versus OBL) as factors on the relevant Polymer Chemistry content. We will also compare the exam scores between two years to see if there is any learning gain due to OBL implementation as the same academics are teaching this topic in both years (2017 and 2018) using a randomized control study design. The participants will also complete a survey open-ended questionnaire that is designed to explore their perceptions about OBL activities. We seek to describe in this paper the usefulness of such approach to this challenge and the measurable outcomes we have achieved so far.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 67, ISBN Number 978-0-9871834-7-7

ASSESSING CHANGES IN CONCEPTUAL UNDERSTANDING WITH THE TCI

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KEYWORDS: physics, gender, thermodynamics concept survey, heat, temperature

BACKGROUND

Thermodynamics is a core part of physics curricula covering a range of concepts such as heat, temperature, properties and behaviour of matter, and laws of thermodynamics. The Thermodynamics Concept Survey (TCS); Wattanakasiwich et al. (2013) is a survey specifically designed to evaluate the fundamental thermodynamic concepts.

AIMS

The aim of this study is to investigate how one particular question on the TCS can be used to measure the gains in understanding of the concepts of heat, energy and temperature due to instruction, and how those gains differ for males and females.

QUESTION OF INTEREST

The question of interest here is Question 4 from the TCS Wattanakasiwich et al. (2013). Note that we do not reproduce the question here to assist in maintaining integrity of test. The question evaluates students' understanding of the heat (energy) transfer during change of state and temperature, by asking students to compare the heat lost when ice and water start at the same temperature, and the temperature is then reduced to well below the freezing point of water. This question is of interest because an analysis of TCS data showed that this question had a particularly large gap in performance between males and females, both pre- and post-instruction.

DESIGN AND METHODS

At UNSW Sydney, approximately 1600 students take the introductory calculus based course, Physics 1A. In semester 1, 2016, a total of 686 (74% males, 26% females) students took the face to face class and completed the pre-test (week 6) and post-test (week 12).

Transition matrices, showing the choices selected by students, were constructed to analyse how students' answer choices changed between the pre- and post-tests. Facility (fraction of cohort answer correctly), gap (difference between male and female facility) and changes in facility by gender from pre-test to post-test were calculated.

RESULTS

The analysis shows that 42% of males but only 31% of females are answering this question correctly pre-test, giving a gap in facility of 0.11. After the three weeks of teaching, the facilities increased. The female facility rose to 53%, and male facility to 64%, which gives a gap of 0.10. Hence there is evidence that there was some learning by both females and males, but the instruction did not reduce the gap. However, a more detailed analysis using a transition matrix to see how students' answer choices changed reveals a more nuanced, and more encouraging, picture. Table 1 shows the transition matrices for male and female students for this question.

Table 1: Transition Matrices for Males and Females

Question 4: Answer B

Males PreTest	Post Test A	B	C	D	E
A	27%	38%	31%	4%	0%
B	7%	82%	9%	1%	0%
C	11%	53%	29%	1%	3%
D	0%	20%	40%	40%	0%
E	9%	50%	22%	0%	19%

Question 4: Answer B

Females Pre Test	Post Test A	B	C	D	E
A	29%	43%	29%	0%	0%
B	5%	62%	25%	2%	2%
C	9%	55%	32%	0%	1%
D	0%	0%	100%	0%	0%
E	11%	36%	39%	0%	11%

CONCLUSIONS

Simple numerical scores, facilities and gaps, on concept inventories do not give a complete picture of learning gains. Nor are they able to capture changes in understanding from ‘wrong’ to ‘less wrong’. It is important to explore the students’ answer choices and how they change, to determine whether a cohort (or sub-cohorts) benefitted (or benefitted equally) from instructions. Further, this simple binary-marking does not allow all students to demonstrate their learning and consequently be rewarded.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 68–69, ISBN Number 978-0-9871834-7-7

GENDER DIFFERENCES IN FIRST YEAR UNDERGRADUATE CHEMISTRY MULTIPLE CHOICE QUESTION ASSESSMENTS

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KEYWORDS: multiple choice questions, gender, student assessment

BACKGROUND

Gender bias in assessments is a concern of assessors due to the potential impact it could have on the validity of assessments, which then impacts overall student results. At The University of Adelaide there is a large enrolment of both male and female students into first-year undergraduate chemistry courses, and all of these courses contain several multiple choice tests as a part of their assessment. A large data set of student multiple choice test results is retained at the University, providing the opportunity to look at multiple years' worth of data in order to determine if any of the questions contain significant gender bias.

AIMS

This research aimed to analyse the multiple choice questions used in first-year chemistry courses at The University of Adelaide from 2012-2015 to test for gender bias that gave either male or female students an advantage in a particular question, and to determine the reasons for the appearance of any gender bias within the questions.

DESIGN AND METHODS

The data used in this analysis was collected prior to the commencement of this research. First-year chemistry students enrolled in Chemistry I and Foundations of Chemistry courses at The University of Adelaide take two multiple choice tests during the semester (both of which are redeemable in the final exam) and one during the final exam. The student results were analysed for gender differences using a combination of Classical Test Theory, chi-squared test and effect size.

RESULTS

Based on the analysis undertaken, there were seven unique questions in Foundations of Chemistry courses, and eleven unique questions in Chemistry I courses that showed consistent differences in the performance of male and female students. These questions were related to other trends seen in the analysis which suggested that female students often had more difficulty with questions that required quantitative or visual skills, while male students tended to miss small, but important, subtleties within questions which resulted in them obtaining the incorrect answer.

CONCLUSIONS

While the majority of the multiple choice questions used by first-year Chemistry courses at The University of Adelaide showed no significant differences between the performance of male and female students, there were eighteen unique questions identified between the four courses that showed significant deviations in performance. This highlights that for at least some question types and/or areas of chemistry, male and female students do not respond in the same way.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 70, ISBN Number 978-0-9871834-7-7

MOTIVATING 1ST YEAR STUDENTS TO DO PRACTICE TESTS INCREASES BOTH PRACTICE TEST UPTAKE AND ASSESSMENT GRADES

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KEYWORDS: practice, quiz, testing

ABSTRACT

First year science courses like Psychology are becoming very large and with students of diverse backgrounds and academic abilities. The use of online quizzes to assess student's learning is an important part of managing the assessment in such large classes. However, many students do not perform well on such tests and fail to use the feedback to alter their learning strategies. In other words, students are seeing the assessment as an outcome rather than a process. While most research suggests multiple choice tests are not ideal for promoting deep learning, they do provide better feedback than no assessment. When the later assessment is similar to the type used for formative learning or practice then even multiple choice can be show to have great advantages for providing feedback on students' learning. Improvements in assessment from formative practice tests might be due to either specific content learning or alternatively from changes in student engagement habits that would have benefits outside the specific content modules being tested. To determine which factor was underlying practice effects we rand a controlled study in a large (n= 628) 1st year Psychology class. The course was divided into modules with a multiple choice quiz after each module. Prior to doing each quiz, students could do up to 3 multiple choice practice tests on the content. Questions for each practice test were unique and none of the questions were also on the assessment quiz. This meant that students could not simply learn the answers to specific questions. After each practice test, students received question by question feedback on their performance. For the 2nd module students were allocated to one of 2 groups where the practice test question make up was content biased. Group 1 received most (80%) of the practice questions from the 1st module 2 topic while Group 2 received most (80%) of their practice questions from the 2nd module topic. The Assessment quiz had equal numbers of questions from each of the 2 module topics. In this way we could determine if undertaking practice tests affected content specific performance or a more general study habit, engagement process. Students were also told that for module 2, if they completed at least 2 of the 3 practice tests they could have a 2nd attempt at Quiz 2. After Quiz 2a (attempt 1), additional practice tests were available that reversed the question bias previously used. For the final quiz, practice tests were again made available before the quiz but the quiz conditions were the same as for Quiz 1 (ie back to baseline).

Prior to attempting Quiz 1, only 30% of students completed 2 or more practice tests. The students completing more practice tests performed an average of 10% higher (69% vs 59%). Prior to the 1st attempt at Quiz 2a, 62% of students now completed 2 or more practice tests with the same advantage as seen with Quiz 1. However, since many more students were scoring better in Quiz 2a, the overall average for Quiz 2a (68%) was higher than Quiz 1 (62%). Students then had an opportunity to do additional practice and complete Quiz 2b. Again, the actual questions were new for each practice test and for Quiz 2b. If we look at the 258 students who completed both Quiz 2a and Quiz 2b we see significant ($t=10.31$, $p<.0001$) performance increases with this group performing at 77% for quiz 2b compared to their average of 68% for Quiz 2a. There were, however, no content specific effects. Students who received 80% of their practice questions on one of the 2 topics did not perform better on that content on the Assessment Quiz than the content they received only 20% of the questions for. This suggests that motivating students to undertake practice tests has general engagement effects rather than training them on specific content. Interestingly for Quiz 3 where the external incentive to complete practice tests was removed, only 20% of the students did 2 or more practice tests with

similar performance differences seen on the Quiz 3 grades as were observed with Quiz 2 and Quiz 1 for those who did vs those who did not do the practice tests.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 71-72, ISBN Number 978-0-9871834-7-7

UNDERGRADUATE SCIENCE-BASED COURSES- ISSUES AFFECTING STUDENTS' PROGRESSION

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KEYWORDS: self-efficacy beliefs,

BACKGROUND

Student progression with science-based courses is a primary concern of science-based departments in universities. For this reason, universities are constantly looking for ways to improve the quality of teaching and learning of science-based courses in order to enhance student retention in subjects such as chemistry. Previous studies have identified self-efficacy beliefs as one of the factors that influence student success and progression with science-based courses. This study investigated chemistry self-efficacy beliefs of undergraduate students studying chemistry.

AIMS

The aim of this study was to identify factors that influence students' progression with science-based courses at university.

DESIGN AND METHODS

This study was conducted in the form of a mixed method cross-sectional study. Chemistry self-efficacy data was initially collected via questionnaire survey in the year 2016 and 2017 from year 1 undergraduate students studying chemistry in Australia, New Zealand and the UK. The results of the questionnaire survey informed the selection of participants to the qualitative interviews who were selected based on having either high or low chemistry self-efficacy scores. A total of 21 participants took part in the recorded interviews. The interviews were then transcribed and analysed and emerging themes noted. In addition, relationship between the emerging themes was assessed and a model developed.

RESULTS

Analysis of participants' interviews revealed several themes or issues that influence students' progression with chemistry. Findings also revealed that that self-efficacy had an impact on the emerging themes. A model was developed from the emerging themes.

CONCLUSIONS

From the results obtained in this study it seems that students who report positive teaching and learning experiences are more likely to report positive feelings and emotions toward learning of science and toward the university teaching staff.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 73, ISBN Number 978-0-9871834-7-7

AN EFFECTIVE IN-CURRICULUM MODEL FOR UNDERGRADUATE STUDENTS' DEVELOPMENT OF TRANSFERABLE SKILLS

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KEYWORDS: graduate employability, skill development

BACKGROUND

The Graduate Employability for Monash Science (GEMS) project was designed to address the issue of decreased employment opportunities for new graduates and the dissatisfaction of employers with science graduates' transferable skills. Previously, this project has reported on the skills needed for graduate employability, as identified from surveys of employers and recent science graduates (Sarkar et al, 2016) and a one-day, extracurricular intervention designed to address students' skills needs notions of employability (Sarkar et al, 2017). The former identified the need to incorporate clear and useful advice within the degree program, the integration of industry ideas and authentic problems, and a range of core skills absent from most science students' experience including commercial awareness, leadership, teamwork and communication, initiative and flexibility/adaptability. In 2018, this project evolved to deliver an undergraduate unit over twelve weeks to provide science students with an opportunity to develop awareness of, and begin to explore these important skills. This presentation will report on the research conducted to evaluate this effort.

AIMS

After successfully piloting an extracurricular student intervention in 2017, we aimed to develop a more extensive and in-curriculum intervention to address the skill gaps identified via the GEMS project.

DESIGN AND METHODS

Data was collected from students enrolled in the unit via three methods. Firstly, students complete a self-perceived employability skills questionnaire at the very start and then final week of semester. These were used to measure whether there was any shift over the duration of the semester. Secondly, a questionnaire was delivered at the end of the semester to take a snapshot of students' perception of the skills developed over the course of the semester. Finally, students completed a group task collating the key ideas and concepts that impacted on their understanding of important issues in the area of graduate employability.

RESULTS Students reported they had the opportunity to develop a wide range of skills during the unit, particularly verbal and written communication skills, teamwork, presentation skills, commercial/business awareness and ethical awareness and behaviour. They also gained a strong awareness of the importance of these skills and a greater recognition of their skill strengths and weaknesses and avenues for improvement.

CONCLUSIONS

Science students demonstrated significant engagement and appreciation for the opportunity to explore skill development within the curriculum. We conclude that a model such as this one has excellent potential for supporting students as they move towards graduation.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 74, ISBN Number 978-0-9871834-7-7

INFLUENCES SHAPING BIOMEDICAL SCIENCE STUDENTS' GRADUATE DESTINATIONS

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KEYWORDS: graduate destination, role model, professional identity, biomedical science.

BACKGROUND

Professional identity describes one's self-perception within an occupational context (Marcia 1996). It presents as a largely subjective construct, characterised by a number of contributing factors. One such influential factor includes students' role models and which has been identified as a critical element in professional identity development (Sealy & Singh 2008). Role models allow students to observe behaviours, traits and actions in a professional setting, and subsequently evaluate the favourable or unfavourable outcomes in each instance (Kenny, Mann, & MacLeod 2003). The professional identity of students in specialised health degrees with clearly-defined professional pathways is well known (Hammond, Cross, & Moore 2016; Ju & Ha, 2018). Further, such students develop a strong professional identity that translates to greater commitment, satisfaction and operational performance in the workforce (Dobrow & Higgins, 2005). However, there has been little focus on the graduate destinations of students in generalist degrees such as biomedical science. This study aimed to identify the influential factors on biomedical science students' professional identity and intended graduate destinations.

METHODS

Second year biomedical science students (n=595) were asked to describe factors that were most influential in their decision to study science and the profession they hope to pursue. Additionally, students were asked to identify role models and how these significant individuals contributed to their identity. Consenting students' responses were subjected to inductive thematic analyses (Braun & Clarke, 2006) to characterise their current and intended destination, and factors contributing to these.

RESULTS

Most students reported medicine as their intended graduate destination (59%), followed by research (26%) and various other allied health professions (6%). Prior learning, postgraduate aspirations and role models were identified as the most influential factors in students' decisions to study science. In terms of role models, students most commonly cited public figures, academics and family. Of the students who reported none or one role model, 75% indicated a single graduate destination; similarly 79% of students who cited two or more role models also intend to pursue one particular profession. Students' relationship to a role model is perhaps most influential in their determination and commitment to realise their intended profession. Students revealed that familial role models within their desired profession provided an intimate insight on occupational expectations beyond the typical, generic understanding of the profession.

CONCLUSIONS

Medicine is the intended graduate destination for most students studying biomedical science. At this stage of their degree, students do not appear to be flexible about possible future vocations, intent on pursuing a sole profession irrespective of the influence of role models. This study informs the conversation surrounding biomedical curriculum design and initiatives to foster students' professional identity development, depending on their intended destination. It warrants longitudinal investigation on how students' professional identity develops over time, particularly in a generalist degree, and if this further influences their graduate destinations.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 75–76, ISBN Number 978-0-9871834-7-7

STUDENT PERCEPTIONS OF A CONTEXTUALISED INTERVENTION IN NURSING NUMERACY

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KEYWORDS: nursing numeracy, contextualised learning, collaborative

BACKGROUND

This study focuses on the numeracy development of first year Bachelor of Nursing students at Western Sydney University (WSU). There is some empirical evidence that many of these students struggle in situations involving medication calculations and other clinical numeracy tasks. Yet the need for them to confidently and accurately complete these tasks is critical, especially when they graduate beyond university and take responsibility for medication calculations involving real patients. The study seeks to build on this evidence by evaluating an intervention involving teaching and assessment methods that are contextualised in a clinical setting.

AIMS

The aim of the study is to determine whether the teaching and learning of nursing numeracy in a clinical context at Western Sydney University changed students' perception of their confidence, engagement and skill in performing nursing numeracy tasks.

DESCRIPTION OF INTERVENTION

During a three-hour workshop in a clinical practice classroom, students worked in small groups to collaboratively solve six problems in nursing numeracy. These tasks were contextualised in the sense that they each related to a simulated patient situated in a mock hospital bed. The student groups moved from patient to patient while completing their tasks, recording their solutions in a worksheet and seeking advice from tutors when required.

DESIGN AND METHODS

The survey was completed by all consenting students (n=744) at the conclusion of the three-hour workshop run in September 2016. The analysis was conducted using standard statistical methods and visualisations in the analysis of ordinal data.

RESULTS AND CONCLUSION

Overall the students indicated that their confidence, engagement and skill had increased as a result of participating in the contextualised nursing numeracy workshop, and that it was helpful for them to be able to do nursing numeracy in a clinical setting. The extent to which students' perception of their improved experience on these indicators was reflected in improved numeracy performance – as measured by pre- and post-tests – is the subject of further review. But the conclusion of this study is that students' perception of their confidence, engagement and skill in performing nursing numeracy tasks changed, positively, following participation in the contextualised numeracy development intervention.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 77, ISBN Number 978-0-9871834-7-7

FUTURE LEARNING: STUDENTS CREATING A MOLECULAR VIRTUAL REALITY PROJECT

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KEYWORDS: virtual reality, molecular visualization, digital literacies

PROBLEM

Virtual reality has become a ubiquitous technology in our daily lives where it is predicted to change education and an industry predicted to be worth over $150 billion by 2021. CSIRO has recently announced a 100 million investment in a new Immersive Environments Lab, a facility purpose-built for applied research into novel augmented and virtual reality technologies (CSIRO, 2018) and every scientific discipline will be significantly impacted by these rapidly emerging technologies. There is, however, a lot of research to be done to determine, where these technologies should be deployed and how they will enhance or complement education and research (Parong & Mayer, 2018). Science graduates who are truly digitally literate will be able to demonstrate a good understanding and appreciation of how these new technologies are impacting their education and future careers. Indeed, failure of universities to provide facilities for students to learn and use these technologies in the near future will be seen as negligent. After all, over the next decade, high school students will be coming to university with already well established digital literacies of coding and making becomes part of the curriculum. A lack of preparedness for the new breed of students who will be arriving within 5 years is, collectively one of our greatest risks.

The challenge is to develop curriculum activities that introduce students to the methods and tools that constitute these important technologies. The other issue is around conducting research to validate how using VR might enhance student understanding of key molecular concepts.

PLAN

The underpinning strategy we used was one of creative engagement where students were asked to think creatively about how they might visualize molecular structures in VR. These activities encouraged lateral thinking and different ways of representing abstract concepts using tools typically associated with CGI and game development. The students learnt how to navigate complex 3 dimensional graphics environments, the basics of texturing and lighting and the underlying code that drive the VR interactive platform. Importantly, these methods were taught to the students by experts in their respective areas, a world renowned molecular animator and a third year science student who is an accredited Unity developer. The activities were developed in collaboration with science students one of whom created red blood cell tutorial videos while the other developed the Unity interface as part of their 3rd year projects. The guiding principle here was for students to be co-creators through a peer to peer teaching approach. Importantly effectively none of the students had any previous coding or VR experience (as determined by a prior survey).

ACTION

We developed a series of tutorials as well as online resources for a cohort of 80 first year advanced first year biology students enrolled in “From Molecules to Ecosystems” at a large metropolitan university. Over the course of four workshops students were introduced to the widely used free 3D animation package Blender and the Unity game engine used by the Oculus Rift headset and Touch controllers. The students used proteins that they were studying in the lecture stream in order to link the activity back to the main coursework.

To do this we made use of the new Immersive Learning Lab at Sydney University which features 26 Oculus RIft workstations. This allowed individual hands on experience of the software and Oculus platforms. The students were given a series of learning activities. First making a red blood cell model in Blender following a series of instructional videos made by a third year student in collaboration with the animation expert. They imported proteins into Blender from the protein data base and prepared the proteins for export into the Unity game engine. Finally, the students were provided with some templates and instructions to create the virtual environment in Unity, import the proteins and move around using the Touch controllers. Each student was assessed individually on their red blood cell and VR environment. Tutorials provided one-on-one assistance where required to support the online learning materials.

The aim of the exercise was not to make the students expert users of the technology. We aspired to give them some level of understanding of the work flows and tools that underpins VR such that they were informed and conversant with this important technology.

REFLECTION

Overall, the Molecular VR project received positive feedback from the students. Despite the steep learning curve the students rose to the challenge and exceeded our expectations. The overall quality of their work was outstanding and they could not have produced it without deep engagement with the learning activities. It was clear that this was a very novel activity for them and comments such as *'we were exposed to technology which we haven't seen before which is cool'*; *'VR itself is very fun to use, and I had never done it before so that was good'*; *'we learnt how to apply it to science which we may not have otherwise have the opportunity to do*'; '*interesting' 'challenging' 'different perspective to science'; 'playing with & experiencing the VR technology was very enjoyable'*. In addition, some students noted that they were *'getting a greater understanding of the protein in VR*' which supports some of the research around molecular representations in VR and the sense of scale, dimensionality and proportion as well as manipulative opportunities that it facilitates (Connor et al., 2018; Johnston et al., 2018). Of course, not all students were as enthusiastic which was understandable as some are not interesting in “coding” etc, however, we stress that the aim of the project was to get all students understanding the basics so that they could engage in informed discussions around this ubiquitous technology. The teaching team also gained valuable insights into developing activities to introduce VR into curriculum as well as understanding how students deal with these new challenges. These learnings have influenced the development of the activities for the next iteration.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 78–79, ISBN Number 978-0-9871834-7-7

LESSONS LEARNED FROM CHALLENGED-BASED APPROACHES TO TEACHING IN 1ST YEAR CHEMISTRY AND PHYSICS

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KEYWORDS: challenge, flipped classroom, laboratory experience

Challenge-based teaching approaches offer the benefit that the ownership of the topic is put into the hands of the student. In a typical approach, students will be exposed to a problem or challenge and through attempting to solve this problem, students not only develop problem solving skills and strategies, but also discover necessary content knowledge. Challenge-based teaching approaches lend themselves very much to a flipped classroom model, where students work in teams to tackle the problems they need to solve. However, in most cases these teaching approaches adopted by educators have been limited to more theoretical concepts and not necessarily to laboratory exercises.

At Flinders University, we have taken the challenge-based approach one step further and have delivered a 1st year chemistry and physics topic completely in a challenge based approach. With no lectures, tutorials, workshops, all face-to-face interactions with students take place inside the laboratory, where students face a series of theoretical and practical challenges. For each task, they have to propose a way to solve the problem, find relevant information and discuss their solution with an academic mentor. They then have to go and figure out the solution, then demonstrate their understanding via an explanation of that solution to the mentor's satisfaction. Additionally, the assessment strategies adopted in each discipline were different. Chemistry had a non-graded pass whereas physics had a performance-based grading system.

While the approach is daunting for students as well as academic staff, most students embraced the approach. Through careful educational design of the challenges, coverage of essential concepts has been ensured. The curriculum covered is probably less broad, but students immersed themselves much deeper in selected topics. Here, lessons learned from a completely challenge-based approach will be presented, and limits and limitations will be discussed.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 80, ISBN Number 978-0-9871834-7-7

INNOVATIVE STRATEGIES FOR ENGAGING FIRST-YEAR ENGINEERING STUDENTS

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KEYWORDS: team based learning, engaging practicals, project based learning, electronics

ABSTRACT

Electronics is a first year topic which is offered to over three hundred first year engineering students at Flinders University. Students find this topic challenging probably because it contains a varied spectrum of modules ranging from analog electronics to digital electronics. Most students doing this topic would not have seen or done something similar in their high school studies, and thus may feel overwhelmed by the subject matter. In the paper *STEM: Australia's Future*, one recommendation made by the Australia's Chief Scientist Prof Ian Chubb was to use "*curricula and assessment criteria … to promote the development of long-lasting skills – including quantitative skills, critical thinking, creativity, and behavioural and social skills – in parallel with disciplinary knowledge*." [1] This was one of the reasons for the impetus to change the way in which this challenging topic of Electronics was delivered to first year university students. There is truly a need to captivate students, whilst making sure that content is delivered with "*confidence and inspiration*". To achieve this, the curriculum and teaching methods were designed and trialled to achieve maximum student interest and learning, to provide students with a positive experience, and to bring them closer to being practising engineers by learning the approaches engineers use to applying knowledge in solving problems. Three innovative strategies, namely Team Based Learning (TBL), Engaging Practicals and Project Based Learning (PBL), were introduced to make a positive impact on student retention and progression, whilst keeping student attrition numbers low. Incorporating TBL in Electronics has resulted in higher achievement test scores, more positive student attitudes, and higher levels of student persistence [2]. "*The group based learning and tutorials was when I found myself gaining the most. The group based learning was definitely the most beneficial to me as it forced us to actually do questions unlike the lectures and tutorials*." In consultation with the engineering technical services group, "Engaging Practicals" were developed where the lab sessions were structured in a way to enable students to discover their own learning. They learned to use various electronic equipment like oscilloscopes, function generators, multi-meters, as well as the software environment of programming an Arduino microprocessor in C. Towards the last 3 weeks of topic, students engaged in the PBL to put their skills and knowledge into a "Robotics" competition where they were given a challenging problem of "Search and Rescue" using their programmed robots to traverse a maze. Student feedback has been overwhelmingly positive, and more importantly all students felt engaged in the challenge. All-in-all in creating a student-centered learning environment in Electronics that actively involves students in their own learning process has led to improved student learning and nurtured academic success.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 81, ISBN Number 978-0-9871834-7-7

BUNNY EARS, BALLOONS OR FLAT DISKS! COMBINING MULTIMODAL VISUAL RESOURCES IN BLENDED LEARNING ENVIRONMENTS

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KEYWORDS: blended learning, multimodal representations, visual fluency, VSEPR

BACKGROUND

Visual representations are so commonplace and critical to understanding concepts in chemistry that it is difficult to imagine learning chemistry without them. However, the ability to translate between them requires the development of visuospatial literacy. Lecturers will usually model their thinking in explaining concepts, particularly in the topic of molecular shape – they may bring model kits to class and combine these with their own drawings and text book images. The shift to increasing online content and expectations for students to engage with content on their own, either in self-regulated learning or flipped classrooms, requires a re-examination of which types of external representations are most useful in supporting learning in these domains. This study aims to investigate students' perceptions of a variety of visual representations related to Valence Shell Electron Pair Repulsion (VSEPR) theory and molecular shape to determine which features of representations aid understanding. This information will inform the development of a variety of 3D printed tactile resources, that when provided remotely, may form effective learning resources for both visually impaired and sighted students.

DESIGN AND METHODS

Undergraduate first year chemistry students have been interviewed to explore their visuospatial skills and understanding of VSEPR theory when presented with multimodal representations, categorized by Gilbert's (2005) modes of external representations in science. Students' interpretation and evaluation of the usefulness of currently used representations (2D and virtual); a self-assembled tactile model; and a prototype 3D printed model will be analysed. The outcomes of these interviews will be used to develop recommendations for developing the visualisation skills necessary for students to understand VSEPR theory through the use of multimodal models. Students' depth of conceptual understanding is being related to: visual spatial competency, accuracy of scientific language, and explanatory frameworks particularly in the role of lone pairs of electrons in determining shape. The student feedback from these interviews is also being used to further develop the 3D printed model that can be delivered in blended learning activities.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 82, ISBN Number 978-0-9871834-7-7

ENHANCING ACADEMIC ENGAGEMENT AND DELIVERY OF INNOVATIVE, HIGH QUALITY TEACHING IN SCIENCE COURSES THROUGH A GRASSROOTS LEARNING AND TEACHING COMMUNITY OF PRACTICE

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KEYWORDS: teaching-only academics, scholarship of teaching and learning

PROBLEM

Upon our appointment as ‘teaching only’ academic staff in 2011, our role was undefined. We learned that ‘teaching only’ academics were very rare appointments within the University and that we were the only two academic staff of this kind in our school. As new academic staff, we felt there were limited opportunities for staff to meet, share and discuss learning and teaching experiences with only a few academics actively involved in scholarship of learning and teaching.

PLAN

In 2011, with the guidance of our mentor, we established the Innovative Teaching @ Waite forum (IT@W) within the School of Agriculture, Food and Wine (AFW) at The University of Adelaide. Our main goal was to develop a forum with like-minded colleagues, to engage academics in scholarship of learning and teaching and improve the quality of teaching by sharing ideas in an informal, supportive environment. Through this forum we encourage our time-poor colleagues to share their teaching experiences (good and bad) on a monthly basis. Presenters from within the school, other faculties and institutions are invited to showcase novel initiatives. The presentation is followed by vigorous discussion, sharing of ideas and always cake! We have a dedicated following of 10-15 academics at all appointment levels. What began as a forum is now a true Community of Practice (CoP) (Wenger, 2000).

ACTION

The IT@W CoP has expanded to include biannual exhibitions of best practice learning and teaching initiatives and staff development workshops such as Flipped Classrooms, Learning Analytics, the Learning Management System and for new academic staff, Teaching for 21st Century Students. Over 75% of survey responses from attendees indicate that the CoP has led to staff implementing changes in their own teaching practice. There is now wider adoption of teaching and learning pedagogies such as Team Based Learning (Michaelsen & Sweet, 2008), Flipped Classroom (Bergmann & Sams, 2014), E-assessment and Online learning within the school. We also launched the AFW Learning and Teaching web page in 2015 and IT@W has its own online site to provide another avenue to disseminate best teaching practice particularly for staff who are unable to attend IT@W.

REFLECTION

The IT@W CoP has not only assisted us to develop and refine our own teaching practices, but has helped our peers to think about their teaching pedagogy and practices. As IT@W has evolved over the last seven years we have provided facilitation, guidance and support to our colleagues and our transformation into learning and teaching leaders has provided us with a unique opportunity to continue to invigorate best teaching practice at our campus.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 83, ISBN Number 978-0-9871834-7-7

COMPLEXITY IN CURRICULUM DESIGN: SURFING AT THE EDGE OF CHAOS

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KEYWORDS: curriculum design complex systems, chaos, science

> *Reductionism' is one of those things, like sin, that is only mentioned by people who are against it. To call oneself a reductionist will sound, in some circles, a bit like admitting to eating babies. But, just as nobody actually eats babies, so nobody is really a reductionist in any sense worth being against.*
>
> Richard Dawkins, *The Blind Watchmaker* (1996), p.13.

We are constantly trying to predict what our students will need in the future and yet the only certainty in traditional generalist degrees, like the Bachelor of Science, is now uncertainty. Where in the past our curriculum prepared students for research, the 21C curriculum has many uber-themes that compete for space. These include expanding access and convenience, collaboration and interdisciplinary learning, innovation and entrepreneurial thinking, authentic real world learning opportunities, tracking and evaluating evidence, re-evaluating academic teaching roles and digital literacies. It is this digital space that perhaps most challenging as some contend that it may fundamentally change transmissive lecture delivery which may lead to the death overall of the teaching and research academic role.

What does this mean for 21C curriculum design? Will the typical linear rational curriculum design using constructive alignment and reductionist approach provide us with the desired curriculum sufficient to steel our students for their uncertain futures. As we live in an increasingly complex world, perhaps we should consider the way that chaos theory, emergence and complex systems thinking could be incorporated into our curriculum design. Complex systems reveal that the non-linear outcomes of interactions among agents (i.e. people) produce patterns which cannot be known in advance. Indeed, most interactions between groups of individuals are often less than rational. Complex systems do not have a blueprint that can determine their overall properties. However, if each agent follows a set of simple rules, even small deviations can result in significant impacts (i.e. butterfly effect) and result in a variable system with diversity which is hardier and more resilient. The advantage of using chaos, emergence and complex systems thinking to redesign the curriculum are several. A major point is that the consequence of any failures in outcomes, shifts the blame away from an individual towards a critical focus on the quality of participation and responsiveness of all players. Importantly, this creates an environment where responsibility for the curriculum design and student experience is shared and owned by all. This talk will describe the process of curriculum redesign of undergraduate and postgraduate Science, Technology Engineering and Mathematics (STEM) curricula in large and complex metropolitan universities in Australia and the disruptive implementation of interdisciplinary capstone units, done by students within and between faculties. For a curriculum to thrive and be transformational in a vortex of higher education change requires the right culture. The conclusion should not be that rational curriculum design is somehow bad and should be avoided, but it is insufficient to create the curriculum culture which will stand our students in good stead in the 21C.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 84, ISBN Number 978-0-9871834-7-7

'LET'S NOT KEEP IT PRIVATE': SCHOOLING BACKGROUND AND STUDENT PREPAREDNESS TRANSITIONING INTO UNIVERSITY

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KEYWORDS: schooling background, student preparedness, academic achievement

BACKGROUND

Non-government school students, have been shown to achieve lower first-year academic success compared to students from government schools (Birch & Miller 2009; Mills, Heyworth, Rosenwax, Carr & Rosenberg 2009). Reasons for this discrepancy are yet to be fully identified. This study investigated schooling background, students' perceptions about their own preparedness for university, their school's contributions to this preparedness, and how these relate to academic achievement.

METHODS

Participants were first year physiotherapy (n=181) and occupational therapy (n=146) students studying anatomy. They were asked to describe their schooling background, their preparedness for tertiary study, and how they feel their schooling background prepared them for university. Responses were coded using inductive thematic analysis (Braun & Clarke, 2006). Students' theory and practical examination marks were compared to preparedness and schooling background.

RESULTS

Non-government school students reported being well-prepared more frequently (45%) than government school students (30%). Further, a higher proportion of government school students felt unprepared (24%) relative to non-government school students (16%). Both cohorts acknowledged their schooling background contributed to the development of their learning habits and independence. Additionally, non-government school students indicated that their school provided a more nurturing environment to foster their development. Mid-semester examination grades suggested a disparity in academic attainment favouring government school students; these findings will be consolidated based on final examination grades.

CONCLUSIONS

Irrespective of schooling background students recognise a school's contribution to their development of learning habits and independence. Students perceived the mechanism by which this occurred to be different with non-government schools potentially providing a more nurturing, scaffolded environment. Despite non-government school students feeling more prepared for the commencement of university, preparedness may not necessarily correlate to academic success. However, this academic success may vary with the teaching mechanisms employed by the different schooling background.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 85, ISBN Number 978-0-9871834-7-7

FIRST-YEAR DIAGNOSTIC MATHEMATICS TESTS

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KEYWORDS: diagnostic test, first-year university, mathematics

BACKGROUND

Many university staff find that students are coming to university with insufficient mathematical skills and knowledge for tertiary studies. One method used to determine what mathematical skills and knowledge students bring to their university studies is to use a diagnostic mathematics test. Once students' skills and knowledge are known, various actions to improve student learning are possible.

AIMS

The first aim was to find the purposes for which diagnostic tests are run, beyond determining students' mathematical skills.

The second aim was study two different diagnostic tests and consider three questions for each:

- For what purposes was the diagnostic test run?
- What actions were taken as a result of the test?
- Was the test considered successful?

THE TESTS

A test for a cohort of first-year engineering students and another for first-year design students were studied. The test for the engineering students was run to decide whether each student should be enrolled in the standard mathematics subject or into a preliminary subject. The second test was designed to require students to gain basic mathematics skills. This was done by allowing students to attempt a basic mathematics test every few weeks during the semester, giving all a chance to reach a threshold. Those who did not reach the threshold by the end of the semester failed the subject.

Data was collected where possible to determine whether or not the tests served the purposes for which they were designed.

RESULTS

Seven purposes for conducting diagnostic tests are presented, with many tests being run for several of these purposes. The two tests studied had very different purposes.

In the engineering cohort the pass rates in the standard mathematics subject improved and in the design cohort a noticeable number of students spent considerable time working on basic skills.

CONCLUSIONS

Diagnostic mathematics tests can have a variety of purposes, and each should come with actions aimed at improving learning. The two tests studied were very different, were run for different purposes and were followed by different actions. In both cases the test had uses other than those originally planned. Each was considered successful and continues to be run in much the same way.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 86, ISBN Number 978-0-9871834-7-7

STUDENT AND TUTOR PERSPECTIVES OF SELF, PEER AND TUTOR ASSESSMENTS FOR LEARNING

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KEYWORDS: self-assessment, peer-assessment, tutor-assessment

BACKGROUND

Actively engaging students with assessment criteria and standards, develops their capacities to judge own and peer work, and benchmark their work (Hamer et al., 2015). Peer-assessment forces students to apply standards to appraise performance, thereby building their own capacity for developing judgement (Tai et al., 2016). Actively engaging students with standards for self-assessment and peer-assessment encourages critical reflection, enhancing their understanding and deep learning.

AIMS

This study aims to identify third year students' and their tutors' perceptions of self, peer and tutor-assessment through an authentic evaluative experience.

INTERVENTION

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 in journal-publishing. Student teams (4-5 members) collaboratively prepared a review on a specified disease topic, peer-assessed 3 reviews, constructed feedback on others' work, evaluated and responded to feedback received on own work, and returned improved submissions for tutor assessment. Moodle Workshop module automated and streamlined the process of student submissions, randomized distribution for peer assessment anonymously, returned feedback, and re-submitted for tutor assessment (Mostert & Snowball, 2013).

METHOD

A questionnaire scoped student and tutor perspectives on self, peer and tutor assessment before commencing the activity. At the end of the four-week activity student and tutor experiences were explored via questionnaires and focus groups. Questionnaire data were analyzed using GraphPad Prism 7.0 while focus group data was de-identified, transcribed and analyzed for emerging themes.

RESULTS

Majority of students were unused to self and peer-assessment, while a significant were unsure of either process in their classes. Although student expectations of the usefulness of self and peer-assessment through this activity were high (71% and 86% respectively), once the activity was completed they rated both to be least useful for learning. Instead, >85% preferred tutor-assessment or the "expert's voice". Students' main concern was that peers were not experts at assessing others and that personal bias would hinder self-assessment. Students confirmed they learnt most and best through tutor-assessment than at any other stage of the activity.

Most of the tutors had facilitated activities that involved peer-assessment, however the majority (7 out of 11) had not been involved in activities with self-assessment. They confirmed that learning was best through tutor-assessment, only 37% saw any value in self-assessment in learning. Qualitative data supported that self-assessment created unnecessary bias and even deemed it unnecessary.

CONCLUSION

Despite the literature confirming the importance of self and peer-assessment in developing critical thinking, metacognitive and evaluative judgement, this study revealed that students and tutors showed a lack of preparedness to undertake self and peer-assessment because of a lack of understanding, experience, and/or confidence related to its importance. It is a clear indicator of the need for such exposure, potentially fostered through the early years in the curriculum.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 87-88, ISBN Number 978-0-9871834-7-7

THREE STORIES OF SCIENCE TEACHING AND REFLECTIVE PRACTICE – COLLABORATING IN TEACHING AND LEARNING SCHOLARSHIP

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KEYWORDS: reflective teaching research

ABSTRACT

This presentation reports on three projects for collaboration between science teaching academics and an academic developer. In each instance, the teaching and learning research goals were, firstly, to make a change to teaching practice, and secondly, to publish the change of practice research outcomes in a teaching and learning journal. Each of the three science educators had an original idea, or, had identified a 'problem' for changing a teaching practice. The academic developer from a central unit professional development team was invited to work collaboratively with each of the science academics. The first story presented here describes how a collaboration resulted in a new teaching activity for a first-year biology class that solved a common challenge related to designing learning to support the diversity of students' biology experience that occurs in a first year of study. As a result of the case study approach to solve the diversity challenge, the resulting reflective process for the science educator and the academic developer led to a deeper understanding of the benefits of intentional, socially-constructed, student to student support within the Biology unit. The second story involves a novel strategy for supporting sessional staff teaching into a large first year ecology subject. The science academic had developed the strategy (peer-pairing sessional staff to team teach the large classes) and invited the academic developer to collaborate on writing about the strategy for publication. The third story describes the early collaboration between a highly experienced science educator and the academic developer investigating how much discipline knowledge students retain over time and the learning practices that best support knowledge retention. In each of these stories, the science educators sought to utilise the academic developer's expertise that would most complement their needs. This presentation might provide stimulus for other science educator interested in finding partners to co-investigate teaching and learning questions.

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MASTERY LEARNING: ASSESSMENT FOR THE FUTURE?

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KEYWORDS: mastery learning, assessment, mathematics

PROBLEM

Assessment based on Mastery Learning (ML) is used in first year mathematics subjects at UTS. It was implemented through online tests with resits, with an optional final examination. Pass rates improved considerably, but investigations (Coupland, Solina, & Cave, 2017) found the assessment model encouraged shallow learning and did not provide sufficient motivation for learning to solve more complex problems.

PLAN

We reviewed the literature on ML, including the founding principles of Bloom (1976) who claimed:

> *most students can attain a high level of learning capability if instruction is approached sensitively and systematically, if students are helped when and where they have learning difficulties, if they are given sufficient time to achieve mastery, and if there is some clear criterion of what constitutes mastery* (p. 4).

Kulik, Kulik & Bangert-Drowns (1990) used meta-analysis to investigate 108 studies of ML at school and university. They found that ML resulted in significant positive effects on student learning as measured by exam performance at the end of instruction. Since this was contrary to our experience, we planned modifications to the assessment model intended to encourage and reward deeper learning. These included a compulsory written final examination with required achievement level, and a change from online tests to paper based.

ACTION

We analysed assessment data to evaluate these modifications. We found that students were maintaining effort through the semester and achieving higher marks on the final exam. When exam performance was compared on individual questions, we found evidence suggesting that the use of paper tests contributed to longer term retention of the material. The paper tests included some exam level questions which could be considered a form of 'elaborative rehearsal' (Craik and Lockhart, 1972) which is known to deepen learning.

REFLECTION

The results indicate work needs to be done to improve the test content and the provision of timely feedback to students about their written mathematics. We also plan to look for ways to introduce students to metacognitive learning strategies (Stanger-Hall, 2012) to help broaden their views on mathematics and deepen their learning approach.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 90, ISBN Number 978-0-9871834-7-7

DEVELOPING DEEPER LEARNING STRATEGIES TO PREPARE STEM STUDENTS FOR FUTURE CAREERS

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KEYWORDS: metacognition, learning strategies, STEM, higher education, FYE

PROBLEM

As universities accept an increasingly diverse cohort of students, many are unprepared for the level of assumed mathematical and scientific knowledge required in first year physical science and engineering subjects, or the level of commitment required, which can impact their progression. Working individually with these students is not feasible in large cohorts. Instead we have investigated the impact on student assessment results with changes in tutorials to encourage deeper learning and equip our students with the tools and strategies that will carry them through their tertiary studies and beyond into the workplace.

PLAN

We investigated how high school background, degree choice, motivational factors, learning habits and behaviours, and personal expectations correlate with assessment results.

In 2017 we ran a pilot survey to test our hypotheses with questions based on metacognition work by Stanger-Hall (2012) in a core physical science subject, Foundations of Physics (FoP, n=143). The questions were refined in 2018 and a baseline survey was run in semester 1 for FoP (n=158) as well as the core engineering subject, Mathematical Modelling 1 (MM1, n=519). Whereas FoP is presently not a prerequisite for follow-on subjects, MM1 is a prerequisite and mastery of MM1 content is considered essential for success in the discipline.

We followed the survey with an intervention where we taught and gave out resources on metacognition and learning strategies. A final survey is planned to investigate changes due to these interventions and correlation with final exam scores. The results of this will be reported at the conference.

ACTION

We conducted preliminary analysis with ANOVA and regression analysis on the survey data alongside students' pre-final exam test scores. Results include: positive correlations with level of maths attempted in high school, student's self-belief in their mathematical ability, importance placed on completing their degree and happiness with their chosen course.

When considering self-reported study behaviours for MM1, previewing and/or annotating the slides before attending lectures was found to aid cognition - mapping. Their action in the lecture and reviewing/rewriting lecture material afterwards had no significant impact on test scores however attempting more than 50% of the practice problems and how they approached the problem solving had a statistically significant impact on test scores. In contrast, the FoP students' only additionally significant factor was whether they had taken time to review the subject outline and add assessment due dates to their diary, indicating a positive time management contribution.

REFLECTION

Findings have prompted us to think more widely about influencing factors. In the final survey we will drill down further on how students have experienced the techniques used in the intervention. In the next iteration of this project, we will develop targeted resources on successful learning strategies based on these findings and an online module for students so that the ‘intervention’ can be delivered in a blended mode.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 91–92, ISBN Number 978-0-9871834-7-7

REVOLUTIONISING THE FIRST YEAR IN BLOCK MODE

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KEYWORDS: block mode, inquiry-based learning & teaching, transition pedagogy

In an Australian first, in 2018, Victoria University (VU) introduced its innovative First Year Model. All first year subjects have been redesigned and taught in short, intensive four-week blocks, one subject at a time, with a dedicated educator facilitating active and collaborative small group learning. The flexible block timetable allows students to work university studies around their complex work and family commitments whilst fostering improved relationships with fellow students and staff.

The model is based on successful application in educational institutions in Sweden, Canada and the United States. Teaching-focused academics worked intensively with a learning design team with a diverse range of skills to redesign the curriculum and assessments of first year subjects, aimed at improving student engagement, learning, outcomes and retention.

The results have been overwhelmingly positive with 88% of first year students positive about their learning experience. The pass rates have improved impressively across all subjects with a shift in marks to the right. In traditionally difficult Anatomy and Physiology subjects in which the fail rate has been consistently high for many years, the block model has resulted in 10-20% improvement in pass rates depending on the cohort.

As an example, in Human Physiology taught to 6 different cohorts, the fail rate was 47.7% in 2017 (n = 398 students) and has been reduced to 16.2% in the first iteration of the block and 12% in its second iteration (n = 397 students, year to date). Higher level grades have remained consistent, with a similar percentage of high distinctions awarded between ‘traditional model’ and block model of the same unit (2016 to 2018 all between 3.3 - 7.2%).

The model has been so successful that VU has recently decided to implement the block model across all year levels.

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STEAM: IS IT ALL JUST A LOAD OF HOT AIR?

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KEYWORDS: STEAM, STEM, communication, transferable skills, theatre

BACKGROUND

The acronym STEAM is increasingly being used where the ‘A’ represents an injection of the arts into traditional STEM disciplines. It is seen as a vehicle for embedding creativity into science curricula at a time when automation threatens to make traditional occupations redundant, and graduates are being asked to couple their skills and knowledge with something extra. Yet few clear examples of how to do this in our tertiary classrooms exists, and other barriers include diminishing face-to-face teaching time, the encroachment on online learning, and busy curricula where there is little room for additional learning activities.

AIMS

This presentation aims to briefly review what is meant by the nascent term ‘STEAM’, and present the results of a study investigating whether students recognise the achievement of key learning outcomes from a STEAM-like classroom intervention.

DESIGN AND METHODS

At Monash University, first year chemistry students have the option of replacing several weeks of lab classes with an assessed activity that fuses chemistry and theatre. Over four weeks students engage in a variety of activities which use performance as the cornerstone for learning elements of the chemistry curriculum. The key piece of assessment is a reflective essay focusing on learning outcomes. The research presented here treats this piece of assessment as rich qualitative data which has been analysed over a number of consecutive years and coded for consistent themes.

RESULTS

This presentation will report on four years of qualitative data in the form of written student reflections, focusing on the capacity for this activity to deliver on key chemistry learning outcomes. Figure 1 reveals the percentage of students who identified particular skill areas developed through the four-week activity. Communication comes through as a strong theme across all components of the activity, through a combination of formal presentation and performance tasks, and an environment that generates for meaningful social interactions.

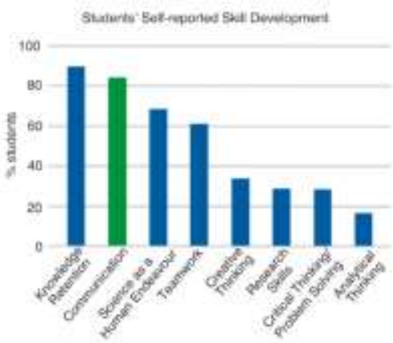

Figure 1. Skill Development

CONCLUSIONS

We have identified that an alternate ‘STEAM’ approach to learning has the capacity to deliver on threshold learning outcomes often left wanting via traditional approaches in science education. Specifically, this includes exploring the culture of performing science, and the importance of creative thinking and improvisation in scientific discovery. These sit alongside strong outcomes in teamwork, critical thinking, analytical and research skills, all built on a foundation of strong communication.

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EMBEDDING INQUIRY-BASED LEARNING IN PRACTICAL LABORATORIES USING AN ASSESSMENT MATRIX

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KEYWORDS: inquiry-based learning, evaluation of laboratories, first year, biology

AIMS

Ambitious revisions of undergraduate curriculum are becoming increasingly frequent events. One aspect which remains relatively unchanged, however, is the importance of practical laboratories. Practical experiences in the 21st century need more than ever to deliver what they need to students, as they become increasingly costly and students more time poor. Our aim was to develop a matrix which could be objectively used by all stakeholder to evaluate the current laboratory practical structure in a large first year biology unit at a complex metropolitan research-intensive university. The framework for our large 2000 student first year biology unit, underpinning majors across life and medical science, was a research-inspired, inquiry-based learning experience that enhances student learning and fosters highly valued and transferable skills and capabilities (Luckie, Maleszewski, Loznak, & Krha 2004, Gormally, Brickman, Hallar, & Armstrong 2009, Meyers, & Nulty 2009). The activities in the practical series were aimed at mirroring the practice of scientists; providing an authentic representation of the field of biological sciences (Darling-Hammond & Snyder 2000) and answering the big biological challenges facing our world. We also wanted students in the practical series to develop skills in problem solving, critical thinking, written and oral communication, digital literacy. Students doing this practicals were expected to work productively in groups and behave ethically and responsibly.

PLAN

Our challenge was to influence and ultimately change the practice of a large group of academic stakeholders from different sub-disciplines within biology.

ACTION

Six main objectives and 11 sub-objectives were developed and used to create an assessment matrix to evaluate the practical program. These were based on the big ideas in biology and what we wanted the practicals to achieve. We paid attention to the relationships between individual elements, how each practical followed concepts from lectures and the alignment with unit, threshold learning outcomes in biology and newly developed graduate qualities of the institution. This matrix was then used to evaluate the current practicals. To do this all academic stakeholders evaluated whether each of 10 practicals met the criteria. This assessment matrix resulted in an objective and unequivocal direction for areas requiring change allowing us to work with academics to re-write or update practicals to better align with our educational objectives. Of the 10 practicals evaluated, six were re-written and four were updated. Following this evaluation and an identification of the gaps, practicals were evaluated again. The results provided a clear and easy guide to understanding what objectives were met whilst identifying any shortfalls (Kirkup & Srinivasan 2008). It also considered which individual practicals were aligned well or partly with our objectives and which were not.

OUTCOMES

This talk will provide an overview of the assessment matrix which has proved to be a useful and inclusive evaluation tool. Academic stakeholder participation in every aspect of development and evaluation increased ownership of the outcomes. Additionally, the format of the evaluation ensured the process was undertaken in a transparent and unbiased manner. This resulted in an integrated practical program for the unit of study encompassing multiple disciplines representing with broad field of biological sciences.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 95–96, ISBN Number 978-0-9871834-7-7

SKILLS DEVELOPMENT IN UNDERGRADUATE MATHEMATICS

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KEYWORDS: undergraduate mathematics, graduate attributes, employability skills, planned curriculum, hidden curriculum

BACKGROUND

In recent years the higher education sector has increased its focus on employability outcomes for university graduates. Increasingly, students expect to graduate with a degree having developed a broad range of graduate attributes, including transferable skills that equip them for the workplace. These skills are communicated to students when universities publish the generic and faculty specific graduate attributes for their degrees.

Many studies have illustrated the skills employers desire in Science, Technology, Engineering and Mathematics (STEM) graduates (Matthews & Hodgson, 2012; Prinsley & Baranyai, 2015; Toland & Hooper, 2012). These skills align with those graduate attributes that should, ideally, be embedded in the learning outcomes of majors within each degree. However, some have proven more difficult to embed into the experienced curriculum in mathematics than others, for example communication skills.

Unintended development of skills, such as values, perspectives, lessons learnt though interactions with teachers, peers, and life experience, are known as hidden curriculum (Pinar, Reynolds, Slattery, & Taubman, 1995). These can often be overlooked in the discussion of what students learn during their university study. Yet the hidden curriculum may be where soft skills, like teamwork are developed without being assessed.

AIMS

Our study aims to gather insights from undergraduate mathematics students at one university. It explores the student voice concerning the importance of developing employability skills within an undergraduate mathematics programme and if the students have experienced this development.

DESCRIPTION AND INTERVENTION

This study focuses on the student's experiences of the enacted curriculum. Specifically, participants were students at the University of Melbourne enrolled in an undergraduate mathematics programme (n=287). Two surveys were distributed, with students being asked to complete only one. One survey included statements about how employability skills (such as written and oral communication, presentation skills, teamwork) were developed when doing mathematics related activities. The second survey did not contain these statements. Both groups were then asked about their experiences of developing these employability skills while studying mathematics.

The intention was to determine whether students have the same understanding as we do, of what employability skills are and of their importance, and also to determine if they think that they are developing them or not.

CONCLUSIONS

Overall, the findings revealed that students believe that employability skills are important but they did not feel that they needed to be included in the mathematics curriculum. In some instances, but not all, providing a context for the skills did increase the students' awareness of how they were developing certain skills.

Findings identified a mismatch between the intended and experienced curriculum when considering the development of particular skills. Three questions require further investigation. Firstly, if the surveys were distributed to other universities would the finding be the same? Secondly, which employability skills can feasibly, or appropriately, be developed in a curriculum for undergraduate mathematics? Thirdly, are mathematics students able to identify accurately which skills they are developing in their degree?

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 97–98, ISBN Number 978-0-9871834-7-7

AN INQUIRY-BASED LEARNING MODULE TO FOSTER CRITICAL THINKING IN A SECOND-YEAR BIOCHEMISTRY PRACTICAL CLASS

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KEYWORDS: inquiry-based learning; e-learning; critical thinking; teaching and learning

ABSTRACT

The key attributes of science graduates include the ability to combine theory with practical application, critical thinking and trouble-shooting skills; attributes that are enhanced through the process of scientific investigation. Unfortunately, there are distinct limitations to providing wet-lab inquiry-based learning opportunities in large classes within the early stages of a degree due to the logistical and financial impost intrinsic to such activities.

To address this limitation a student-centred inquiry-based learning module – set within the adaptive Smart Sparrow platform – has been designed to examine a student's understanding of experiment design and analysis through the integration of scientific experiments and theory behind the associated content. The learning module covers the common biochemistry and molecular biology techniques taught in *BCMB20005: Techniques in Molecular Science* (a second-year biochemistry practical subject) framed in such a way that there are three projects, each with a general theme to overexpress and purify a protein. Students must select a project to interrogate and examine and are provided with lists of materials and equipment available to facilitate their decision-making processes; essentially leading students through a 'virtual' scientific investigation, which is the cornerstone of practical-based teaching.

In this presentation, I will present an overview of the module with some examples of student activities designed to foster critical thinking and troubleshooting of experimental design and analysis, along with preliminary data evaluating the module.

Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 99, ISBN Number 978-0-9871834-7-7

STUDENT PERCEPTION OF SCIENCE COMMUNICATION PRE- AND POST-COMPLETION OF A COMMUNICATING SCIENCE COURSE

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KEYWORDS: science communication, student perception, word cloud

ABSTRACT

Science communication is a fundamental aspect of public understanding of and engagement with science (Bubela et al., 2009). Science communication can take myriad forms, and it can be difficult for scientists to find a way to communicate their research in a way that makes them feel comfortable. In addition, a lack of exposure to current thinking about public understanding of science may contribute to the perpetuation of the flawed 'deficit-model' of science communication (Simis et al., 2016) and inhibit scientists' ability to have meaningful engagement with the public about their work.

Students enrolled in the University of Adelaide course "Communicating Science" are at the interface where they begin to see science communication not only from the perspective of being public consumers of scientific information themselves, but also from the perspective of becoming a scientist who will one day have the responsibility of communicating their results to the public. The course focuses on building skills in written and oral communication, as well as introducing current thinking about public understanding of science more broadly.

We were interested in how students viewed the communication of science before and after they had completed the Communicating Science course, and whether completion of the course changed their perceptions of science communication. Student responses to the open-ended question "What do you think of when you hear the words 'science communication'?" were collated into word clouds to enable the identification of common themes. Students were asked the same question at the start and at the end of the course, and the word clouds derived from each were compared.

Analysis of the word clouds showed that prior to course completion, students' perception of science communication focussed on knowledge and presenter-driven aspects. However, post-course completion, students' perception had changed to focus much more on engagement and discussion. This shift in students' perception is aligned with changes in the field of public understanding of science over recent decades (Bauer, 2009), and in particular the movement away from the 'deficit-model' to more interactive, participatory and two-way approaches (Bubela et al., 2009). These findings suggest that our students will be more open to participating in engagement-based science communication activities.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 100, ISBN Number 978-0-9871834-7-7

BEYOND 'THE SCIENTIFIC METHOD': WHAT SCIENCE IN PRACTICE CAN TEACH STUDENTS ABOUT THE NATURE AND PROCESS OF SCIENCE

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KEYWORDS: scientific literacy, nature of science, critical realism, scientific method

AIMS

This theoretical paper has a practical aim: to empower science academics to use examples from their own or their colleagues' research to illustrate the nature and process of science at a depth that goes beyond 'the scientific method'. Scientific literacy is an important intended outcome for all undergraduate science students, whether they are the small minority of students who pursue a career in science research or amongst the majority who follow an alternative career path. Scientific literacy means more than acquiring knowledge of scientific concepts. It also requires a bigger-picture understanding of the nature and process of science in a societal context. The Learning and Teaching Academic Standards (LTAS) project published a set of five Threshold Learning Outcomes (TLOs) for science in 2011. The first of these was 'Understanding Science', which states that "on completion of a bachelor degree in science, graduates will demonstrate a coherent understanding of science by (1.1) articulating the methods of science and explaining why current scientific knowledge is both contestable and testable by further inquiry and (1.2) explaining the role and relevance of science in society" (Jones, Yates, & Kelder 2011, p. 11). Some universities in Australia have used the TLOs to inform science curriculum development, including them in course and subject/unit intended learning outcomes.

The value of including the nature and process of science has been recognised, but often the understanding of what this means is limited to teaching students 'the scientific method'. While there is certainly a scientific approach to investigating the natural world, the term 'the scientific method' can reinforce students' misconceptions of the nature and process of science (Hodson, 2008). Students may view the scientific method as a predetermined step-by-step approach to solving scientific problems, much like a set of protocols or procedures. Students' experiences of recipe-style laboratory classes can also reinforce this misconception. Of course, science in practice is much messier than a common set of steps, and different disciplines employ a wide range of strategies to explore natural phenomena.

RESULTS

This paper presents a conceptual framework that could assist in showing students how science works without simplifying this to a universal set of procedures. The framework is based on Roy Bhaskar's critical realist philosophy for the natural sciences (Bhaskar, 1975). Unlike postmodern or positivist conceptions of science, critical realism acknowledges that scientific knowledge is of an independent reality, whilst at the same time mediated by human perception and social context. The framework helps students and staff to think about their own assumptions about science and to interrogate ways of knowing. It can be used with contemporary or historical examples of scientific investigations to illustrate aspects of the nature and process of science. A specific example of research into proteinase inhibitors (Johnson, Miller, & Anderson 2006) will be used to demonstrate how the diagram can aid in showing general features of science with discipline-specific variations.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, pages 101–102, ISBN Number 978-0-9871834-7-7

INVESTIGATING FACTORS THAT INFLUENCE STEM INTEREST AND ATTITUDES

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KEYWORDS: STEM, interest, attitudes

BACKGROUND

There has been much previous research into factors that contribute to development of STEM interest and attitudes. The development of technology and the internet has led to changes in how information and entertainment are distributed, and these factors have not been covered in previous studies.

AIMS

This study investigates if the development of technology-related factors has influenced individual's interest and attitudes towards STEM disciplines including the exploration of trends across generations and Science and Engineering fields.
The research questions explored are:

1) Which factors have the greatest influence in the creation of interest in STEM courses, and have these factors changed between generations, i.e. age groups?
2) Which factors give rise to positive and negative STEM attitudes across STEM and non-STEM involved individuals, and are there trends between disciplines? The main research aims addressed in the article

DESIGN AND METHODS

A self-reporting, retrospective survey was developed for both online and hardcopy distribution to university students and adult-aged general public. The questions and methods were based on the Venville et al. (2013) study, wherein scientists were asked to reflect on what made them interested in science. The survey contained 44 questions, including a scale for participants to indicate their interest and attitude levels towards STEM, and 20 Likert questions asking participants to evaluate how influential each of the factors was on their interest levels in STEM. The survey also included a section covering demographics, asking participants to indicate their age, gender, continent of origin and ethnic background. These were included to elucidate any trends in demographics and high-ranking influential factors, and to see if an individual's interest in STEM could be affected by their background.

The survey was distributed to STEM university classes and the general public through the use of social media, classroom visits, and face-to-face recruitment at Scitech. Hard-copy surveys were also distributed in undergraduate chemistry and engineering classes at Curtin University. These classes were selected based on the expected higher number of STEM students enrolled.

PRELIMINARY FINDINGS

A total of 442 responses were collected for the study, with 283 coming from undergraduate chemistry and engineering classes, and 159 from general public. Differences were found in how interest and attitude factors were rated between age groups and STEM disciplines, and the general trends across all ages and STEM fields were found to be consistent with existing literature.

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Proceedings of the Australian Conference on Science and Mathematics Education, Flinders University, 26-28 September 2018, page 103, ISBN Number 978-0-9871834-7-7

ENGAGING STUDENTS WITH MULTIPLE PATHWAYS FOR PROBLEM SOLVING

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KEYWORDS: problem solving, engagement, video resources

BACKGROUND
Problem solving is a multifaceted activity, influenced by cognitive, motivational, and behavioural factors. Cognitive factors include content knowledge, understanding of concepts, and process skills. Student difficulties, while solving scientific problems, are usually due to lack of content knowledge, misconceptions or alternative conceptions, or poor problem-solving strategies. Students often believe that complex scientific problems have a single correct solution pathway, whereas in reality many pathways will reach the same end-point. One area, where complex problem solving is challenging to students, is molecular spectroscopy.

AIMS
According to the expert thinking theory, it is possible to identify (i) differences in task performance between novices and experts and (ii) a variety of problem-solving strategies demonstrated by experts. We hypothesised that, through the recognition and appreciation of multiple possible strategies for solving complex problems, students would explore their own understanding of the topic and improve their problem-solving skills. The aim of this project was to investigate how students engage with problem-solving plurality in molecular spectroscopy and how such engagement affects their learning outcomes.

DESCRIPTION OF INTERVENTION
We have developed videos illustrating a range of strategies for solving spectroscopy problems (~100 recordings for 21 problems). These videos demonstrate the approaches used by scientists with different levels of expertise (from honours students to senior researchers) to solve problems of varying complexity. This collection allows students to see alternative sequences for solving the same problem, and that approaches used by an individual will differ based on complexity of the problem. Modelling expert problem solving, through recorded examples, was designed to: (i) demonstrate alternative approaches to solving a given problem; (ii) introduce students to the types of prompts to guide them through the process; (iii) encourage explicit reasoning necessary for successful conceptual problem solving, and (iv) foster the development of metacognitive self-regulation skills through the inclusion of feedback mechanisms for monitoring, evaluation, and reflection. Such an explicit modelling instruction strategy is deliberate in order to transparently demonstrate to students the aspects of expert problem solving. The videos were implemented in a 2nd year unit alongside tutorial classes.

DESIGN AND METHODS
We used a mixed-method design of collecting quantitative and qualitative data. Online engagement analytics were collected in 2017 via Moodle and in-class engagement metrics (63 participants). The effect of video recordings on student learning and skills were monitored via (i) surveys and qualitative student comments and (ii) analysis of assessments results. Appropriately modified version of the validated problem-solving video survey and focus groups were used.

RESULTS
In 2017, students demonstrated improved learning outcomes, compared to previous cohorts (for equivalent assessment). Students' engagement with the resources was grade-motivated and/or limited to the intrinsically motivated fraction of the cohort. Feedback received from students has

identified possible strategies to increase engagement with the resources. These measures will be tested in 2018, together with the pre- and post- diagnostic test.

CONCLUSIONS

Video resources had a positive impact on students' learning outcomes. Student engagement with resources varied between students of different motivation profiles. Further work to optimise engagement strategies is needed.

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SCIENCE THROUGH DIFFERENT CULTURES

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KEYWORDS: Indigenous science, increasing cultural awareness

BACKGROUND

In a changing and complex future, the ability to understand and search for other points of view cannot be underestimated. I will present one example of how we are structuring some activities to allow students small moments that enable their cultural awareness to grow. Value and understanding of Indigenous science is surveyed before and after the students complete a 5 x 4 hour mini lab project to assess impact. Students are also prompted to reflect on their own connection to place and land, as well as the importance of that connection for them. This approach aims to encourage students to make a personal link, stimulating respect and curiosity about Indigenous place-based worldviews.

LABORATORY ACTIVITIES

We have introduced a small group, mini-project for third year chemistry students into the Advanced Analytical Chemistry class at Monash. Students extract and analyse chemicals from the Sandpaper Fig leaf, which is a traditional skin infection remedy for Aboriginal communities in many parts of NSW and Queensland. The students examine the chemicals in the leaf to look for likely biologically active molecules. Students compare samples grown off-country (Monash) and on-country (Cairns) to see the impact of change of location.

Connection to place is an important concept for Aboriginal communities, and extends to plants and animals. The students are led to both the Indigenous science, and the western science impact of growing a plant outside its natural habitat. The focus of the project is on using the analytical techniques and assessing the differences. Importantly, there is little added content that deals with questions of connection to place or the traditions of Indigenous science/medicine, only a 23 minute video. The topic of Indigenous science and connection to place is exposed simply by putting students in this context, and structuring the investigation around the same species grown in to vastly different locations.

The learning experience is no lesser because of the context chosen, in fact students learn better with a well-contextualised activity. There are opportunities in every science subject to add activities that reveal generally over looked aspects of how science and culture interact. What was the immense astrological knowledge of the pacific navigators? How was it communicated across generations? How and when did different societies come to the realisation that the world was round? What we can learn from the incredibly deep understanding that Indigenous peoples all over the world have of the natural world?

CONCLUSION

I will present the changes seen in perception of Indigenous science and medicine, as well as understanding in connection to place, before and after participating in this laboratory project.

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TPACK: UNPACKING HOW WE APPROACH ONLINE TEACHING

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KEYWORDS: pedagogical content knowledge, online learning, blended learning

GOAL

To summarise the collective approach of tertiary educators for the development and application of Technological Pedagogical and Content Knowledge (TPACK) in science education and disseminate those findings to the community.

BACKGROUND

The way in which we teach is changing as the demands of our students change. For many Australian tertiary educators this has manifested in the form of transitioning to online or blended learning formats. We are facing in some ways an identity crisis – how do we preserve the elements of face-toface teaching that make us unique and effective teachers? As educators within this space we regularly apply expert knowledge of best teaching practices and the content we wish to teach in the form of our Pedagogical Content Knowledge (PCK). One area that is often self-taught or missed is developing an understanding of technology and how we can align our teaching with these new delivery modes. This presents a significant challenge for both new and experienced educators to rapidly develop our technology knowledge and incorporate these new skills into our teaching. One approach to address this challenge is Technological Pedagogical and Content Knowledge (TPACK). Through this workshop we will introduce and discuss TPACK and explore how this approach may assist retention of our unique style, history and collective experiences (PCK) that define our institutions. This workshop will focus on the application of TPACK within the chemistry realm but all are welcome given the broad applicability of PCK and TPACK.

AIMS

To generate discussion and facilitate the sharing of our collective experiences on how best to apply the TPACK lens in the current context of the changing face of education and roles of teachers. Discussions will revolve around how educators develop new PCK in online environments and whether TPACK is a viable method for developing online learning environments: • What differences are there between applying PCK in face-to-face environments to online learning environments. i.e. the Technology Knowledge (TK) part of TPACK? • How are people developing their TK and transitioning their PCK into TPACK? What are the challenges faced? • Does the TPACK approach offer a practical and feasible approach to developing online learning experiences?

DELIVERABLES

Through this workshop we hope to facilitate the following deliverable outcomes:

• An opportunity for collaboration and sharing of experience, specifically enabling a chance for cross-pollination of experiences to investigate similarities and differences in how this translation has been interpreted in different teaching spaces and contexts.

• Professional development for both new and experienced educators recently tasked with the transition to online or blended learning.

• A summary of the discussion from this workshop will be distributed to attendees and synthesized into materials accessible through ChemPCK.

WORKSHOP

INTRODUCTION (15 minutes)
We will use this time to provide a surface background on what constitutes PCK and TPACK using examples and scenarios of where this has been integrated into modern practice. This will then be placed within the context of the push to shift our education practices into online and blended learning spaces including some of the commonly voiced challenges in this process.

WORKSHOP TASK (30 minutes)
How would you approach this? In small groups participants will be asked to share the current state of their teaching practices and how they have approached the transition to online or blended learning for a specific part of the content that they teach. We will encourage participants to record challenges that have been faced with a focus on identifying common hurdles that impede this transition. Participants will then be asked to consider TPACK and what outcomes they visualize as a result of applying TPACK. During this time, we will rotate a small number of participants from each group to encourage cross pollination of ideas between groups. Finally, as a group, participants will generate a list of online tools and attempt to group/align these with the teaching practices of their respective institutions.

DISCUSSION AND REFLECTION (30 minutes)
As a whole, we will share and compare our interpretations of TPACK and the alignment of online tools with our teaching practices. Furthermore, we will collectively recognize specific challenges the community share and how we might address these when moving forward. With these in mind, groups will come together to consider any changes that may be made to their previous task output.

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TOOLS FOR ENGAGEMENT: ADDRESSING THE PARTICIPATION ENIGMA IN STEM

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KEYWORDS: engagement, Inquiry-based learning, gamification

BACKGROUND

As educators of large first year cohorts, we know that regular attendance and participation in all aspects of University life is the first step to a successful University career. Students who ask questions, regularly seek clarification, build relationships with peers and teaching staff, are more likely to achieve a passing grade in the topic. These anecdotal statements are supported by research in the field which suggests that positive engagement with both the academic and social aspects of University life is an important predictor of student success and retention (Larmar & Ingamells, 2010; Lowe & Cook, 2003; Nelson, Quinn, Marrington, & Clarke, 2012). In recent years, there has been a decline in student attendance on campus, perhaps associated with a move to a more flexible learning environment and the availability of online lecture recordings (Yeung et al. 2016). In STEM topics with a practical component, attendance is still high as the laboratories are often compulsory or tightly associated with assessment. This gives us an opportunity to foster student engagement with the learning material and to help students build their understanding of the content and develop a passion for STEM.

WORKSHOP DESCRIPTION

In this workshop, participants will have the opportunity to experience some of the tools for engagement currently in place in first year biology. At Flinders University, first year biology is delivered through two core topics, Molecular Basis of Life and Evolution of Biological Diversity. Both topics have high student enrolments, large teaching teams and a diverse student cohort. The first part of the workshop will showcase general tools which are utilized during both large laboratories and lectures to build relationships with peers and teaching staff, and to encourage participation. The second part of the workshop will focus on the use of inquiry-based learning to foster engagement, with participants taking part in an inquiry-based laboratory. The final part of the workshop will focus on the use of gamification to promote engagement, with participants playing 'Clipbird Island', a game used to teach students about evolution and natural selection.

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DIGITISING CHEMISTRY TEACHING

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KEYWORDS: e-learning, laboratory simulations, smart worksheets, electronic lab books

AIMS

The aim of this workshop is to introduce a number of new digital resources for teaching and enhancing the learning of chemistry in secondary and tertiary levels. Also to share experiences of the logistics of implementation of such resources in the University environment.

SOURCES OF EVIDENCE

There is an increasing push by Universities to develop more fully online units. This trend towards online or eLearning is creating a dilemma for academics who teach science subjects, such as chemistry, where hands-on laboratory skills form an essential part of the learning process. Developing fully online chemistry units is going to create students who will not have any practical laboratory skills, which are crucial in chemistry degree. However, we do recognize that "as students increasingly need to juggle the competing demands of work, family and study, the ways in which they engage with Higher Education institutions is changing" (Bower, Dalgarno, Kennedy, Lee, & Kenney, 2014). Also, with the financial stresses of the Universities, there is a need for Universities to become more adaptable/flexible in terms of the delivery of the teaching, but at the same time make sure that, in particular science students, still have the necessary practical skills. This is where "the use of technology is playing a key role…..." (Bower et al., 2014)

There is a now a vast number of digital chemistry resources, which can be utilized to provide a more flexible learning environment for students, particularly for students who are working and/or have family commitments, enhance their understanding of abstract chemical concepts and increase their engagement in the learning process. Resources such as Labskills simulations, smart worksheets, electronic lab books, Online Web Learning (OWL) and TechSmith Relay, can be implement within the practical laboratory aspects of the chemistry unit to not only enhance the learning process, but also allow for more flexible learning, without actually replacing the lab component of the unit.

MAIN ARGUMENT

Although, there is a tendency for Universities to create fully online units, in science areas, we should keep the practical component of the units and utilize digital resources to increase the flexibility of learning and enhance the understanding of difficult concepts. Digitization of chemistry units will provide the flexibility of blending of practical skills with online learning.

CONCLUSIONS

This workshop will introduce some new digital chemistry teaching resources and discuss experiences from implementation of these resources in first year chemistry units at Edith Cowan University. In particular the focus will be on how these resources were utilized to increase flexibility of student's learning and how they were blended into the practical classes.

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DESIGNING BETTER STUDENT LEARNING EXPERIENCES IN PHYSICS

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KEYWORDS: project based learning, design labs, first year physics, third year physics, physics education, computational physics, teaching practices, LEGO

ABSTRACT

This year our discipline day will focus on discussions covering: laboratory teaching in physics, the Einstein-First project, and delivering a third-year course in Computational Physics.

Our first session begins with an overview of an informal approach to project based learning in a first-year physics lab. Over three years James Cook University Physics has taken an informal approach to merging Project Based Learning (PBL) with a skills-based laboratory subject. The students in this class are set a task of choosing an experiment out-of-the-box then using PBL to achieve its expected function. They need to learn the operation of every piece, collect or design missing pieces, calibrate as necessary, and complete the experiment. A log book and short presentation completes the activity.

In our second session David Blair from UWA presents the Einstein-First project: Introducing Einsteinian concepts of space, time, light and gravity throughout the school curriculum. This approach uses activity based learning with extensive use of models and analogies. Results show students from years 3 to 12 are highly receptive to the concepts. We have obtained quantitative results from interventions that vary from a single day to 20 lessons. We measure improvement factors for conceptual learning to find the improvement factor for girls exceeds that of boys, significant long term retention, and test scores typically improving by a factor ~4. Participants will be introduced to Einstein-First using videos and activities to demonstrate our approach, including the use of phones for data collection. We will discuss how Newtonian concepts are incompatible with modern discoveries, such as gravitational waves, and how this format opens minds to exciting future discoveries.

The evolution of delivering a third-year course in Computational Physics makes the third session, addressing the high-level goals of the course and the tactics used to achieve them. The students' experience with the course and examples of their achievements will be presented.

A fourth session looks at a novel method using LEGO race cars in a physics lab to increase student understanding of uncertainty, and as a motivation for physics practicals.

Each presentation will be followed by an open discussion with participants.

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PROVIDING MATHEMATICS SUPPORT TO ALL SCIENCE STUDENTS

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KEYWORDS: mathematics skills in context, mathematics support

ABSTRACT
Mathematics instruction that supports key areas of science, engineering, commerce and beyond makes up a significant proportion of our mathematics teaching at university.

1. How do we facilitate the rich conversations with colleagues that allow mathematics instructors to understand what is required by those disciplines and how can we extract or construct examples that help students transfer their mathematics skills to these contexts?
2. In many cases, mathematics departments design subjects for specific purposes, for example mathematics for engineers or mathematics for life sciences. But there is a vast amount of mathematics being taught (or assumed) in curricula that we may not even be aware of.

A recent initiative to establish a university-wide maths support service, uncovered widespread (and mainly incorrect) assumptions about students' quantitative knowledge and ability.

How do we provide mathematics support broadly to students, particularly in subjects where mathematics and statistics are not taught, but assumed?

Be prepared to contribute your ideas and examples of how maths support is managed at your institution.

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CHEMISTRY– ACCREDITATION AND NETWORKING FOR EDUCATION RESEARCH

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The Chemistry Discipline Day activities

1. Recruitment, orientation and training for RACI accreditors (Ben Fletcher, RACI accreditation coordinator will be in attendance)
2. Networking for Chemistry Education Research – an opportunity for matching the interests and capabilities of novice, enthusiastic and experienced Chem Ed researchers
3. RACI Chem Ed Division meeting

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CREATIVE ENGAGEMENT IN THE BIG NEW CURRICULUM

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KEYWORDS: coding skills, real world skills, representation of data

ABSTRACT

We are facing a new breed of students who will be at our doors soon with coding skills and other capabilities that are largely foreign to us. In this workshop we will discuss some of the approaches that we could consider taking with some examples of activities that are already being implemented. We will then dive into a particularly interesting approach to engaging students in coding by analysing climate change data and creating some stunning and accurate visualizations. This means that YOU will put yourselves in the shoes of several hundred students and use your own computers to learn some very basic code and use templates to create and communicate your very own representation of climate change data. We will also explore a simple tool for data sonification. These are real world skills everyone needs and this will introduce you to the pleasure and joy of playing with real data in new ways.

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