Beyond Academic Quality:

Lessons from the creation of a new Engineering Degree

D.A. Carnegie, J. Eldridge and C.A. Watterson
Faculty of Engineering
Victoria University of Wellington
New Zealand
dale.carnegie@vuw.ac.nz

Abstract— **An investigation into the initially high attrition rates in our new Engineering programme uncovered a number of non-academic factors that led to poor rates of student engagement. Dealing with today's "millennials" has required us to focus on meeting student expectations to a greater extent than we ever expected. Indeed, once we began to understand the modern, technically motivated student, we overhauled our first year engineering offering, as our focus on the traditional delivery of "enabling" subjects (physics, mathematics, programming) was failing. The result has been a substantial increase in student satisfaction and in the number of students gaining a GPA that enables them to proceed in engineering study.**

Keywords—student retention, student expectation, student engagement)

I. Introduction

In 2007, our university introduced an engineering degree that focusses on the modern, niche, ICT-related areas of software, networking, electronics and computer systems. These were expanded forms of courses previously embedded (and sometimes hidden) in physics or computer science programmes. We aspired to produce high quality, technically capable graduates who would be equally comfortable transitioning directly into industry or progressing to post-graduate study. Whilst our engineering programme has been exceptionally successful, with growth more than triple the business case expectations, it has not been without its challenges.

Specifically, student retention between the second and first year of our programme was far lower than what we anticipated. As detailed in section III, entry into the engineering programme is "mostly" open-entry, and we expected some attrition due to factors of poor academic ability and/or academic preparation from secondary school. However, the first years of the programme saw some of our more academically capable students exit the degree.

To understand the reasons for this, we undertook a series of qualitative and quantitative analyses that yielded vital information regarding the non-academic aspects of student retention. Whilst an extremely in-depth search of the literature does produce corroborating support for our findings (for example [1][2]), these non-academic contributors to retention often take a secondary position to the more quantifiable academic ones.

This paper progresses by introducing our degree, detailing the changes to our secondary school assessment that led to our decision to allow mostly open-entry into the programme and the analyses we conducted on student perceptions and satisfaction. The paper then details corrective actions we employed and endeavors to estimate their success (or sometimes the lack thereof).

II. Background

Naively, we believed that it would be an academically straight-forward task to attract ICT-interested students into our new engineering degree. Certainly we were mindful of Washington Accord accreditation and the required graduate attributes. Consequently we ensured that project management, ethics, professional practice, and industry engagement (etc.), were included in the programme to make it a distinct degree (from a science offering) – although these courses do occur in the later years of the programme.

We benchmarked this new degree against well established and highly reputable existing international engineering providers and utilized existing courses where possible to minimize establishment costs. In short, we thoroughly prepared the academic quality of our degree, and ensured compliance with the graduate attributes required of Washington Accord accreditation.

The resultant first year of the programme would not look unfamiliar to most Engineering academics. Recalling that our point of difference in our engineering programme is its focus on ICT/High-tech engineering, we offered majors in Software, Networking, Electronics and Computer Systems Engineering. These majors built on expertise developed within the university. Although new majors have subsequently been (or are in process of being) developed in Computer Graphics, Cyber Security and Sustainable Energy, all of these continue the emphasis on high-technology/ICT engineering. We have no intention of ever offering the more traditional forms of civil or structural engineering.

Our degrees require eight, 15-credit courses per year; four per semester. These eight courses varied depending on the major. All students completed a core set of four courses

- COMP102 – Introduction to Computer Programme Design

978-1-5090-5920-1/17/$31.00 ©2017 IEEE

- COMP103 – Introduction to Data Structures and Algorithms
- ENGR101 – Engineering Technology

Then, depending upon the major, students then had a different set of requirements.

For Electronic and Computer Systems engineering, the additional first year comprised:

- MATH142 – Calculus (noting that almost all of our students needed to do the lower level MATH141 Calculus course as a pre-requisite)
- MATH151 – Algebra
- PHYS114 – First year physics I
- PHYS115 – First year physics II

Networking required:

- MATH142 – Calculus (and probably MATH141)
- MATH151 – Algebra
- MATH161 – Discrete Mathematics and Logic
- SWEN102 – Introduction to Software Modelling

And finally Software Engineering majors required:

- MATH161 – Discrete Mathematics and Logic
- SWEN102 – Introduction to Software Modelling
- STAT131 or 193 (some form of Statistics)

There are two immediate points to note here. The first is a lack of a common first year. This was (and still is) highly lamentable, however, our Software Engineering team states (with high justification) that their target students often have not done final year calculus or physics at secondary school, and the Electronics and Computer Systems teams refuse to relinquish such enabling subjects at first year. For the purposes of securing the initial accreditation to the Washington Accord, a physics requirement (PHYS122) was also added to the networking (at the expense of MATH142) and software engineering majors. However, this disparate first year offering did make it almost impossible for students to transfer between majors, especially between Electronics and Computer Systems and the Software stream.

Yet this combination of computer science, physics, mathematics and an introductory engineering paper would not appear to be fundamentally different to many engineering degrees at quality tertiary institutions.

III. Secondary School Preparation

The authors have detailed elsewhere [3][4] the issues of the changes to the New Zealand secondary school educational assessment and specifically the creation of the National Certificate of Education Achievement (NCEA). In summary, only four grades are awarded to students in their final three years of secondary schooling {Not Achieved; Achieved; Merit; Excellence}. No percentage grades are awarded. Further, each subject is divided into modules, each with its own assessment. The student is free to choose which modules they wish to be assessed in. It is theoretically possible (for example) for a student to opt out of the differentiation and integration modules in final year mathematics with calculus. Further, the awarding of the grades is also problematic, there (for example) being many ways to earn an "Achieved" grade [5]).

Consequently, we had low faith that the grades accompanying the students out of secondary school were useful predictors of likely success in tertiary engineering study. An in-depth comparison of such grades was conducted across multiple NZ institutions [5] and generally showed either no, or quite poor correlation. This study did indicate that students with poor secondary school grades (that is a predominance of "Achieved" over "Merit" or "Excellence") were capable of success in our (and other institutions') engineering degree(s).

The result of this is that we decided to allow mostly open entry into our engineering programme. The "mostly" refers to the requirement that the students had to at least be able to enter the required mathematics and physics courses – that is, have some secondary school preparation in these subjects. Instead of setting a high level entry requirement based on grades we did not trust, we instead elected to make a decision whether students could progress in engineering study after their first year GPA had been established. We require an above average B GPA (noting that C- (grade value "1") is the lowest passing grade, A+ (grade value "9") the highest) in order for students to progress. The B average then, equates to a numerical GPA of 5.0. Students who failed to attain this GPA were not permitted to continue studying for a Bachelor of Engineering (BE), but could transfer to a Bachelor of Science (BSc) with no financial or course penalty.

A direct result of this is that we did expect a reasonably high attrition rate purely on the basis of academic ability and/or academic preparedness. What we did not expect, as introduced in section I, was the very low rate of progression, nor the number of high achieving students who were not progressing with engineering study. This prompted the investigation into the causes of this attrition.

IV. Student Responses

We engage our first year engineering students in two surveys throughout the year. The first asks questions primarily aimed to assist in our recruitment and outreach programmes, and also to give us an understanding of NCEA preparation. The second focusses more on their experiences during their first year at Victoria University.

What was concerning, and a factor that informed much of this paper, was that in 2010, in response to the question whether we were meeting {All, Most, Some, None} of their expectations of engineering study, only 6.8% of students responded that we were meeting All of their expectations. Nearly 15% reported that only Some expectations were being met.

Delving in further to their experiences, we asked what courses they found the hardest for their engineering study. Overwhelmingly, the electronic and computer systems engineering students had problems with PHYS114, with qualitative responses indicating it was lack of adequate mathematics the compounded the problem. There was a correspondingly high response for MATH142 and MATH151. COMP103 also rated as being difficult. However, we recorded the results of Table I, indicating particularly in these mathematics and physics courses, that a completely unacceptable number of students were failing to achieve the B grade threshold. Particularly for the Electronic and Computer Systems engineering students, the requirement of all of MATH141, 142, 151 and PHYS114, 115 meant that very few were gaining the overall B grade GPA over their required first year courses.

TABLE I. STUDENTS NOT ACHIEVING B GRADES BY COURSE

	% scoring < B grade
MATH141	85
PHYS115	67
MATH151	63
PHYS114	62
MATH142	59
MATH161	46
COMP103	45

Student engagement in social activities was more difficult to determine. Students were asked to rate their engagement in student activities and clubs on a 10 point scale (0 – 9) [6]. There was a moderate engagement – means around 4.3 – 4.7 were recorded IF we asked in the first trimester. However, the repeat question asked at the end of the year indicated a decrease of 1.2 – 1.5 on these mean scores. We can infer that either the students were disillusioned with the activities of these clubs or that their workload increased which prohibited more active engagement.

However, qualitative responses to the question "what do you feel are the major weaknesses of the BE programme", yielded comments such as

> "*The first year I don't really feel like im studying engineering. Doing ENGR101 was good but after that its very dispoint" [sic]*
>
> *"It almost feels as though we are not doing engineering degrees in the first year due to the large amount of non engineering (math) papers involved"*

These results did give us much to work on.

V. ENGINEERING ENGAGEMENT

Engineers are not the same as scientists.

This is an extremely important distinction that can be easy to forget, or at least to prioritize. The Washington Accord accreditation criteria emphasize this difference, and most practicing engineers would probably have their own definition of the difference. However, a trap we fell into is to assume we can rationalize resources by sharing "the enabling courses" with science students. This was reflected in the student quotes from the previous section. Specifically, upon consideration of section II, this programme of first year study does not look dissimilar to that of a first year science student. In fact, only ENGR101 and (for software engineering students) SWEN102 were unique to engineering.

It is fair to say that the architects of this initial programme (which included the primary author) were a few decades out from their own undergraduate experiences, and saw this as an acceptable approach that utilized existing courses whilst providing the students with the necessary content to progress in engineering.

Our first few years of student surveys revealed the flaw in this approach. The students wanted to come to university to study engineering, and with an attitude that others have found to be typical of the "millennials", they wanted immediate gratification of this desire. A first year filled with enabling material was not satisfactory. Many were not prepared to wait even until second year to engage in "real" engineering. In these first years, we lost students who had performed well – and had achieved the minimum GPA. We lacked the resources to track these students and to provide an exit interview – we only discovered they had left when they did not enroll in the following year. However, guided by the student surveys, it was clear that these students wanted to immediately engage in what they perceived as "real engineering activity and study".

The specific factors that students identified were:

- The courses were science courses, not engineering
- They felt alone and isolated – courses and social activities were dominated by science students
- The mathematics was irrelevant
- The physics was too hard

Section VII details the (very successful) strategy that we engaged in to solve the mathematics perception problem. Section VIII details the (unsuccessful) strategy we employed to solve the physics problem (we do not think the material is too difficult, rather it presented out of context for an engineer).

To address the first point, we acknowledged that indeed, in the first year of the degree, engineering students were being lumped in with science students, often in 7 out of their 8 required courses. Only software engineering had a course for engineering students that ran in the second semester. This meant that there was no course, or activity, that brought all engineering students together in the second half of their first year. To remedy this, we removed the SWEN102 course, and replaced it with an ENGR110 Engineering Modelling and Design course to be taken by all of our engineering students in 2014. Not only did this course bring all the engineering students together, but it also endeavored to reinforce mathematics and physics material in an engineering context. The course has received mixed reviews from students, however holistically, the introduction of this course did have the desired "coming together" effect.

We also made substantial changes to ENGR101 [3][7][8] informed by literature studies in particular [9-15]. We changed the course from being a content driven, introduction to technology course, to more of an engineering skills course. The course cumulates in the students working in groups to construct a mobile robot that must compete in an Olympiad of events (such as sprint racing, drag racing, weight lifting. Not only is this fun (as reported by the students), it satisfies the student expectation requirements – that is, they get to design and construct an actual artefact – the core of engineering. Having to compete in this Olympiad also introduces another core aspect of engineering – design compromise. The students cannot design their robot only to excel in (say) speed. It must be able to successfully compete in all events. We also changed the course so that the introductory lectures covered transition issues from secondary school to tertiary study. Again, this was motivated by the lack of preparation the NCEA system was providing these students. Specifically we cover the development of study skills, the inability to "play" our system (as they did at secondary school where they could elect which parts of a course they would be assessed in), and also that regurgitation was not valued.

VI. Engineering Belonging

Although providing a course that immediately met student expectations of engineering study (ENGR101) and ensuring that there was a dedicated course to again bring all of the engineering students together in semester 2 (ENGR110), we realized that as this was a new programme, engineering students were struggling to find their identity. This situation is compounded by the reputation many engineering institutions have of a very active student engineering group – often involved in high-profile pranks or social activities. Given that our student cohort is very strongly male (an issue that we are still endeavoring to rectify – as are very many institutions in the Western World), this lack of an active social environment was disappointing.

This was something that we could not completely solve as academics, but nevertheless, we could help mitigate. Short of the ethically dubious, and university prohibited action of providing endless quantities of beer and pizza, we elected instead to promote an engineering identity by providing all students with a free engineering tee-shirt (Fig. 1). Students could optionally purchase (at cost) a similarly designed sweatshirt (hoodie). This simple action was extraordinarily effective. It is very common to see many students wearing these shirts, not only at university, but throughout the city as well. Indeed Faculty staff are often seen wearing them too. We liken this effect to that of supporters of a sporting team wearing their "kit". It identifies you as belonging to that group with the camaraderie and social acceptance that this brings. Of course we also provided some financial support to an engineering student group – that primarily runs gaming LANs and similar events – this is probably standard for any engineering teaching institution. However, it was the adoption of this "uniform" that seems to have had a profound effect on this sense of engineering identity and belonging.

Fig. 1. The VUW Engineering "Uniform", teeshirt on the left, hoodie on the right.

VII. Mathematics

From section II, all of our engineering students must complete one or more first year mathematics courses. However, as discussed in section V, mathematics was overwhelmingly rated as the course(s) that students self-rated that they struggled most with and felt least prepared for. It is tempting for us to blame a large part of this on the secondary school assessment criteria (section III), but we also noted that these millennials have different expectations than students of several decades ago. In the primary author's direct experience, it was not uncommon for lecturers to historically instruct their first year class that "you will need to know this for the engineering problems you'll face in year 3 or 4". And it was true. However, the same approach does not work with many of our modern students. If they do not immediately understand the context of the topic they are studying, many do not engage. Remembering that a B average GPA is required for these students to progress, any lack of engagement in these mathematics courses risked the students failing, or perhaps achieving a low passing grade that reduced their GPA below the threshold of 5.0 for continuation in the engineering degree.

A more in-depth exploration of this certainly did confirm that engineering students saw little relevance in learning proofs, axioms, corollaries etc. that are essential topics for a mathematics major. Instead they wish to use mathematics as a tool to solve their engineering problems. This attitude was apparently quite widespread amongst our first year student cohort, particularly for the Electronics and Computer Systems engineering students who were not only required to engage in the MATH142 Calculus class, but then had to almost immediately apply that learning in their two physics courses. Potentially, these students had three mathematics (MATH141, 142, 151) and two physics course grades suffering from poor engagement. This was having a major impact on our retention rates, even from students who had attained "Merit" or "Excellence" grades at secondary school

So serious was this problem that we engaged in a complete overhaul of our first year mathematics courses [16]. Realizing that mathematic majors still required the content and style of delivery of the existing courses, but that engineering students required something very different, we created 3 new engineering mathematics courses. ENGR121 replaced MATH141, ENGR122 replaced MATH142 and ENGR123 replaced MATH161.

We did not endeavor to lower the difficulty level of these courses, rather to present the mathematics material in context. We even went so far as to include laboratories, sometimes including robots, to reinforce the topics. For example, robots of different speeds are provided, and through vector addition the students need to position and orient them so that they will intercept each other.

Comparing to the historical curriculum of Section II, the revised programme structure was now:

For ALL engineering students

- ENGR121- Engineering Mathematics Foundations

Electronic and Computer Systems engineering students additionally require:

- ENGR122 – Engineering Mathematics with Calculus

Software and Networking now additionally require:

- ENGR123 – Engineering Mathematics with Logic and Statistics

This structure has the added bonus of a common course in introductory mathematics for all majors, making it easier for students to change major if they wish. Students who might wish to pursue higher level mathematics are still free to select the original mathematics offerings if they wish (since the ENGR courses are not accepted as a prerequisite for many higher level mathematics courses), but very few select this option.

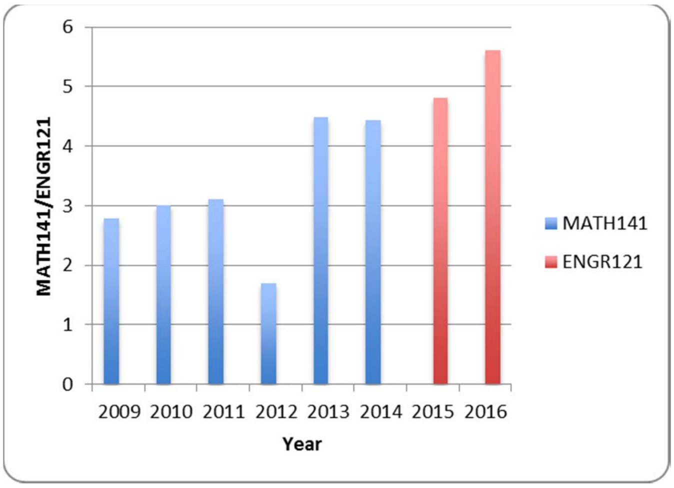

Fig. 2. GPA of MATH141 vs. ENGR121

The results have been extremely pleasing. Fig. 2 shows the histogram of engineering students' GPA in MATH141 and its replacement ENGR121 over the last 8 years. Remembering that the GPA level of 5 is the threshold for continuation, we can see that even in this introductory course, the average grade achievement (for engineering students) in this course was substantially well below this threshold. It is also interesting to note the significant dip in 2012 that corresponded to a change in the lecturer of the course. However, even in the first offering of ENGR121, the highest GPA ever was achieved, and for the second iteration (as teaching style improved and the laboratories were refined), there was a substantial increase. These improvements are highlighted further in Table III discussed in section IX.

This effect is even more apparent for the calculus MATH142 class (Fig. 3).

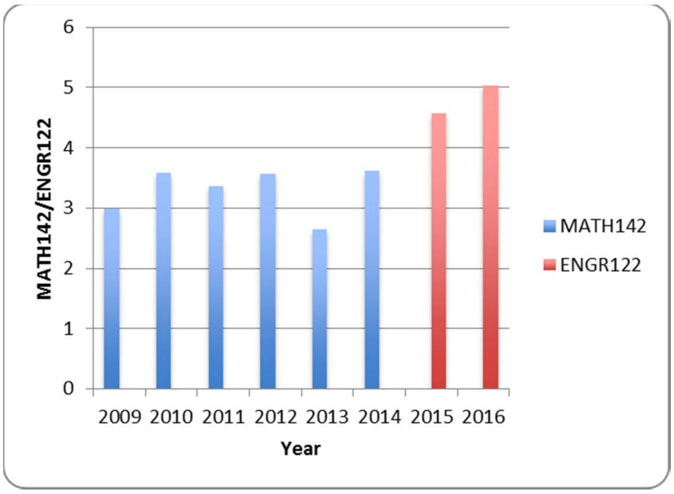

Fig. 3. GPA of MATH142 vs. ENGR122

To quantify the effects that these changes have had on student retention and progression is difficult given that multiple interventions were enacted and it is almost impossible to isolate the effect of a single variable. However, on-going student surveys (asking the same questions as previously), no longer yield a predominance of issues with the mathematics courses (121,122). We consider this to be a substantial success.

VIII. PHYSICS

Noting the issues with mathematics, as previously discussed, there was also a clear problem with the physics engagement. Again, the courses of PHYS114 and PHYS115 were the first year courses required of physics majors, and our initial assumption was that this would also serve the Electronic and Computer Systems engineering students. However, as indicated in Fig. 4, the average grade for engineering students in PHYS115 never rose above 3.0. This, combined with the scores in MATH141 and 142, resulted in an unacceptable 60% attrition of these students after their first year.

To mitigate this, we endeavored to mimic the actions we were taking with the mathematics courses, that is, to design a physics course with an engineering context; ENGR142. However, there were some fundamental differences in how we approached this. First, engineering staff did not directly contribute to the teaching, either of the lectures, or of the supporting laboratories. Second, the School of Physics, in an attempt to rationalize resources, co-taught half of ENGR142 with the existing PHYS115. So over half the content of the course did not change, and that half that did, was presented without significant input from engineering staff. As Fig. 4 illustrates, this has not been successful. In fact in the first offering of the course in 2015, engineering students scored their lowest GPA to date.

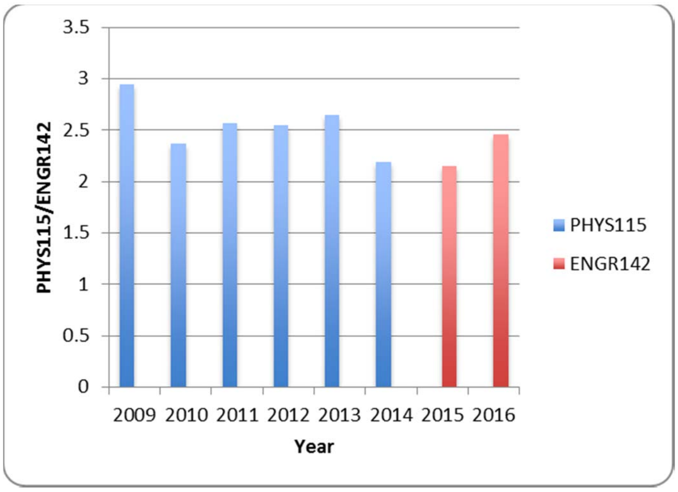

Fig. 4. GPA of PHYS115 vs. ENGR142

We now understand the reasons for this, and motivated by a new major in sustainable energy being offered in 2018, we have more fully engaged with physics for a massive overhaul of the ENGR142 course, and extending this to a bespoke introductory physics course in the preceding trimester, ENGR141.

To conclude this section, the authors do want to reiterate the relationship of sections VII and VIII to the paper title. Although there are necessarily some changes to the content of these ENGR courses (especially compared to the pre-existing MATH courses), there was no attempt to dilute the complexity of the material. It was the context of presenting the material that changed, not the academic expectations of student ability or preparedness. We firmly believe that it is the student attitudes of willingness to engage that have effected the changes in the mathematics scores, and (we hope) eventually in the physics scores.

IX. Results

To reiterate, none of the actions detailed in this paper have significantly altered the academic difficulty of the material being presented. It is true that some content has been lost as other content is being emphasized in the mathematics courses, and some second year courses have had to adjust their material as a result. Given this, it could perhaps be argued that this has catered for the less academically able (or prepared) student. The authors don't completely refute this statement, but claim that it is the student willingness to engage with the material, and to feel part of an engineering cohort that has been the substantive change.

As mentioned previously, it is not possible to isolate the effect of each of these changes since many occurred at approximately the same time. Holistically, we have three indicators of overall success.

1. Changes in student survey results
2. Changes in the number of students achieving the minimum GPA and progressing in engineering study
3. Changes in the overall retention of engineering students, particularly between years one and two.

To gauge how well we were now meeting students expectations, Table II below shows the change in student responses to the question whether we were meeting {All, Most, Some, None} of student expectations of engineering. It is clear there has been a steady increase in students stating that all of their expectations were being met. As of 2016, only 3% indicate that only some, or none (0%) of these expectations were being met – down from nearly 15% in previous years. We consider this to be an excellent result.

TABLE II. Meeting Student Expectations

	% responses all students		
	2010	2012	2016
All expectations met	7	20	34
Most expectations met	78	66	63
Some expectations met	15	14	3
No expectations met	0	1	0

In section IV, qualitative student responses criticized the lack of engineering focus at first year. There have been no such qualitative responses recorded since we introduced the engineering mathematics courses and ENGR110. In 2012, PHYS114/MATH142 and COMP103 were rated as the most difficult courses (from qualitative comments). In 2016 this has completely changed, and now the most common complaints are for ENGR123 (it was felt that there was too much content in this), and PHYS122, the course Software and Network engineers are required to as an introduction to physics. Whilst not discussed in this paper, the main problems with this course were a perceived complete lack of relevance to the domain of engineering the students were studying, and a poor lecturer. This is being addressed for 2018.

Extending Table I to reflect 2016 data yields Table III below. We have made some extremely significant gains from MATH141 → ENGR121 and MATH142 → ENGR122. The increased mathematics seems to have also assisted PHYS114 pass rates. ENGR123 still requires work (as also reflected in the student qualitative survey), and ENGR142 is a failure. As an aside, it is interesting that some of our software engineering faculty members are accepting of the ~50% gaining below a B grade in COMP103 – they see this course as a gate-keeper to quality assurance in later years of the programme. Conversations on this issue are continuing.

TABLE III. IMPROVEMENT ON B GRADE ACHIEVEMENT BY COURSE

2013	2013 % scoring < B grade	2016 course equivalent	2016 % scoring< B grade
MATH141	85	ENGR121	32
PHYS115	67	ENGR142	81
MATH151	63		
PHYS114	62	PHYS114	27
MATH142	59	ENGR122	31
MATH161	46	ENGR123	46
COMP103	45	COM103	51

Finally, student indicators of activity in engineering social events have not significantly increased, with consistent means scores (now on a 1 – 10 scale) still around 4.5. However, in response to feeling part of the engineering community at Victoria University, the mean response is 6.9 with only 13.5% of the students recording a score below 5. The mode response is 7.

X. CONCLUSION

We have obviously been successful in helping the students to generally engage more in mathematics that is essential to an engineering programme. ENGR121 and 122 in particular have been successful, ENGR123 less so. This has had a flow-on effect into PHYS114 engagement, but we have failed to reproduce this success in the engineering physics course, ENGR142. The reasons for this are known, and are primarily due to a lack of concrete engagement from engineering faculty staff. We have increased student satisfaction in terms of meeting their expectations, and the number of students achieving the threshold B grade has significantly increased.

Actual retention data is difficult to analyze given we have experienced growth of 14.8% in 2016, and tracking to a further growth of 15% in 2017. Many of these are new students – of an even more diverse academic background. 36% more students achieved the B GPA threshold in 2016 than in 2015, but again these figures are influenced by increased enrolments.

There is still work to do. We are engaging in a massive overhaul of ENGR141, and we need to engage better with mathematics for ENGR123. We also need to work on staff expectations around the COMP103 course. However, we believe that we have made significant progress, and our 2017 curriculum is now very much a modern first year engineering one, rather than science with an engineering course included.

REFERENCES

[1] C.E. Davis, M.B. Yeary, and J.J. Sluss, "Reversing the trend of engineering enrollment declines with innovative outreach, recruiting and retention programmes," IEEE Transactions on Education, vol. 55 (2), pp 157 – 163, May 2012.

[2] L.E. Bernhold, J.E. Spurlin, and C.M. Anson, "Understanding our students: A longitudinal study of success and failure in engineering – with implications for increased retention," Journal of Engineering Education, pp 263 – 274, July 2007.

[3] D.A. Carnegie, and W.N. Browne, "Factors that affect the Design of a Successful Engineering Programme: A case study," Proceedings of the 5th IEEE Global Engineering Education Conference, Istanbul, Turkey, pp. 1399 – 1404, April 2014.

[4] D.A. Carnegie and C.A. Watterson , "Issues of recruitment and retention for a new engineering provider," Proceedings of the 43rd Frontiers in Education Conference, Oklahoma City, Oklahoma, pp. 665 – 671, October 2013.

[5] D.A. Carnegie, C.A. Watterson, P. Andreae, and W.N. Browne, "Prediction of success in engineering study," Proceedings of the 3rd IEEE Global Engineering Education Conference, Marrakesh, Morocco, pp. 57 – 65, April 2012.

[6] D.A. Carnegie and C.A. Watterson , "Increasing student retetntion and success: Survey Results and the success of initiatives to create an engienering student community," Proceedings of the 2nd IEEE Global Engineering Education Conference, Amman, Jordan, pp. 191 – 200, April 2011.

[7] D.A. Carnegie, C.A. Watterson, W.N. Browne, J. MacKay, M. Lock, J. Williams and M. Forret, "Strategies to improve engineering retention," Proceedings of the 3rd IEEE Global Engineering Education Conference, Marrakesh, Morocco, pp. 101 – 110, April 2012.

[8] C.A. Watterson, W.N. Browne, and D.A. Carnegie, "Steps to increase student engagement and retention in first year engineering," Proceedings of the 2nd IEEE International Conference on Teaching, Assessment and Learning, Bali, Indonesia, pp. 1 – 6, August 2013.

[9] M. Thomas *et al.*, "The transition from secondary to tertiary mathematics education," Wellington: Teaching and Learning Research Initiative, 2010.

[10] Richard M. Felder, & Linda K. Silverman, "Learning and Teaching Styles In Engineering Education," *Engr. Education*, vol.78, no.7, pp.674–681, 1988.

[11] Richard M. Felder, and Joni Spurlin, Applications, Reliability, and Validity of the Index of Learning Styles, *International Journal of Engineering Education*, vol. 21, no. 1, pp.103-112, 2005.

[12] J. Clark *et al*., "Border crossing and enculturation into higher education science and engineering learning communities", *Research in Science & Technological Education*, vol.26, no.3, 2008, pp.323 –334.

[13] T. J. Parkinson *et al*., "Engaging Learners Effectively in Science, Technology and Engineering: The pathway from secondary to university education," Ako Aotearoa, New Zealand, 2011.

[14] C. Woodhead, A Desolation of Learning-Is This The Education Our Children Deserve?, Pencil-Sharp Publishing Ltd, 2009.

[15] B. S. Bloom, Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. David McKay Co Inc, 1956.

[16] C.P. Moore, C.A. Watterson, and J.A. Eldridge, "Practical laboratory classes to improve engagement and achievement amongst engineering students taking first-year mathematics," Frontiers in Education Conference, pp 1 – 7, October, 2016.