Te Whatu Kairangi

Name of nominee(s): Professor Richard Easther

General Award - Innovation in learning, teaching, and curriculum

Word count of nomination: 3715 + 301 (Hosking)+200 (Greenwood)+241 (Richards) **[Total 4457]**

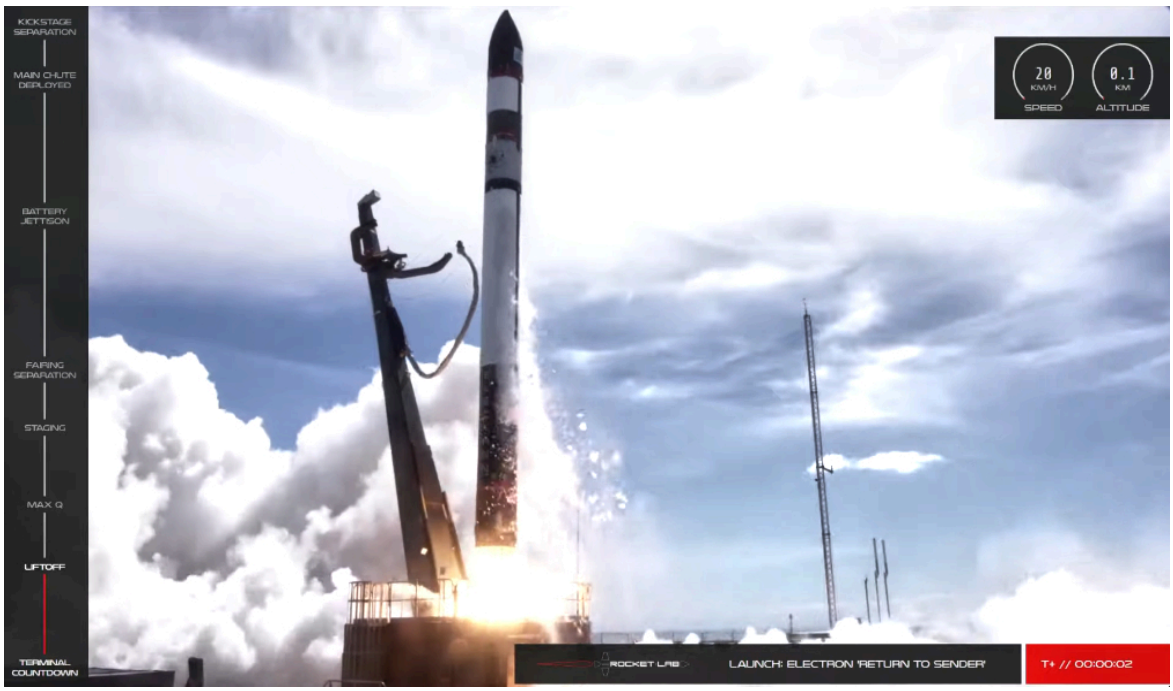
Duration of any audio or video included: N/A

Overview

As a kid I wanted to study the stars and the three decades I have spent exploring the origin and evolution of the Universe is the fulfilment of that childhood aspiration. However, a child's imagining of science differs from the adult reality. As a teenage consumer of scientific biography I learnt that university employment is a key milestone for an aspiring scientist (or at least the kind of scientist I aspired to be) but the teaching component of these roles was not a big part of those narratives. Since then, my journey as a scientist, a teacher, a communicator, and as a leader, has convinced me that contributing to the learning and understanding of others often does more to advance our fields than our personal research.

What happens in our classrooms is ours to shape. At the University of Auckland we rebuilt our physics programme from the ground up, including the introduction of "studio" physics in place of lectures in core Stage One courses. We improved performance and progression through the undergraduate degree and built a better framework for a rapidly growing PhD student population. We deepened engagement with Te Tiriti, strengthened support for Māori and Pasifika students, and became the first academic unit in New Zealand to gain a formal equity certification.

In the wider University context, I co-created Science Scholars, a nationally unique, faculty-wide scheme providing support, mentoring, and research opportunities to students pursuing science-based careers which inspired further programmes across the University. Thanks to my involvement with the Auckland Programme for Space Systems, I had a role in the first satellite to be built (outside Rocket Lab itself) and launched to orbit from New Zealand. Beyond the University, I developed major science communication initiatives in both New Zealand and Australia.



Electron rocket carrying student-built payload APSS-1 into orbit.

Stage One students in studio course

Teaching Leadership: Physics [Criteria D]

Arriving at the University of Auckland in late 2011 after being recruited to the role of Head of Department in Physics, I saw that the programme faced complex, interrelated challenges. The offering had evolved in response to mutually inconsistent requirements, and lacked coherence and structure. Concerns about falling numbers had prompted the dilution of prerequisites but there was scant support for underprepared students.

In 2013 I used an external review to generate momentum for change, ensuring that the panel included individuals with expertise in Physics Education Research and reputations for plain speaking. The visitors' opening gambit was to ask us what we would tell a prospective student who wanted to know why they should study physics at Auckland. There was an awkward, lengthy silence.

In the wake of the review, I convened Century Two, a working group charged with reassessing both curriculum and pedagogy. It operated separately from our regular Teaching Committee; everyone was welcome to join and participation grew as the effort progressed. The project's moniker arose because 2014 was the Department's 100th anniversary as a standalone unit. This framed its work as a birthday present to the Department from itself, building a fit for purpose undergraduate offering as we began our second hundred years. The goal was not to remediate shortcomings but to ensure the best outcomes for students and for the field, so we could say:

The University of Auckland provides a world-class physics education in an inclusive learning environment where all students realise their potential, developing quantitative, communication and collaborative skills that support their future success.

Studio teaching space, University of Auckland

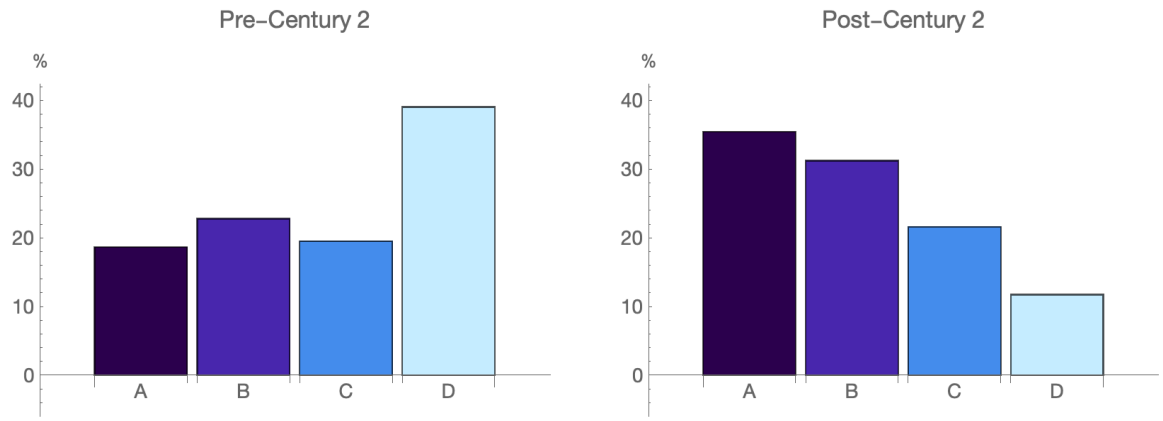
A key leadership challenge is summed up by the aphorism "Don't tell me what you value, show me your budget, and I'll tell you what you value." Century Two was supported by committed resource; we used buyout funds generated by research success to recruit a Physics Education Research specialist and staff with lead roles in Century Two received workload credit. Our efforts were thus research-informed; the Department supported two staff members through Postgraduate Certificates and we ran all-hands sessions on the research literature, looking at local and international models.

There is broad international consensus on the core content of an undergraduate physics major. Delivering this underwrites the intellectual coherence and credibility of a programme, supports students seeking advanced study, and facilitates international student recruitment. However, the schema rests on a first-year "physics with calculus" sequence requiring more high school preparation than many New Zealand students receive. We were determined not to exclude students lacking this background, many of whom are in key equity groups. This challenge was addressed via top down design, and the principles of constructive alignment were vital to Century Two.[1] [Criteria B,E&F]

Specific solutions included:

- Multiple entry points, appropriate to varying high school backgrounds, with data-driven guidance on the preparation associated with success at each entry point. This includes a "three-semester Stage One" option for less prepared students that retains a three-year path to graduation.
- Core Stage One courses offered in both semesters, increasing flexibility for students.
- A core curriculum at Stage Two with clear prerequisites in Physics and Mathematics.
- Key mathematical topics included in core Stage Two courses.
- Clear pathways in geophysics, medical physics, photonics, theory, and astrophysics.

[1] E.g. Biggs, *Enhancing teaching through constructive alignment*, Higher Education **32**, *347–364 (1996)*



Combined grade distributions for 200 Level "core" courses, before and after Century Two. Data from the four prior and two years post-Century Two (pre-Covid).

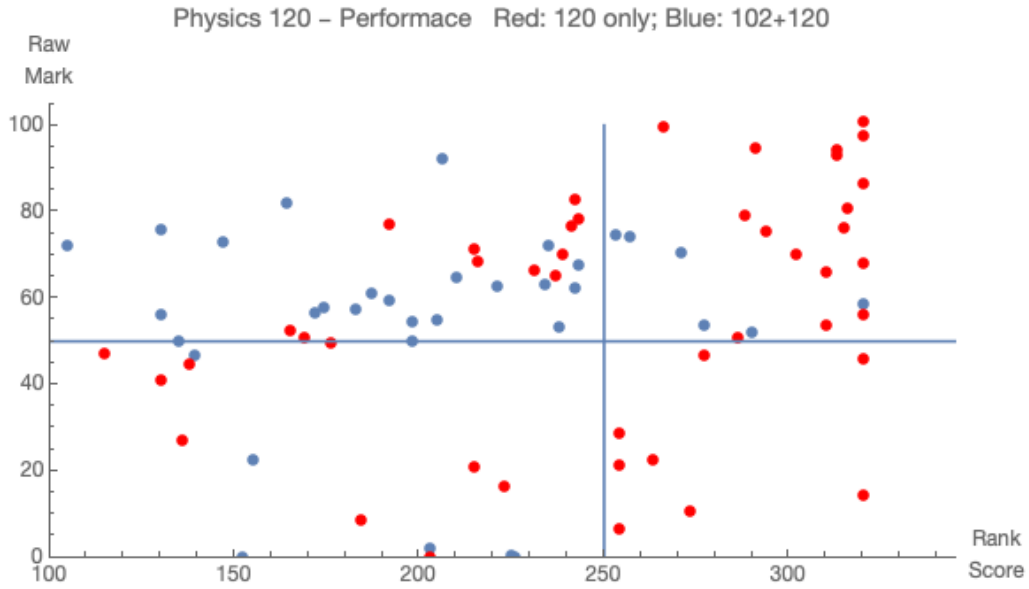
Student engagement was at the heart of Century Two. [Criteria A&B] Pedagogically, by far the biggest step was the introduction of Studio Physics at Stage One, replacing traditional lectures with active learning.[2] We completely overhauled our junior laboratory to create a dedicated 120-seat learning environment, requiring liaison with multiple university units, including Property Services, audio-visual experts, accountants, timetabling, Faculty Academic Committee, and outside acoustics consultants. I took responsibility for these relationships, seeing that they were crucial to success.

Concurrently, we added weekly tutorials at Stage Two, regular problems sessions at Stage Three, and opportunities to present and undertake independent investigations at Stage Four. The programming language Python is now standard across the department, with numerical problems introduced at Stage One, enhancing student acquisition of computing experience. The innovations in pedagogy, format, delivery and assessment were rolled out after two years' preparation (including the construction of the Studio teaching space) from 2017-19 touching every course in physics.

The biggest quantitative improvements in performance are at Stage Two, as illustrated above. The redesigned programmatic structure slashed an unacceptable failure rate. The average passing grade also rose; C grades previously outnumbered A grades; post-reform the opposite is true. Grades need not reflect learning (especially with changes to both curriculum and assessment) but students are demonstrating mastery of more challenging content than previously. [Criteria A]

We successfully transitioned to Studio delivery at Stage One. The results of the studio courses were initially comparable to their lecture-based predecessors but we are now seeing significant improvement in the pass rate in PHYSICS 121, the gateway to 200-level courses. The programme has produced clear improvements in problem-solving and group work.

[2] Developed at NCSU and brought to international attention after adoption by the Massachusetts Institute of Technology. See, e.g. Beichner, Robert. *The SCALE-UP Project: a student-centered active learning environment for undergraduate programs*. White paper for the National Academy of Sciences (2008).



Outcomes in PHYSICS 120 (the first course in the two-semester calculus-based sequence), in Semester 2, 2021. Blue points denote students on the "three semester Stage One" track; red points are students on the standard pathway. Students with a rank score below 250 are much more likely to pass PHYSICS 120 if they have previously taken PHYSICS 102, validating the hypothesis underlying the "three semester Stage One". [Numbers from single semester to control for Covid-related variation.]

Studio teaching (and flipped classrooms generally) challenges student expectations of university study and require teaching staff to develop new skills. We have built a core group of expert Studio teachers and our programme receives great reviews and; recent student feedback includes[3]

> *The "Lectorial" style of teaching was very helpful for collaborating with students as well as learning the content.*
>
> *The way that this course was taught in the studio was exceptional. The interactivity and discussions really helped in developing a greater understanding of each concept and how to use them.*

One surprise was that the "three-semester Stage One" track was avoided by many students unprepared to leap into a calculus-based course, with predictable consequences for their success. The eventual solution was simple: we identified that these students aspired to transfer to the Faculty of Engineering whose guidance to students needed modification to reflect our programmatic change. This simple fix emphasises the importance of understanding drivers of student behaviour and avoiding perverse incentives in programmatic design. Following the tweak to the Engineering requirements we saw a large increase in enrolment in the precursor course (PHYSICS 102) and the expanded cohort achieved strong results in 2020 and 2021. This change coincided with the Covid pandemic but we are optimistic that we are cracking a long-standing challenge for quantitative STEM subjects which is key to the success of priority learners in these disciplines. [Criteria B&D]

[3] 2021 reviews, Physics 120, Semester 2 (Primarily in-person)

For me, one detail that summarized the move to active learning was that the original heavy rectangular rimu lab benches (part of the building's original fit-out) were re-purposed into round tabletops for the Studio teaching space. Beyond the lived commitment to sustainability, this room is now the heart of our programme. All undergraduate Physics students pass through this space and beyond its immediate pedagogical value Studio is building a cohesive cohort. Stage Two tutorials are delivered in the Studio space and collaborative learning strategies instilled at Stage One are clearly enhancing learning outcomes in later years. [Criteria A,B&F]

Much teaching innovation is undergraduate-focussed. However, during my Headship the PhD population grew fivefold (from 12 to 60), reflecting the Department's simultaneous research success. I recognised that this cohort deserved the same focus as our undergraduate programme, especially as most PhD students would no longer be known to most staff. As a consequence, we:

- Established regular "cohort seminars", focussing on developing community and imparting soft professional skills. Initially led by academic staff, these are now self-managed.
- Formalised celebrations of student success.
- Appointed a departmental PhD Mentor to assist students with concerns about supervision, bullying or harassment, and general wellbeing.

These initiatives helped the expanded PhD cohort survive its "growing pains" and remain well-integrated into the Departmental community. In particular, the Mentor initiative identified several students in difficult situations which could then be proactively addressed. [Criteria B&D]

Te Tiriti, Equity and Teaching [Criteria B,D&F]

On arrival I boosted support for the University of Auckland's Tuakana scheme in the Department. We recruited tutors with strong cultural competence and ensured that their work was integrated into Department's offerings, increasing engagement with Tuakana by physics students. A specific marker of progress was the appointment of Dr Kannan Ridings, who himself came up through Tuakana, as a Lecturer and lead of this programme in 2021, following the completion of his PhD.

More broadly, an Equity Working Group was established 2015, becoming a core part of the Department's management structure. It was instigated by a group of staff members (A-Prof Vanholsbeeck, and Drs O'Neale and McGoverin), a reminder that in healthy organisations good ideas come from everyone, and supported by my efforts to create an internal climate in which staff felt safe and empowered to advocate for equity issues.

The Working Group launched a conversation around gender, race, sexual orientation, and gender identity within the Department, both with regard to our professional lives and our teaching. In particular, it oversaw successful applications for Bronze (2016) and Silver (2018, 2020) Pleiades Awards.[4] These awards are not just a recognition of achievement but provide a framework within which equity issues can be identified and addressed. In particular, Pleiades includes a focus on student experience which we assessed with detailed surveys, hiring an external facilitator to run

[4] Run by the Astronomical Society of Australia and modelled on the Athena SWAN programme. Auckland Physics appears to be the first academic unit in New Zealand to have earned this type of certification.

focus groups with current and past non-male students. This process identified specific, actionable concerns which have supported ongoing continuous improvement.

Separately, I initiated an emphasis on equity outcomes in hiring; the proportion of non-male teaching staff has moved from around to 5% to close to 30%, a change with massive impact on the ability of the Department to recruit and support students.

Teaching Leadership: Faculty and University [Criteria D]

In 2014 I co-founded the University's Science Scholars programme with Profs Cather Simpson and David Williams. This Faculty-wide flagship aims to recruit and extend strong science students at the University, creating an "enrichment" programme across all disciplines in the Faculty.

Science Scholars was a first for New Zealand, incorporating features from programmes in the United States and Australia. It provides students with mentoring, exposes them to topics across the sciences, enabling them to think critically about the production of scientific knowledge, the relationships between Western science and Mātauranga Māori, the role of science in society, and the internal dynamics of the scientific community. On top of this, Science Scholars provided what we believe is a first-in-New Zealand opportunity for its participants to engage in for-credit undergraduate research, and mentoring and cohort-building are key to its design.

Science Scholars runs through the three years of the BSc and has now recruited nine cohorts of students, or close to 500 individuals, many of whom have had spectacular individual success. Their experiences have been strongly positive; to quote from students who have completed the programme:

> *It has given me greater enthusiasm for science in general, a greater understanding of some of the complex issues involved with science and greater confidence in my ability to contribute to science.*
>
> *The 3-year well-structured Science Scholars Programme has helped me understand what's going on around our world and what needs to be done. It inspired me to contribute to the world from a scientific perspective by not only educating future generations but also increasing public awareness and understanding of the problems we are facing, and ultimately make a difference in the world.*
>
> *It has had a tremendous positive impact and brought me closer to lecturers and other people which I would never have ever met or talked too without it!*

The establishment of Science Scholars was led by Prof Simpson; my role included input to the programme design, securing internal funding, recruiting teaching staff, and championing the programme across the Faculty. I participated in its governance, including a year as Director when I facilitated the inclusion of a significant "science and society" component in the First Year curriculum. I remain involved as a mentor, but my final contribution to the management of Science Scholars was establishing dedicated position for the Director, after which I wound down my own engagement.

Science Scholars has existed long enough to evolve and grow. A 2019 review clarified the presentation of the programme to high school students. As originally conceived, NCEA rank scores were emphasised to create a programme that was unabashedly elite. However, this had the

Students assembling “cubesat”.

unintended consequence of deterring applications from students who would benefit from the programme, and it has been repositioned in the light of this understanding.

Science Scholars motivated similar programmes across the University; the newer Arts Scholars programme mirrored our initiative and the Dean’s Leadership Programme in Engineering likewise drew on Science Scholars for inspiration.

I am a champion for the Auckland Programme for Space Systems [APSS], in which student teams compete to design small satellites (“cubesats”, 10cm on a side), with the best entry being selected for construction and launch. Mr Jim Hefkey (Engineering) is the driving force behind the APSS, which attracts participation from students across the university. I helped design the competition, secure funding, build a collaboration between Science and Engineering, and managed complex external relationships supporting the project. This included taking responsibility for the payload permit application — formal permission from the New Zealand government to launch an orbital spacecraft; perhaps the most exciting “paperwork” I will ever tackle.

The initial cubesat, APSS-1, was launched into orbit by Rocket Lab on November 16, 2020. Despite running into technical issues it was the first satellite built and flown by any New Zealand organisation outside of Rocket Lab itself, a milestone for the University and the country.

The APSS has reached hundreds of students and has been a life-changing opportunity for some of them, and positive outcomes include the creation of three separate start-up companies. Separately, APSS was a foundation for Te Pūnaha Ātea|Space Institute, a major effort by the University to engage with the opportunities provided by space. I led the formation of TPA|SI, and served as its initial, interim Director.

Nanogirl show, Auckland Town Hall

Teaching Leadership: Science Communication [Criteria D]

Beyond the University, I am deeply involved with Science Communication as a practitioner and facilitator. I provided science advice for all episodes of the TV series *Nigel Blows Stuff Up* and was a consultant for Brisbane's successful bid to host the Australian offshoot of New York's World Science Festival, running annually from 2016 to the present.

In 2014 I instigated MoTAT's now-annual STEM Fair; to quote MoTaT director Michael Frawley

> *Richard was the founding father of the STEM Fair at MOTAT and his enthusiasm and enabled it to go from strength to strength and is now inspiring the next generation on innovators on an annual basis. The STEM Fair laid the foundation for a similar event in Tauranga.*

For several years I helped bring science-themed programming to the Auckland Arts Festival, including the first "mainstage" productions by Dr Michelle Dickinson's Nanogirl persona; as she says:

> *Richard played a critical role in helping to get the Nanogirl Live science show onto the big stage. Thanks to his efforts and support, the show is now an international success continuing to inspire young people across the world.*

Evaluation and Reflection [Criteria C&E]

When I first stepped into the classroom as an Assistant Professor at Yale University I was far better prepared as a scientist than a teacher. However, foreshadowing my task at Auckland, I found myself in a group of colleagues who engaged deeply with Physics Education Research as Yale was then revamping its undergraduate physics offering, leaning on approaches championed by leading

physicists Mazur[5] and Wieman[6], making quantitative assessments of active and peer learning initiatives with "before and after" testing via standardised tools, and introducing me to the formal study of pedagogical practice and curriculum design.[7] This has had an enduring impact on my own practice which recognises the important of learner interactivity, of peer to peer connections and the authenticity of the learning experience.

Very much inspired by Wieman, as a teaching leader in a field with a deep disciplinary identity my goal has been to apply the same that rigor to our teaching that we bring to our science – paying heed to the research, testing hypotheses, and being prepared to be surprised by what we find.

Learning is a fundamental human activity, and human beings are social animals: studying in an academic setting allows us to acquire knowledge and methodological strategies that were codified and organised by other human beings. We now live in a world in which brilliant lectures are available to all at the click of a mouse. However, my goal is always to build a community of learners rather than simply serving as a supplier of learning materials and opportunities. Active learning methodologies contribute to creating that community and are key to putting it to use. [Criteria D]

Academics often treat formal leadership as an encumbrance to avoid rather than a challenge to tackle with a skillset that can be acquired and polished. As with teaching, I found myself supplementing seat-of-the-pants leadership with active reflection, engaging with literature that solidified and informed my practice. I came to understand my strategy as *values-based leadership* – good leadership begins with knowing yourself and where you stand.[8] As a byproduct of our teaching reforms, Century Two developed leadership capability within Physics at Auckland. This is reflected in the current leadership team, all of whom (including the new HoD) had key roles in Century Two, further embedding the changes we made.

A marker of progress has been watching Physics become a role model for teaching and learning at Auckland. Likewise, both Science Scholars and APSS are now signature programmes for the University. Our work has been judged positively by our peers, as evidenced by the inaugural Faculty of Science Departmental Teaching and Learning Award in 2018 (right), awarded to the Department as a unit. Over the last decade, Faculty-level teaching awards have gone to Physics at a rate that is more than double our overall share of academic staff. Personally, I was the recipient of 2020 Faculty and 2021 University awards for teaching leadership.

For me, our response to Covid was a further and unanticipated test of our transformation. Century Two deepened the cohesion of the Department and our

[5] Eric Mazur, *Peer Instruction A User's Manual* - Prentice Hall Series in Educational Innovation (1999)

[6] Carl Wieman, *Improving How Universities Teach Science: Lessons from the Science Education Initiative,* Harvard (2017)

[7] David Hestenes, *Force concept inventory,* The Physics Teacher **30**, 141 (1992)

[8] Harry Kraemer, *From Values to Action: The Four Principles of Values-Based Leadership,* Jossey-Bass (2011)

engagement with the craft of teaching. This combination of expertise and *esprit de corps* carried us through the disruptions of lockdown. I have never been as proud to be part of a group as I was when we successfully grappled with the pivot to online teaching in March 2020.

At heart, I am still the kid that looked up at the sky and wanted to figure out how it worked. I find a strong resonance with the words of the University of Auckland's new strategic plan, *Taumata Teitei*, that "deep disciplinary knowledge is a critical enabler of successful collaboration." For me, my love of my personal corner of science is a platform from which I can support learning within my own discipline, my institution, and beyond.