The Impact Of Integrated Tutorials in Supporting First Year Student Progression In Engineering

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Abstract— **In this full paper we describe an innovative practice regarding the design and introduction of compulsory, small-group, holistic tutorials into our core first year engineering courses. Instead of traditional tutorials which seek to reinforce lecture content or provide guided help with assignments or test revision, these tutorials specifically focus on connecting topics between all courses a student is currently taking. They also aim to clearly demonstrate the value of a cohesive body of knowledge, instead of rote-learning of facts from individual areas. Tutorials are accompanied by practical demonstrations, and collaborative, guided discussions.**
The inclusion of these tutorials, along with other minor changes to the course content, has shown marked improvements in students' grades, retention, student evaluations and, most importantly, a change in many students' perception of the value of a coherent body of knowledge separate to that necessary to perform well in assessments. Such tutorials appear to have positively affected the retention rate of engineering students in our degree programme.

Keywords- integrated tutorials, student retention, holistic pedagogy in engineering

I. Introduction

Globally, professional technical qualifications such as engineering degrees are often associated with low retention and high failure rates compared to other academic programmes. The reasons for this are complex and numerous, but often a lack of preparation or ability in mathematics and physics is cited as a major contributor [1-6]. In New Zealand and internationally, many universities restrict entry to tertiary engineering programmes based on students' performance in High-School mathematics and physics. However, our research has noted, that for the ICT forms of engineering such as Software Engineering, High School grades have not formed a good predictor of eventual success [7]. Additionally, such restrictions often discriminate against those from lower socio-economic backgrounds.

For a variety of reasons, including equity considerations, at Victoria University of Wellington (VUW) we allow a more open-entry model, and instead require the students to achieve an above-average GPA over their required first year courses in order to progress. However, this more open-entry policy delivers a broad range of abilities into our first year engineering courses, and traditionally our less-prepared students have struggled to the extent that they are unlikely to ultimately graduate with an engineering degree.

In the following sections, we outline the nature and requirements of our degree, detail some conventional and some novel interventions we have historically employed, consider the success of these interventions and then discuss the motivation and impact of a more overarching/holistic approach to the problem and the implementation of integrated tutorial support.

II. Student Progression Criteria In VUW's Engineering Degree

VUW is a relatively new entrant in the tertiary engineering education provision market, having established the engineering degree (building on prior expertise expressed in a variety of science degrees) in 2007. We decided to operate in a niche area of engineering, that of the high-tech/ICT areas, and not compete with the existing national providers of the more traditional engineering disciplines of civil, structural, mechanical etc. Currently we operate in the areas of software, internet, cybersecurity, computer graphics, artificial intelligence, electronics, signal processing, communications, mechatronics, renewable energy, and superconductivity. Whilst linked under the high-tech/ICT "umbrella", very different skill sets are required of these students. For example, mechatronics, electronics, superconductivity, signal processing & communications all require strong mathematics and physics, and traditional predictors based on High School grades in these subjects do show a high correlation with eventual success (measured by progression rates at the tertiary level) [7]. However, the more software based subjects show no such correlation. Computer graphics is in the middle, more mathematics and physics knowledge is required than the other software areas, but less so than the hardware subjects.

The failure of a predictor based on High School grades led us to allow a more open entry approach to our engineering degree, however students need to gain a B GPA or above in order to progress into year 2 of engineering study. To put this in context, in the New Zealand system, a minimal pass grade is a C- which spans the range of 50-54%. The (difficult to achieve) grade of A+ is awarded for the outstanding students who score 90% or above. Otherwise grade ranges progress in 5% increments, so a B grade is 70 – 74%. For those courses that employ bell-curve gradings, approximately 50% of *passing* students might be assumed to have a grade below a B. However, our expectation is that we are attracting the better students, and our goal is for 60% of our students to progress past this GPA test at first year. Our grade distribution is summarised in Table I below.

TABLE I. GRADE EXPLANATION AT VUW

Mark range	Grade	Indicative Characterisation
90 – 100	A+	Outstanding performance
85 – 89	A	Excellent performance
80 – 84	A-	Excellent performance in most respects
75 – 79	B+	Very good performance
70 – 74	B	Good performance
65 – 69	B-	Good performance overall, but some weaknesses
60 – 64	C+	Satisfactory to good performance
55 – 59	C	Satisfactory performance
50 – 54	C-	Adequate evidence of learning
40 – 49	D	Poor performance overall, some evidence of learning. **Fail**
0 – 39	E	Well below the required standard. **Fail**

III. HISTORICAL INTERVENTIONS/IMPROVEMENTS IN THE CURRICULUM

In an effort to increase the student progression rate (discussed further in section V) the Faculty has implemented a number of improvements in course content and curriculum requirements, including some rather novel initiatives. It is worth considering the scope of these changes in order to place into context the latest initiative, that of the holistic tutorials.

To begin, students in the early years of the engineering programme did not feel as though they were engaged in "real" engineering in their first year due to the heavy requirements for them to take the "Enabling" science courses of mathematics and physics. We addressed this by having a dedicated engineering course each semester, by introducing mathematics material in context in these courses, and replacing core mathematics and physics course requirements with new courses focusing on the delivery of the mathematical and physics concepts in an engineering context [8]. The change in student engagement, in particular for the new engineering mathematics courses, was profound. As detailed in [8], comparing 2013 results when the students were enrolled in core mathematics courses, to 2016 when our engineering mathematics courses were being offered for the second time, reveals a dramatic change.

Specifically, the number of students gaining a B grade or better in these new mathematics courses (compared to the previous core mathematics offering) rose from 15% to 68% in the introductory ENGR121 engineering mathematics course, from 41% to 69% in the first year calculus course ENGR122, but stayed static at 54% for our discrete mathematics ENGR123 course.

There is some undesirable fluctuation in these numbers depending upon the lecturer assigned to the course in that year, but otherwise these courses were a huge success. The context of the material was crucial. The emphasis was no longer on axioms, theorems, corollaries, proofs, but more on the application of the material. There are even laboratories in these courses, where (for example) robots are used to illustrate aspects such as vector addition. This success was not initially repeated for the change from a core physics course into an engineering physics course. Issues of cross-department communication and an unwillingness to alter these courses from a more traditional physics approach hampered our efforts, but we are very optimistic that these issues have now been resolved for the next offering of the course.

In order to meet student expectations of an engineering degree, it is important to produce near-immediate engineering deliverables particularly in the first year dedicated engineering courses [8]. The introduction of an autonomous robot challenge in the introductory first year course was widely embraced by the students. The capstone of this first year course was the testing of the developed robots over an Olympiad of events [9]. Student satisfaction in our degree offerings, as reported in [9] significantly rose. Nearly 3 times as many students reported on the highest satisfaction category following these changes.

IV. STRUCTURE OF THE ENGINEERING DEGREE AT VUW

It is useful to compare the progression in the required courses from the degree's inception in 2007, to its form a decade later reflecting these changes. We are unable to agree on a common first year due to the perceived differing (and extensive) requirements for our software vs. hardware students, and so two sets of first year course requirements are presented.

Invariant (2007-2018) and common to all engineering

COMP102: Introduction to Computer Program Design

COMP103: Intro to Data Structures and Algorithms

ENGR101: Engineering Technology

Hardware First Year (additional) Curriculum

2007 required

MATH113: Calculus I

MATH114: Algebra and Discrete Mathematics

PHYS114: Physics 1A

PHYS115: Physics 1B

2017 required

ENGR110: Engineering Modelling and Design

ENGR121: Engineering Mathematics Foundations

ENGR122: Engineering Mathematics with Calculus

PHYS114: (as above but changing in 2018)

ENGR142: Engineering Physics for Electronics

Software First Year (additional) Curriculum

2007 required

MATH114: Algebra and Discrete Mathematics

STAT131: Probability and Decision Modelling

SWEN103: Introduction to Software Modelling

Introductory physics course added 2008

2017 required

ENGR110: Engineering Modelling and Design

ENGR121: Engineering Mathematics Foundations

ENGR123: Engineering Mathematics with Logic and Stats

+ Choice of an introductory physics course including first year computer graphics.

A more complete description of these courses can be found in our second FIE paper submission [10]

In summary, we can see the progression in the hardware requirements from core mathematics and physics courses (delivered by the mathematics and physics departments and focused on potential mathematics/physics majors) to an incorporation of the material into an engineering context. For the software students, a similar change has been effected with the mathematics course STAT131 replaced by ENGR123, MATH114 replaced by ENGR121, and the ability to use a computer graphics course to cover the physics requirement.

V. Historical Improvement In Progression Rates

Table II presents the student progression rate since 2007. The first column is the year the student first enrolled in engineering at VUW. Subsequent columns indicate the number of students from that entry year that attained this GPA requirement. So (for example) for students who first enrolled in our degree in 2007, 22 of them attained this GPA requirement in that year, 9 completed the requirement in 2008 and one completed in 2009. This yields a total of 32 students from an initial intake of 111, or a 29% total progression rate (where 20% [22/111] students attained the requirement in their first year of study).

As illustrated in Table II, historically, the number of students achieving the progression criterion in their first year is only in the mid 30% range. Sometimes students have delayed taking a required course (perhaps to keep their options open) or have re-enrolled in a course that they did not do well in, and therefore achieve the requirement in year 2. Overall however, our overall progression rate has been in the low 40% range, well below our 60% target.

This constant progression rate has been a source of some frustration to the Faculty of Engineering, especially given the large number of initiatives that have been implemented to improve these. However a deeper analysis of the data reveals a more encouraging figure. Our first year enrolment numbers have more than doubled over the last decade. Our entry diagnostic test (test details described in [10]) indicates that at least in terms of mathematics and physics ability, the skill level of this increased number of students is broader than our original intake. The fact that we have maintained an approximately constant percentage rate of progression, means that we are passing more students, some of whom may not have made it through an earlier incarnation of the programme. Indeed in terms of absolute numbers, we have almost tripled the number of students progressing past this GPA cut-off criterion. But we still have yet to achieve our 60% goal.

Our current thinking is that many of the historical initiatives have been rather narrow, or siloed, i.e. addressing individual subjects rather than the first year experience holistically. A further analysis of our student cohort uncovered that many of our students were still missing the connections between courses necessary for learners to assemble a coherent body of knowledge.

To address this need, we introduced compulsory, small-group, holistic tutorials into our core first year engineering courses. Instead of traditional tutorials which seek to reinforce lecture content or provide guided help with assignments or test revision, these tutorials specifically focus on connecting topics between all courses a student is currently taking. They also aim to clearly demonstrate the value of a cohesive body of knowledge, instead of rote-learning of facts from individual areas. Integrated learning is certainly not a new line of thought, many other researchers/institutions have adopted such pedagogical principles, but we have not found any that have reported on an approach similar to ours.

TABLE II. Percentage of students Attaining B average or above in required first year courses

Entry	n	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	%1year	Total(%)	Total (#)
2007	111	22	9	1									20	29	32
2008	92		21	17	1								23	42	39
2009	113			31	13	6							27	44	50
2010	120				35	15	2	1		1			29	45	54
2011	109					25	23						23	44	48
2012	172						57	17	3	2			33	46	79
2013	156							44	13	8			28	42	65
2014	166								51	19	2	1	31	44	73
2015	170									61	10	3	36	44	74
2016	223										83	8	37	41	91

VI. Integrated Curriculum in the Literature

A reader might ask "What is an integrated curriculum?" The term is used rather broadly. For example, an integrated curriculum can mean the integration of different subject material or skills into one class or course, or the integration of course material in different courses to provide a balanced course of learning within a single year or across years. It can also mean the integration of modes of thinking to practice both practically and theoretically.

However, at the heart of the concept is the desire to connect forms of knowledge to other forms of knowledge and in doing so improve a student's conceptual and practical ability [11] [12].An integrated curriculum which aims to show the significance and relevance of knowledge has many benefits for educators and students. That said, while many educators believe in the value of integrated curriculum vs. separate subject curriculum, there is no consensus. The issue of integrated curriculum has been discussed in relationship to High School education for some time and has been gaining gradual acceptance since the 1980s in the US [13]. Educators in the last two decades have been quick to buy into the need for this integrated curriculum for STEM subjects prompted by national initiatives in many countries designed to increase graduates [14][15]. The "STEM crisis" has prompted many universities to investigate integrated curriculum as a means of increasing graduate numbers [15] but it is still not a widespread practice [16].

Within Engineering tertiary providers there have been many successful initiatives that have incorporated either design principles, or used project based learning to combine inter-disciplinary subject matter into traditional engineering classrooms [17-19]. For example, Loughborough University in the UK, developed a successful project based approach that incorporated small group learning and enquiry based tasks to encourage a conceptual based understanding of mathematics for engineering students [20].

These initiatives have the desire to show students the connections between subject matter and to encourage them to think in this manner. [16] refers to these various methods for combining integration of engineering thinking and content under two categories: context integration and content integration, context integration being the integration of engineering design to teach disciplinary content. Content integration is the integration of engineering thinking with specific subject content to teach multiple learning objectives in an activity.

Unfortunately, in New Zealand there has been little effort within engineering tertiary education to embrace the context integration or content integration model at a first year level. Subjects like mathematics or physics are still being largely taught as discrete or independent subjects and while Project Based Learning does exist within specific courses, this is done mostly in the later years of a student's study. First year has been primarily viewed as a place to learn fundamental skills in subjects before learning to integrate these skills with an engineering mind-set until later years. Certainly this was also the situation for our initial offering of our engineering degree.

VII. Integrated Tutorials

The "Integrated Tutorials" in ENGR 101 and ENGR 110 at Victoria University began in 2016. These tutorials, while attached to ENGR 101/110, cover material from the entire first year engineering programme. The main purpose of the tutorials is to help students see how ideas in their courses are connected and how they can be used together in broader problem solving. In addition, the tutorials offer a venue for preparing students for tests in their classes and respond when it is clear that many students are having difficulty with a particular topic in one of their first year classes.

Example: RGB tutorials

As an example of linking ideas between classes, we have run one series of tutorials (2-3 sessions) in which we discuss RGB display and image file format technology. This series of tutorials begins with a demonstration of colour mixing using a thinly silvered ("one-way") mirror box. This demonstration is adapted from the well-known "Pepper's Ghost" physics demonstration in which a candle appears to burn inside a beaker full of water. In the RGB version, a red light is placed inside the box and a green light is placed in front of the box. The green light is initially off, so the mirror appears to "turn on the light and change its colour." The students are asked how the mirror "turns on the green light and changes its colour. We explain that a truly "one way" mirror, that lets light go one way but not the other, would violate reversibility of light rays and does not exist.

We next launch into interactive demonstrations that show students how thinly silvered mirrors can appear to act as one-way mirrors when one side is darkened, and how they can overlay images. Students are then asked to predict what they will see when both the red and green lights are turned on. Many correctly predict that this will result in a yellow light and indeed, when the green bulb is turned on, a yellow light is visible. We progress by discussing the addition of waves of different frequencies, and using sound as a proxy, show that the idea that a high frequency wave (green light) and a low frequency wave (red light) add together to make a medium frequency wave (yellow light) is incorrect mathematics and physics. This is reinforced using diffraction grating glasses that separate light into its constituent colours: a sodium lamp produces true (later called spectral) yellow while a combination of red and green light produces fake (later called perceptive) yellow. We leave students with the question: why do red and green appear to make yellow?

We then use purpose-built software for mixing colours, called ComputerColours, to make a yellow patch on a computer screen. A strong magnifier again reveals red and green lights (within each pixel).

At this point we discuss the structure of the human eye and the workings of rods and cones. We discuss how red and green light cause the same electrical response in the cones that spectral yellow light would cause, and thus the human vision system perceives them as the same. This is the essence of RGB technology: we can simulate a target colour by using varying amounts of red, green, and blue to cause the same electrical response in the cones that the target colour would cause.

Students mix colours to produce pink and brown, and discussion of what colour means follows.

The series of tutorial exercises continues with discussion and activities teaching that an image is a set of red, green, and blue lights on a screen and the data is stored in a 250 × 400 array in which an array element gives the colour of a pixel. Array element (0,0) for example gives the colour of the pixel in the upper left corner of the image. We note that the amounts of red, green, and blue in a pixel typically vary from 0 – 255, giving one byte of data per colour per pixel. We illustrate that this is enough for most purposes by having students verify they cannot easily tell the difference between R = 200 and R = 201 for example. Next we learn to combine the R ,G, B values into a single 24 bit number using bit shifting and build understanding of what bit shifting means by studying the formula

$$\text{Colour} = (256)^2 \times R + (256 \times G) + B$$

which has the same effect as shifting G by 8 bits and R by 16 bits. We use a csv file created by a spread sheet as a grey scale image array, predicting from the spread sheet what the image will look like.

This series of tutorials continues after a lecture on data compression with experiments saving 250 x 400 pixel images in bmp, png with lossless compression, and jpg with lossy compression. We save a single colour image, and an image made up of entirely random colours, a relatively simple image, and a relatively complex image in each of these formats and discuss the results.

This series of tutorials links ideas from physics (optics, thinly silvered mirrors, and reflection), computer science (arrays, computer colours), ENGR 101 (bit shifting, data compression), and engineering maths (base 2 maths, matrices).

Example: Engineering Ethics

As an example of studying the nature of engineering, we have a tutorial exercise on engineering ethics. This tutorial exercise allows students working in small groups (2-5 students) to choose one of three scenarios in which they imagine themselves faced with ethical issues while working as an engineer. This year students have responded to the tutorial questions in the first tutorial of ENGR 101 (term 1) and will be asked to respond again, in the last tutorial of ENGR 110 (term 2), and then compare their answers. We plan to write a paper on how the students' perception of ethics develops over the course of the first year.

The scenarios include being asked to work on cyber weapons for New Zealand and/or for another country, development of software that invades privacy, and knowing that a product under development is faulty. The group discussions are moderated by a tutor who asks students to describe their thinking at various points. Students are encouraged to think about the harm their action or inaction could cause and the responsibility of engineers in these circumstances. In the initial tutorial, near the start of the first term, students are not encouraged to consult professional engineering body statements on engineering ethics. By the time these questions are revisited near the end of the second term, the students will have studied professional body ethics statements.

Logic Races (Psychometric tests)

A particularly fun and integrative set of tutorial exercises involves "logic races." In these exercises questions adapted from psychometric tests are mixed with problems related to all of the first year engineering classes. The problems are displayed on a screen with students given 15 – 60 seconds to solve the problem, and then a new problem is displayed. A typical relatively easy problem, adapted from psychometric testing, might be:

20 seconds to answer: The day before yesterday was the day after Sunday. What will be the day after the day after tomorrow?

A few example topics include:

- Selecting a sequence of statements that prove a claim
- Finding patterns in sequences of numbers, letters, and diagrams
- Time and distance problems
- Class-related problems from maths, programming, and engineering classes: for example, integrating by finding the area under a graph or differentiating by finding a gradient (very quickly).

These problems serve to sharpen thinking skills and help students learn to work under time pressure. Students mark their own tests, and any student getting above 50% gets a chocolate fish or similar. This creates a competitive but friendly atmosphere in which many students will work surprisingly hard. This particular example is indicative of an integrative approach to *skills development* rather than *content understanding*. This skill development is an important attribute that is often neglected when the performance metrics are content aligned.

Example: Power Plant

Our university has recently introduced an undergraduate major in renewable energy. To support this discipline in the integrated tutorials, a series of tutorials were run that involved the creation of a simple model of the energetics and economics of a coal-fired plant that involved Java programming, physics, mathematics and engineering modelling. Our plan is to extend these tutorials next year so that the model extends beyond the plant to the full-life cycle, including environmental aspects and compare these to a renewable energy plant (wind and/or photovoltaic).

Course Support

While the integrated tutorials are primarily designed to help students link together ideas from across the curriculum, we also use these tutorials to respond to specific problems in first year courses as they arise. For example, if we find students are having difficulty with proof by induction covered in the engineering maths course, we may respond by using part of a tutorial slot to work on these. Similarly we have run tutorial exercises on Newton's Third Law and other topics.

The tutorials are assessed on participation. A student only needs to submit a reasonable amount of work on 8/10 tutorials in a term to get full marks for the tutorial part of ENGR 101, which comprises 10% of the course mark.

VIII. Evening Tutorials

The evening workshops are organized quite differently from the Integrated Tutorials and traditional course-specific events. Students attending the workshops work alone of self-organize into small groups working on assignments and/or studying for their various first year courses. On a typical night there will be individuals and groups working on computer programming, mathematics, introductory engineering, and other courses. The tutorials are scheduled for Monday and Wednesday nights from 5:00 PM - 8:30 PM in a seminar room that can accommodate over 40 students. Refreshments are served, typically corn chips, and there is often a somewhat festive atmosphere. Students clearly make friends at the workshop and at least some community building takes place.

Tutor support during the workshops is provided by the senior tutor and student tutors supervised by the senior tutor. Typically there will be at least two student tutors plus the senior tutor supporting students in each session. This arrangement allows the senior students, ranging from second year to Ph.D. students, to serve as role models for the younger students. In addition to helping the first year students, the tutors benefit by solidifying their understanding of the material and developing communication skills. These paid tutor positions are considered desirable by senior students and there is competition for them. In fact, tutoring at the evening workshops is so popular that we often have unofficial volunteer tutors attending.

The workshops are very much student-led, with students working on whatever they most want help with, typically assignments due soon. The tutors circulate in an effort to monitor whether there are particular problems or concepts that many students are having difficulty with. When such a problem is identified, the senior tutor will sometimes give an impromptu "lecture-let" and/or make up related example problems for the students wanting help. Recent examples of this include polynomial long division, oblique asymptotes, and "Challenge-level" problems in computer programming. This is invaluable experience for the tutor and is very effective role modelling.

On some occasions, often a few days before a test, parallel test review sessions are taught by the senior tutor in another location. These test review sessions are more traditional tutorials: they are instructor-led and are usually held in a lecture theatre as they attract too many students for a seminar room. The most common activity in the test review sessions is working through an old test or exam.

One of the more positive aspects of the workshops is the gender balance of students attending. Although women only comprise 18% of the total number of students in the course, they regularly comprised between 44% and 50% of the tutorial attendees. Although it is dangerous to assume too much from this statistic, we confident in reporting that at least these tutorial sessions are not alienating women from attending.

IX. Results

Ethics approval was obtained so that we might survey the student attitudes to these tutorials. Of the students in these integrated tutorials, there were 113 respondents, 69% were SWEN majors, 25% ECEN majors (noting that ECEN comprises approximately 20% of the ENGR101 enrolment figures). 16% of the respondents were female (from a cohort comprising 17% female students – so women responded to the survey in approximately equal proportions to male students).

On a 10 point Likert Scale (where 1 is not important at all and 10 is extremely important), in response to the question: "Please rate how successful you feel the *integrated tutorials* were in linking material your classes and illustrating how the material from classes fits together"; 88% of students responded with a grade of 7 or higher (mode was 8 [42.5%], median was 7.6).

Similarly in rating how helpful the *integrated tutorials* were for developing your understanding of engineering as a profession, again 84% responded with a grade of 7 or higher – mode was a very pleasing 9 (25.7%), with the median being 8.1. 81% of students responded with a grade of 7 or higher when asked if these tutorials increased their interest in engineering –the mode response was a remarkable 10 (30.1%), with a median of 8.5. Only 4% of students responded to this question with a grade of 3 or lower.

There was a scattered grade distribution to the question as to whether these integrated tutorials improved their grade performance – which did not surprise us. Only 56% of students thought it did (rating 7 or higher), 15% responded with a grade of 3 or lower (mode 8 [22.1%], median 7.0). We do not consider this is as a negative result – the goal of these integrated tutorials was not class grade specific.

Qualitative comments were mostly very positive. One of the more extensive comments summarises the general feeling well:

> "The best aspect about the integrated tutorials is that they were more relaxed, and did not have the worry of ensuring that the knowledge was stuck in out [sic] heads so that we can recite it for tests. It was instead more here is some knowledge that may be of interest to you, and if you do pay attention, it will help your understanding for the lectures/labs."

Another student reports:

> "They were interesting, the focus didn't seem to be on achieving a mark or getting through a bunch of work but rather being introduced to interesting concepts and ideas, and showing us how to apply some of the topics from other courses"

There was a small cohort of students who did want a more grade focussed approach, but these were overwhelmed by the number of students who when asked in the survey "What do they think could be improved", answered "Nothing", "No Suggestions", "think it's pretty good", "pizza", "more free food".

A few students did think that the progression was too slow and that the content had been covered before in other lectures. However, about an equal number of students wanted these tutorials to go slower. So it was difficult to extract any consensus about any specific way in which these tutorials might be improved in the future.

The results were somewhat different for the *evening tutorials*. From 104 respondents, and again recording Likert results as 7 and above as being positive, and 3 and below as being negative, 73% of students felt that these workshops helped in the understanding of the academic content in the classes (mode 10 [29.8%], median 8.4) whilst 10% were negative in their opinion. There were only 50% of students who thought that these helped in their understanding of engineering as a profession (modes of 8 and 10 [15.2%], median 7.2), 18% thought that they didn't. However, 72% of students thought that these helped with grade performance in class (mode of 10 [32.4%], median 8.6), 13% didn't. 76% felt that these made them feel part of a learning community (mode 10 [40.4%], median 9.0); again 12% felt it didn't.

In the qualitative comments, students generally stated that they voluntarily came to the evening tutorials because they were having difficulties in specific courses. One indicative comment:

> "The best part… was the fact that [the tutor] walked us through difficult problems in PHYS114/ENGR142 where we would otherwise had to go to a scary physicist for help"

> "Personally, I found the evening time slot fantastic. Dealing with serious mental health issues and (associated) insomnia, there were times where these workshops were the only thing I could attend, but the quality of the workshops meant that I could still keep up with what was going on in class with assessments."

Regarding how these evening tutorials might be improved, again we had requests for free food, but an overwhelming number of students said that they couldn't think of anything. There was some desire for some of the tutorials to be specific to a particular course and to have more tutors. One quite detailed comment did comment that he thought that some students were there just to copy down the solutions to test/exam problems, and that his/her preference would be for more time to be spent on the students who came prepared with specifics questions, and

> "less catering to the lowest common denominator who haven't attempted anything yet and are just looking for their work to be done for them. I realise this is unlikely to change considering the [School's] values of producing as many engineering graduates as possible rather than the best engineering graduates possible."

Whilst there was only one such comment, it is an interesting one – but one we reject. We believe at the conclusion of our degree, all graduates are quality ones, but some students have a lower-level starting point than others.

It is interesting that on average, second year students (who had taken these tutorials (both integrated and evening) last year) on average had a ~4-5% more favourable response rate to first years who are currently engaged (only for the last five weeks as at the time of this paper preparation). Perhaps the full effectiveness of all of these tutorials becomes more apparent either in hind-sight, or as the tutorials progress. We will survey the students again at the end of our academic year (October) to determine if there has been such a shift in these student attitudes as well.

Holistically, it is difficult to gauge the real effectiveness of these tutorials on the overall student performance. Examining the retention data, the 2017 student retention data diverges from our historical trend. Copying the 2015 and 2016 data from Table II (for comparison purposes) and inserting the 2017, we achieve Table III. The main feature here is that we have achieved our historical total retention after one year, rather than the normal 3 years exhibited by the historical data. On this basis, we might reasonably assume that at least another 10 students will achieve their required GPA this year, for a total 2017 progression rate of at least 49%. If so, this will be the highest progression rate in our 11 years of offering the degree. We have not changed any other aspect of the first year in 2017, and so whilst we cannot categorically state that the introduction of the integrated tutorials was the cause of this increase, there is a strong likelihood that this has helped some of our marginal students to make the appropriate "connections" between all of the material and in doing so, succeed better in the course grading. So there is a correlation, but we certainly have not established causation.

TABLE III. PERCENTAGE OF STUDENTS ATTAINING B AVERAGE OR ABOVE IN REQUIRED FIRST YEAR COURSES LAST 3 YEARS

Entry	n	2015	2016	2017	%1year	Total(%)	Total(#)
2015	170	61	10	3	36	44	74
2016	223		83	8	37	41	91
2017	187			82	44	pending	pending

X. CONCLUSIONS

Overall, absolutely the success of the integrated workshops/tutorials is dependent upon the personality and enthusiasm of the tutors. However, these same tutors were historically employed in more traditional types of tutorial assessment. The students certainly feel that this integrated form of support helped them with their understanding of engineering as a profession, linking the material between classes and increasing their interest in engineering. They were less positive regarding a direct benefit in grades.

The voluntary evening tutorials were primarily attended by those with specific course difficulty, and unsurprisingly these scored higher in the questions regarding grade improvement.

The correlated, (but not necessarily causal) relationship with increased first year retention is extremely encouraging. We do need a few more years of data to determine if this initial retention increase is sustained.

Resource issues are always paramount for any Faculty. It can be difficult assigning valuable tutorial support for the holistic engineering issues rather than course grade specific ones. Our evidence so far however, is that such integrated support is achieving results that course-specific approaches have not, and that these do have a holistic effect on improving engagement and (ultimately) retention.

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