HORIZONS 2020 TRENDS IN TECHNOLOGY EDUCATION

Signal
ICT GRADUATE SCHOOL

Martyn Rivett & Stuart Charters

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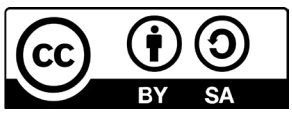

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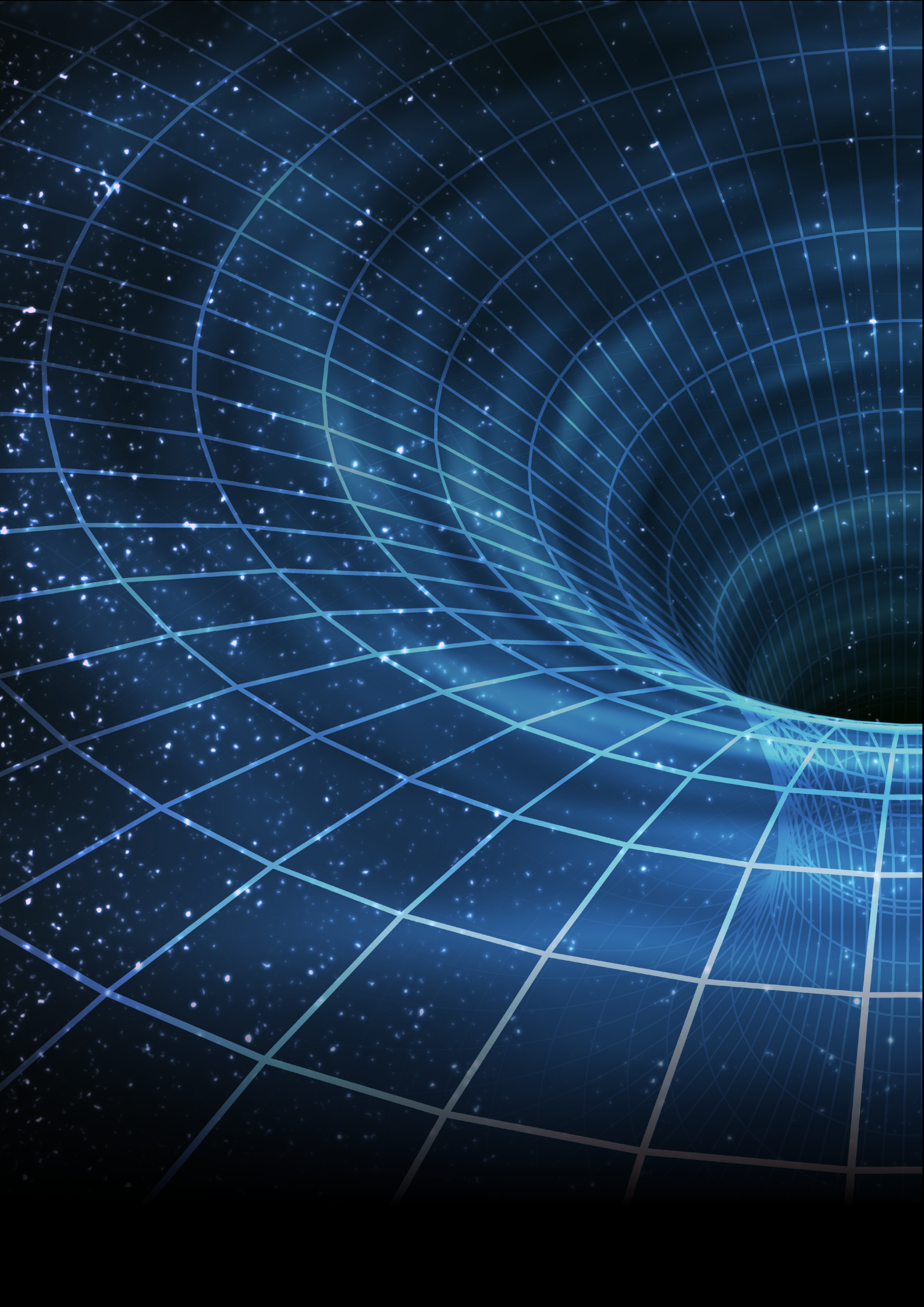
Contents



i. Preface

This main body of this document was created in the last quarter of 2019, when the global impact of COVID-19 was yet to be felt. Reflecting on our work in April 2020, it is sobering that tangled complexity a few short months ago now appears straightforward compared with what we will contend with over the coming months and years. While much is not yet clear, COVID-19 has brought many latent issues into painful clarity - and will force us to confront realities that we have pushed ahead of us for years.

As was the risk of pandemic itself, many of these issues are easily seen by those ready to look. For example, the report highlights glaring gaps between the needs of businesses and the skills and quantity of candidates entering the workforce from technical education, and identifies the dependence of NZ and other Western education systems on revenue from international students - and the risks should it dry up, as it has almost overnight. It also discusses the challenges of delivering valuable and responsive technical education in a complex technical and economic landscape in constant flux. These are not new issues, but they are much harder to ignore in our post pandemic future.

Fortunately, wielded well, technology cuts stronger for us than against us, and nowhere has this been more apparent than in the COVID response itself. Data and analytics have informed global action at every level, AI is accelerating the hunt for a vaccine and the world (and not least education institutions) is suddenly reliant on collaboration technologies and the internet, keeping the global economy on life support while the virus runs it's course. ICT is preserving relationships to keep the isolated sane, and filling gaps where out existing systems can't respond - many lives will be saved through the ingenuity of technical makers 3d printing ventilator components which can't be found on the open market.

When the dust settles on the 'new normal', it's not a stretch to suggest that businesses and individuals will look to technology to insure themselves against the risks and pain they have experienced. Businesses will build online routes to market, individuals and institutions will develop modes of working that deliver continuity and income in lockdown. Necessity is ever the mother of invention.

The unfolding events will drive a step change in demand for technical solutions and the skills to implement, operate and maintain them - and require a corresponding response from a technical education system which was already struggling to meet the needs of it's stakeholders. From a New Zealand perspective, we will no longer be able to rely on the option to import skills from offshore, making it all the more imperative for our ICT training to step up and match the ability of our rugby teams to build home grown talent.

The themes considered by this report - responding to technology developments, meeting the needs of businesses and students, creating responsive and effective education delivery and contributing to the social fabric - are no less relevant today than in the very different world in which they were originally considered - and arguably far more so.

Identifying problems is easy - but even before COVID-19 we were faced with the need to examine our assumptions, challenge the inertia of our systems and work to create adaptable, collaborative institutions capable of maintaining quality and trust as they adjust to changing needs. These conclusions stand up well as we look to a future where the few illusions of stability that remained to us have been swept away.

More than ever, the fundamental dependencies and interconnectedness of our systems has been made apparent - and as has always been the case, our ability to collaborate, adapt and evolve with the changing world around us will be the difference between success and failure.

ii. Executive Summary

This report represents an attempt to review the technology education landscape as of late 2019 and identify the key considerations and trends relevant to interested parties considering their own futures, the needs of their businesses, and the evolution of education institutions and services over the medium term - a timescale of years to decades. It considers the then current state of the education landscape in NZ and globally, reviews the dynamics in play in the near term future and examines feedback from direct Signal stakeholders across a range of areas.

Building on these sources, we conclude with a range of suggestions and observations in respect on the way forward from here. While 'here' looks rather different from a few months ago, the same structural issues remain, and as argued above, the COVID-19 event simply adds urgency to the need for solutions.

Technology education is faced with unprecedented challenges. The scale and scope of technology change being absorbed by the system, the unpredictability of uptake of specific technologies, and the rapid evolution of local and global markets would test even the most agile and skilled of organisations, let alone a regulated sector that has existed in a semi stable mode over the long term. Add to that the increasing pace of innovation, the rapid recent shift of technology from an enabler / resource role to a critical / core capability and the complexity of the issues created by these changes and it's not surprising that cracks are appearing.

And appearing they most certainly are. The world of work has changed, and technology education has not kept pace. Many indicators demonstrate a shortage of ICT skills to meet the needs of businesses, with the shortage of supply driving a steady increase in ICT salaries over a 30 year period - but counter-intuitively, higher education enrolment in NZ is flat to falling.

In many ways more disturbing is the fact that the graduates who are leaving ICT higher education are not equipped with the skills businesses need. The World Economic Forum has identified a core shift in needed skill-sets over the last 5 years:

in 2020	in 2015
1. Complex Problem Solving	1. Complex Problem Solving
2. Critical Thinking	2. Coordinating with Others
3. Creativity	3. People Management
4. People Management	4. Critical Thinking
5. Coordinating with Others	5. Negotiation
6. Emotional Intelligence	6. Quality Control
7. Judgment and Decision Making	7. Service Orientation
8. Service Orientation	8. Judgment and Decision Making
9. Negotiation	9. Active Listening
10. Cognitive Flexibility	10. Creativity

Figure 1. Top 10 skills in the future of jobs. *Source*: World Economic Forum

Meanwhile Deloitte describes the mismatch in stark terms:

> *"Millennials are simultaneously overqualified and under-skilled: Data from an OECD study reports that 15% of Australian graduates are overqualified for their jobs, working in fields which do not require a degree. Meanwhile, the World Economic Forum is advocating that traditional learning is leaving graduates without the skills they need to contribute in the workplace."*

These forces are changing the nature of a career. Deloitte indicates that the typical half-life of a technical skill is approximately 2 years, 44% of companies agree that their careers are less than 5 years and 60% of millennials think 7 months of tenure means they're "loyal".

This potent mix of technology and job churn is driving a critical need for lifelong learning for individuals, and an increased emphasis on adaptability, solution orientation and the people skills to co-create successfully in a changing workplace - and in turn this is driving the need for agility and flexibility in education provision. The ability to change has become a critical survival characteristic.

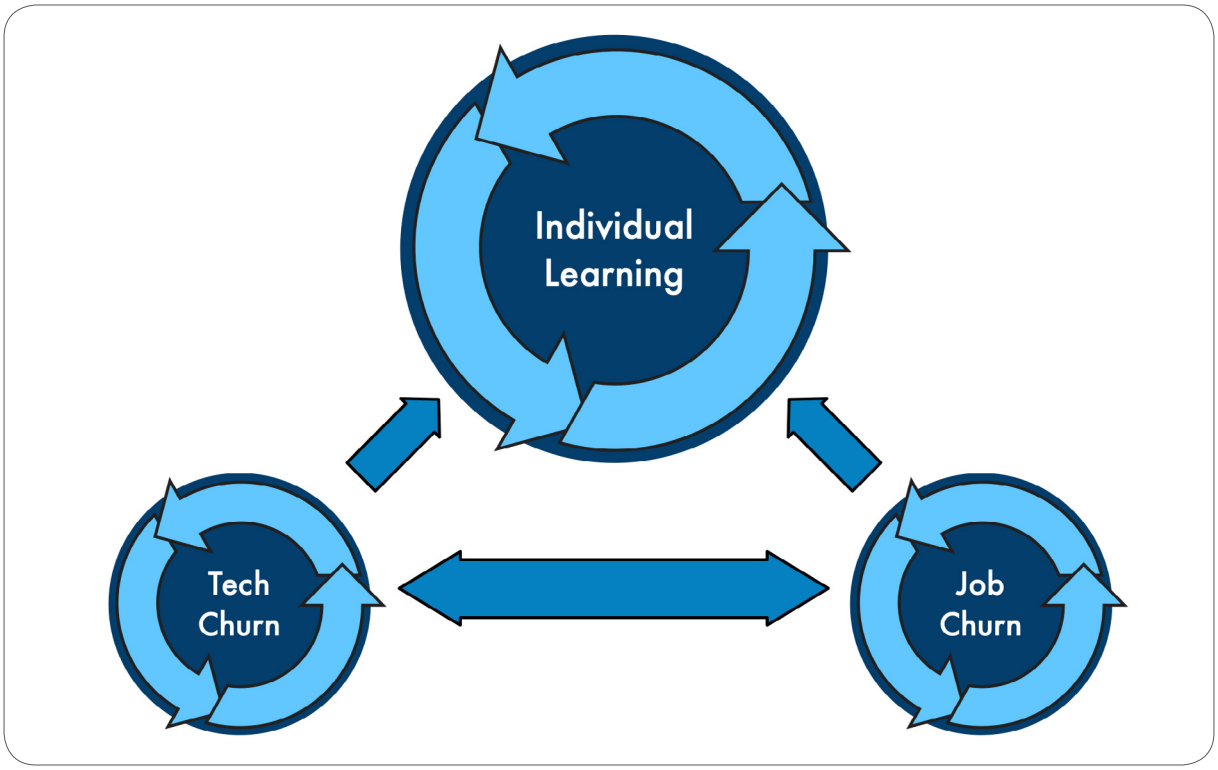


Figure 2. Dual disruption on lifelong learning

Unfortunately, identifying the problem is the easy part - finding the right solution is much more challenging. In producing this work we undertook a survey of stakeholders, and the analysis of the response underscores many of the issues outlined.

To conclude the discussion we offer suggestions on what a future system should seek to achieve - it will need to:

- Grow the foundational skills, confidence and mindset to support students as they continue to learn and grow themselves throughout their careers.
- Provide personalised learning supported by expert coaching and guidance.
- Be responsive to the developing technology environment and prioritise resources effectively towards the important developments.
- Educate students to be both technically skilled and effective interpersonal contributors.
- Creates responsible technical citizens.
- Maintain and grow technical skill-sets within the NZ marketplace and reduce the need for and expense of importing offshore skills.
- Focus on active, collaborative learning and practical, real world experiences, fostering fluency and real world capabilities.

Meeting these objectives in the data age will require us to re-imagine the role of the educator, moving ever further beyond traditional delivery and certification, towards challenging new roles:

- Curator and pathfinder to relevant, high quality content.
- Guide and sense maker to help students interpret and digest their learning.
- Business consultant, to help students to bring their learnings into real world work environments.
- Mentor and coach to assist when things are challenging.
- Motivator and challenger, to ensure students hold themselves to account.
- Networker and connector, bridging between students and businesses to make meaningful and valuable introductions for both.
- Agile optimiser, constantly assessing and improving content, tools, techniques and methods of delivery.
- Learning theorist, helping students to establish optimal learning skills and to manage the demanding task of maintaining focus in the modern attention economy.

These are not trivial tasks - Nevertheless, as learning culture continues to be driven by the evolution of technology and work, institutional evolution will be necessary for survival - and again, the organisations and societies who engage most effectively with the processes of change will come out ahead.

While it's not clear exactly what form this new system will take, it is clear that it will need to be one which can move with the times to balance the conflicting demands of stable quality and constant reinvention.

It's equally clear that technical competence is of critical national importance in the modern global economy - and if we can navigate these waters successfully the potential benefits for NZ are readily apparent.

Perhaps Technology Education is the new infrastructure?

1. Introduction

Technology and business landscapes are evolving rapidly, and challenge us to think carefully as we navigate the road ahead.

This report looks to the horizons of higher education, technology and the wider economy to consider some of the emerging themes and trends which will be relevant to educators, students and industry over the coming years. Its intent is to shine a light on issues and possible impacts and both provoke and support interested parties to consider their responses.

In many senses, the themes discussed are not new, and you don't have to look far to see the advancing impact of technology on education. The generation of students now entering higher education have never known a world without a widely available internet and the tools and opportunity to find the information they need on demand, at will.

Much has been said about how these forces are driving fundamental changes in education, but few more powerfully than Sue Suckling, who, then Chair of NZQA, told the 2016 Singularity University Australia NZ summit that "the era of qualifications as we know it is over".

Since then, the pace of change has shown no sign of slowing - on the contrary, the impact of technological progress is reaching ever further into our businesses, institutions and everyday lives, as the spiralling cycle of innovation creates "the next big thing" faster than even the most skilled IT professionals can keep pace with.

In this potent environment, the role of technology educators is more challenging and important than ever. As we educate the workers and leaders of an increasingly technical society, we must have the foresight to look to the future with open eyes and the courage to think honestly and carefully about the possibilities we find there.

Welcome to the Horizons 2020 Trends in Technology Education Report.

2. About SIGNAL

SIGNAL ICT Grad School is a collaborative undertaking between major higher education institutions in the South Island, delivering a range of graduate level information technology courses to students wishing to build their ICT skills and/ or increase the ICT focus of their roles.

SIGNAL works closely with partners in businesses and the wider economy to provide practical engagement opportunities for students and to ensure that the teaching and skills that it provides remain relevant. A vital channel for this is an active industry placement program, which forms an integral part of each student's course, matching students and businesses to deliver real world projects.

SIGNAL aims to do things differently, explore boundaries, test new approaches and deliver industry focused outcomes.

Within the core SHIFT program this is evident in a variety of areas: a studio approach to projects and a co-working space for students means they are free to leave project materials out as if in a professional work place. The SIGNAL workspace is embedded within a technology co-working hub, supporting opportunities for student - industry interaction, and the SIGNAL studio spaces are made available for industry events to further promote engagement.

The “in work, for work, at work” approach of XTEND, SIGNAL's professional development program, blurs this boundary again, acknowledging that study and work are deeply interrelated, each fundamentally impacting on the other. A focus on reflection in this program helps participants develop greater effectiveness in the workplace and develop skills supporting independent future learning. A consistent outcome for XTEND graduates is the discovery that time to reflect is not “idle” or “wasted” but an essential tool for the developing professional.

SIGNAL is a collaborative undertaking of:

3. About this report

The primary objective of this report is to explore trends impacting the SIGNAL ICT Grad School, based in the South Island of New Zealand. While this implies particular areas of focus, in reality many of the issues apply widely across industries, geographies and technologies. With that in mind, the report also considers general matters relating to technology higher education globally and in the context of the overall development of industry and society.

In his series "Non-Obvious", Rohit Bhargava describes trends as "observations on the accelerating present", and this report uses that definition as a starting point to consider the changes happening today which are likely to continue, accelerate, and impact SIGNAL's areas of responsibility. Given the scale and scope of the topic areas, this report remains high level, favouring scope and breadth over detail and depth.

To ground the discussion, SIGNAL undertook a small survey to investigate priorities between and within these key topics as seen by our direct stakeholders. Topics were grouped into five key areas, and each is discussed in turn in relation to a wider review of literature/viewpoints.

The areas considered are as follows:

1. **Tech Developments** - the evolution of relevant technology subject matter and the areas of priority for SIGNAL in considering where to focus its resources.
2. **Industry Objectives** - the needs and priorities of SIGNAL's industry partners.
3. **Student's Skills and Needs** - areas in relation to non-technical skills and capacities SIGNAL provides to students.
4. **Teaching and Service Delivery** - priorities in respect of the tools, methods and institutional capabilities SIGNAL needs to deliver on its mission.
5. **Developing New Zealand's Social Fabric** - considerations of a wider perspective on SIGNAL's position as an technical educator in an increasingly technologically driven global society.

In alignment with SIGNAL's core mission to augment the skills of graduates and "in career" professionals, the report prioritises matters related to the education of tech professionals, rather than wider issues of overall education - though in many cases these overlap. In recognition of the critical importance of meeting the skills requirements of industry we have also considered the ongoing feedback of our industry partners in compiling this report.

Before we look to the future, however, it is important to ground ourselves in the present and how we got here.

Kia whakatāmuri te haere whakamua
I walk backwards into the future with my eyes fixed on the past

4. The Changing Context of Education

In 2006, in what was to become the most watched TED talk of all time, the international advisor on education Sir Kenneth Robinson said:

"If you think of it, children starting school this year [2006] will be retiring in 2065. Nobody has a clue.. what the world will look like in five years' time. And yet, we're meant to be educating them for it. So the unpredictability, I think, is extraordinary."

14 years later, as those children traverse higher education and enter the job market, those words are more insightful than ever. The overall social and economic impact of technical progress is beyond the scope of this report, but in 2019 it is trivial to assert that the scale, significance and unpredictability of change has been, and still is, extraordinary - and it shows no sign of slowing. Figure 3 gives a sense of the dizzying pace of technology development, the complex interplay of issues and some of the possibilities to come.

Figure 3. More Scenarios Added to our Emerging Future.
Source: https://frankdiana.net/2019/11/19/more-scenarios-added-to-our-emerging-future/

As well as the obvious challenges this has created for educators trying to respond to the increasingly dynamic needs of student and employer stakeholders, one might hypothesise that such a volatile technological and social environment would increase the thirst for education. Oddly this does not appear to be supported by the facts – at least on high level examination. From a global viewpoint, education participation has been rising for decades, driven [at least in part] by increasing participation and duration of compulsory schooling and increasing participation in tertiary education.

In New Zealand however, as in many "developed" countries, participation rates have been relatively static for some time, with around 5% of the working age population studying for bachelors and higher degrees, with a level of variance by ethnicity.

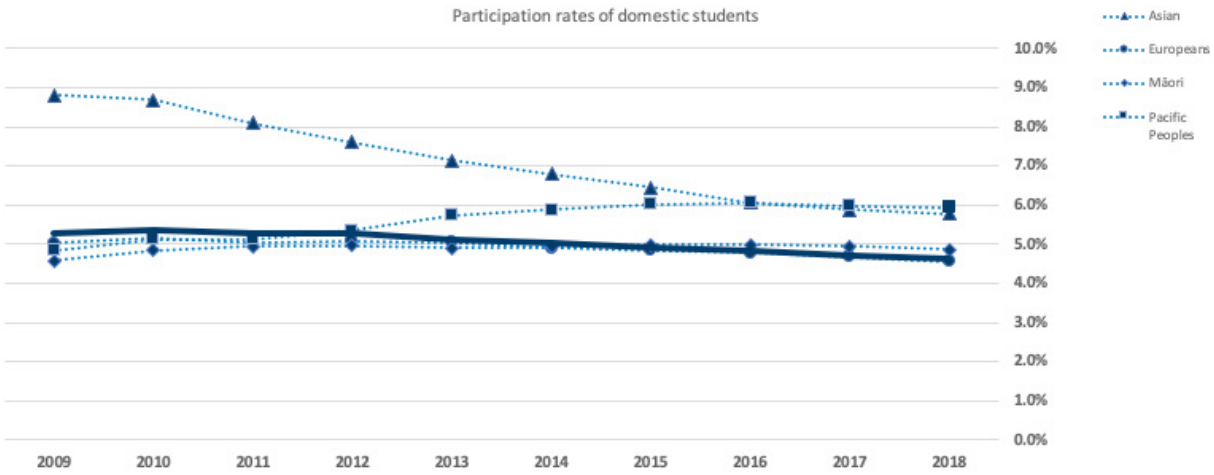


Figure 4. Student Engagement Participation. *Source:* https://www.educationcounts.govt.nz/statistics/indicators/main/student-engagement-participation/participation_rates_in_tertiary_education

The NZ Ministry of Education's 2019 Education Demand Forecast predicts this trend to continue, with forecast enrolment [in Equivalent Full Time Students] falling slightly in 2019 and then flatlining to 2023:

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Universities	115,670	114,860	115,350	114,230	115,440	113,910 (±2,750)	113,330 (±2,750)	113,390 (±2,660)	113,520 (±2,560)	113,530 (±2,490)
Polytechnics	55,200	54,450	53,590	51,090	50,140	48,520 (±2,890)	48,190 (±2,880)	48,760 (±2,780)	49,540 (±2,670)	50,120 (±2,600)
Bachelors degrees	111,580	109,000	108,210	106,160	106,180	102,530 (±4,830)	101,460 (±4,870)	102,140 (±4,850)	103,110 (±4,810)	103,700 (±4,790)
Lvl 8–10 postgrad study	28,410	29,270	30,490	31,040	31,980	32,550 (±1,050)	32,270 (±1,160)	31,390 (±1,010)	30,320 (±840)	29,430 (±750)

Forecast →

Table 1. 2019 Education Demand Forecast. *Source:* New Zealand Ministry of Education 2019 Enrolment Demand Forecast

Leaving aside speculation on the causes, this forecast creates tangible issues for education institutions. Given current funding models and budget pressures at a national level, some sector participants foresee ongoing pressure on institutional budgets. Even if budgets remain flat, it should be noted that these forecasts do not account for changes in, for example, the mix of subjects which students enrol in, which can generate significant administrative overhead.

In an attempt to maintain and grow institutional funding against this background of flattening or even decreasing (in real terms) budgets, many institutions turned to the growing international demand for education, and sought to recruit overseas, fee paying students. In late 2019[1] Education data provider Holon IQ estimated the that there will be seven million international students by 2030.

Sourced from HolonIQ's interactive visualisation of global student flows, Figure 5 gives an overview of recent student flows to New Zealand (left, at 11 o'clock), and which countries they have been coming from.

Figure 5. *Source:* HolonIQ's interactive visualisation of global student flows

[1] A pre-Covid-19 Crisis estimate.

While this approach has been a valuable source of additional revenue for many institutions, it potentially comes at a price. If we consider it as a "horizontal" approach – i.e. seeking new markets for existing product, rather than a vertical solution to develop new products to better fit consumer demand, it may be increasingly challenging to maintain unless the underlying service evolves to meet changing market needs.

Institutions also expose themselves to risks in changes in international volumes and the "brand value" of NZ as an education destination. This is not speculation – a single tweet can destroy a whole international market, as was the case when a Canadian government statement on Saudi Arabia's human rights record was met with outrage and the withdrawal of students studying in Canadian institutions.

Closer to home, we have experienced significant disruption to student flows due to the Canterbury Earthquakes, changes in immigration policy and delays in immigration processing, through SARS and now in late 2019 / early 2020 the impact of Coronavirus.

Most worryingly from an education sector perspective – despite course enrolments falling, output is not keeping pace with demand for technical skill-sets. Despite this infusion of global talent, technology skill shortages persist in the NZ economy, with 16 of 57 job codes listed on the NZ immigration long term skills shortage lists being ICT related:

Electronic Engineering Technician, Telecommunications Network Engineer ICT Project Manager, Telecommunications Engineer, Organisation and Methods Analyst, ICT Business Analyst, Systems Analyst, Multimedia Specialist, Web Developer, Analyst Programmer, Developer Programmer, Software Engineer, Software Tester, Software and Applications Programmers, Database Administrator

Scarce technology skill-sets are a global issue, and as the digital transformation of institutions and organisations continues across the globe, demand is driving widespread shortages across a variety of functions. According to Statista, a survey of 3645 CIOs and IT leaders across 108 countries indicated the following rates of respondents reporting skills shortages:

	2017	2018	2019
Big data / analytics	42%	46%	44%
Artificial intelligence	-	-	39%
Cyber security	-	-	39%
Enterprise architecture	34%	35%	34%
Business analysis	34%	31%	31%
Development	25%	24%	-
Project management	26%	25%	-
Technical architecture	32%	36%	-
Security and resilience	28%	35%	-

Table 2. IT functions suffering from skills shortages according to IT leaders worldwide in 2017 and 2019. *Source*: Statista

Anecdotally, feedback from industry participants and hiring managers in NZ indicates a particular difficulty in sourcing experienced resources and matching requirements for specific, niche or high level technical expertise.

This inability to access directly needed skills is further compounded by the rapidly growing scope and complexity of the technologies available to businesses - and their global competition.

These challenges can be observed (alongside the impacts of local market sizes and labour sourcing approaches) in vacancy statistics - for example in Figure 6, an indicative snapshot of vacancy listings in early December 2019 on Seek, a key site for advertising NZ professional vacancies.

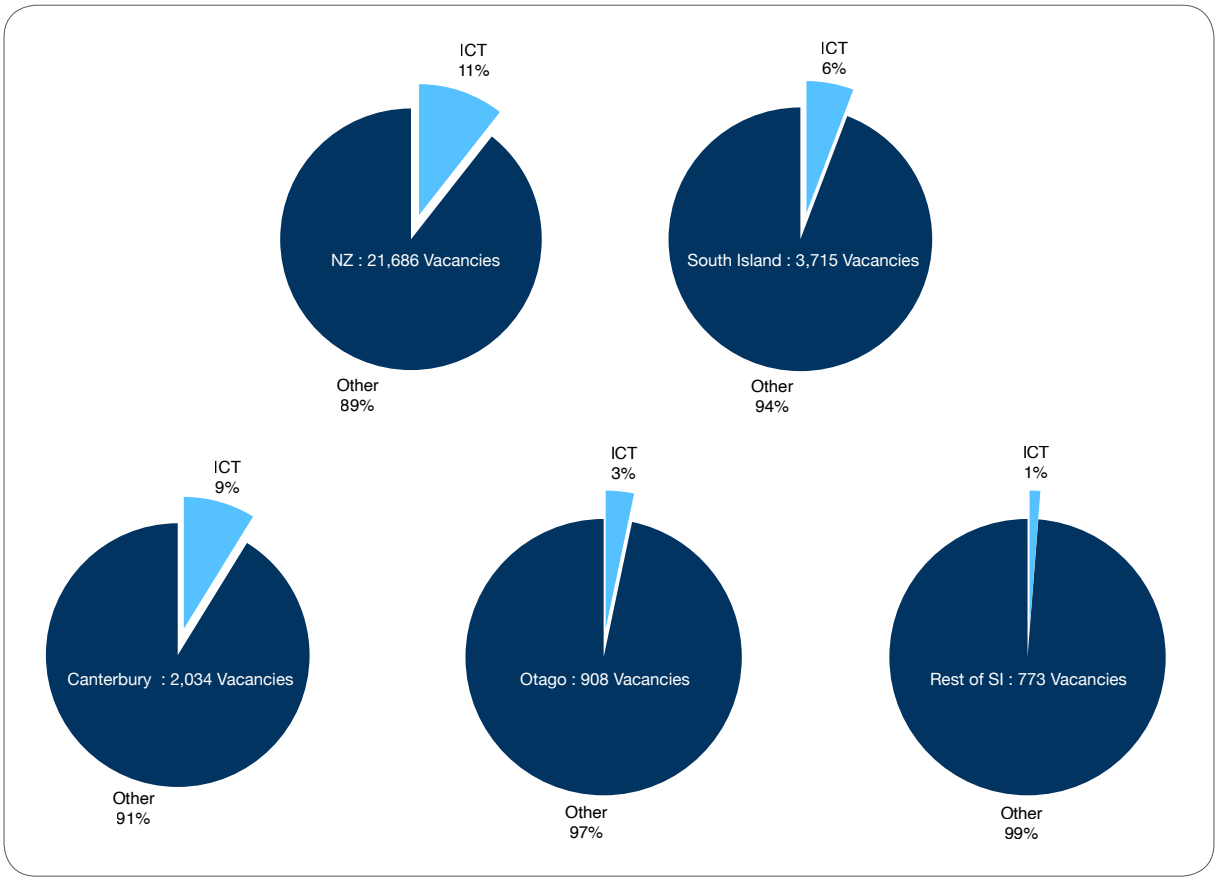


Figure 6. Advertised vacancies by region - snapshot - early December 2019. *Source:* seek.co.nz

In considering the numbers of advertised jobs, the reader should be aware that much local hiring in Canterbury and Otago takes place through word of mouth contact either direct from hiring business to candidate or via recruiters, so these figures are likely to understate volumes.

Despite these shortages, the local ICT sector continues to grow - for example, the number of people employed in ICT in Canterbury has trended upwards across the past decade despite the impact of the Canterbury quakes. Regrettably, it was not possible to source comparable data for the other South Island Regions.

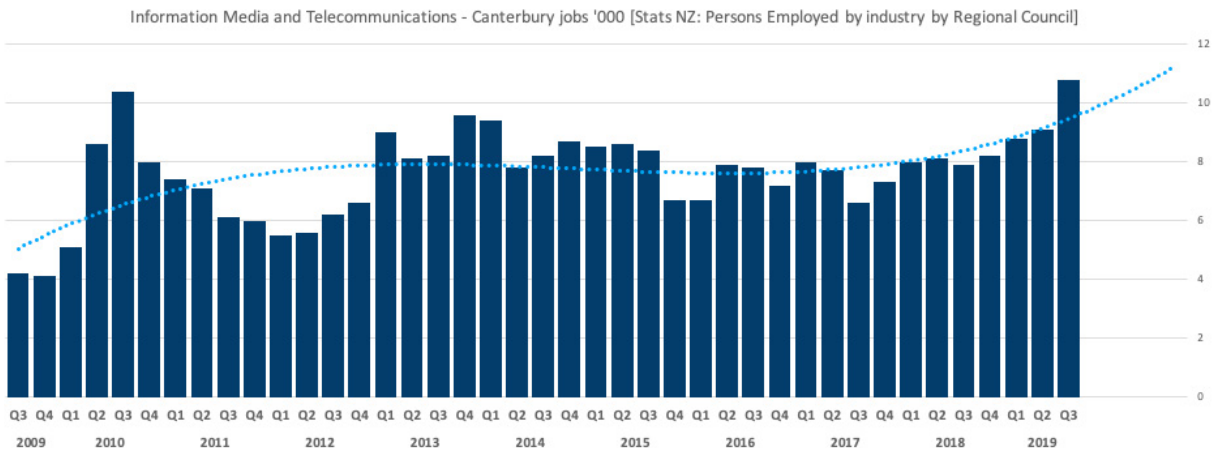


Figure 7. Canterbury ICT Jobs 2009-2019. *Source*: Stats NZ

This scarcity is playing out in steadily rising rewards for ICT skills. The national trend in Figure 8 has been steadily rise for 30 years - though interestingly showing signs of slowing in more recent periods:

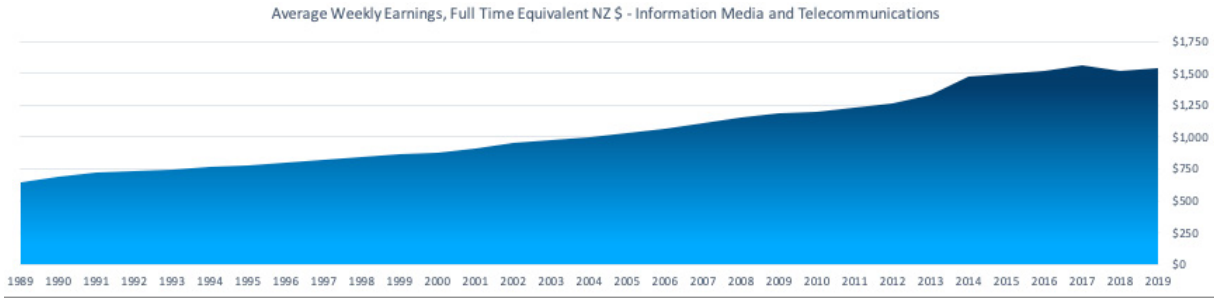


Figure 8. ICT average weekly earnings (FTEs) by Industry and Sex (Total Both Sexes). *Source*: Stats NZ

One contributory factor to this slowing may be a mismatch between the needs of business in a volatile economy and the skills of students exiting the current education system. This recent statement from Deloitte underscores the view that the "product" is not meeting the needs of "consumers".

Millennials are simultaneously overqualified and under-skilled: Data from an OECD study reports that 15% of Australian graduates are overqualified for their jobs, working in fields which do not require a degree. Meanwhile, the World Economic Forum is advocating that traditional learning is leaving graduates without the skills they need to contribute in the workplace.

Turning to the wider economy, analysis by the World Economic Forum indicates a significant shift in orientation towards the skills needed to manage complexity and to evaluate, plan and act in new environments:

Figure 9. Top 10 skills in the future of jobs. *Source*: World Economic Forum

Taken together these trends in increasing complexity and the scarcity of skilled resource represent a pressing issue for both industry and educational institutions as they strive to reinvent themselves in the new digital economy.

5. The Future is Now

"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn."

- Alvin Toffler, Future Shock, 1970

Via Nick Burnett and the Future of Learning Conference, Christchurch 2019

Our world is increasingly complex.

The NZ Government Service Innovation Lab's recent "Emerging Technology 20 year landscape" map illustrates this clearly. The map is a catalogue of new and emergent tech, and It's almost disconcerting to realise that innovations like blockchain, virtual and augmented reality, machine learning and facial recognition are already "here and now" technologies with increasingly widespread real world deployment.

Meanwhile, things that are still sci-fi to most will apparently be mainstream within 5 years. As Brain Computer Interfaces, Digital Assistants, Conversational interfaces and Quantum computing hurtle at us, human beings and our social structures struggle to keep up - consider, for example, our difficulty ingesting the social, political and psychological impacts of social media - a technology which, at 15 years old, is almost a prehistoric relic, and a relatively simple proposition compared to, for example, the possible impacts of Artificial Intelligence.

These self reinforcing, exponential innovations are like ink dots on an inflating balloon - each dot growing larger as the balloon expands, and new dots appear in the gaps. Greater again is the complexity and value potential of combining these disciplines in ever more complex ways - for example automating IoT supply chain and procurement with blockchains, or AI controlled agricultural drone sensors. Immense real world value and disruption springs from the exponential opportunities for connection between disciplines, capabilities and industries - and as much real world risk is created by the growing interdependence of our systems.

You could be excused for needing a moment to think, but there is no such luxury - technology marches forward regardless. As Kevin Kelly argued in "The Inevitable", the new capabilities generated by advancing technology will have their impact in some form, and while we can channel and shape specific implementations, the underlying technology cannot be "undiscovered" - just as eventually each becomes intertwined with existing capabilities and a foundation for future ones.

These forces are just as much at play in education itself. Consider for example the impact of the following examples on learners, institutions, and industry.

- The ubiquitous availability of information at low or no cost, on demand and at the point of need.
- The replacement of expensive print by cheap digital services and the flow on impact on academic publishers and the validation, curation and availability of information.
- Increasingly rich opportunities for remote teaching and learning and the capacity to connect to experts anywhere on the planet.
- The impact of diminishing technology lifespans on content selection and the availability of the knowledge required to teach.
- Software systems, tools and apps as enablers and accelerators.

To put some tangible examples around these themes:

- For a monthly fee of US$39, learners can subscribe to O'Reilly Media's Safari, an online knowledge base granting unlimited access to technical books from more than 200 publishers and a host of other self-led training resources.
- The Entertainment Technology Centre at Carnegie Mellon University advises students to be mindful of a high risk of short term hardware obsolescence when choosing the platforms for their projects.
- SciHub, a pirate archive of copyright academic papers was launched in 2011 - as of October 2019 it claims to hold more than 76 million papers and to serve 400,000 requests each day - free of charge.
- In 2018, police in Ohio, US picked up an eight year old boy who drove himself and his younger brother to McDonalds in the family van by teaching himself using YouTube.

Unsurprisingly, these forces, and many others, are also rapidly changing the nature of a career. According to Deloitte in late 2019:

- The typical half-life of a technical skill is approximately 2 years.
- 50% of millennials will live to 100 years old, and they expect to have 10-12 jobs by the age of 38.
- 67% of employees believe they must continuously re-skill themselves to stay in their career, and 58% believe they will have a new career within five years.
- 44% of companies agree that their careers are less than 5 years.
- 60% of millennials think 7 months of tenure means they’re “loyal”.
- Career development and learning are almost doubly as important in millennial's assessment of the desirability of a workplace in comparison to compensation, benefits, and work environment - training is the number one most desirable benefit.

Taken alongside flat Higher Education participation, this last point starkly illustrates the gap between need and delivery.

These dual disruptions of technology churn and job churn are driving a new emphasis on individual, lifelong learning and the need for the modern employee to navigate a difficult and ongoing balancing act between the development of short term, point skills addressing specific issues and deeper, more fundamental knowledge bases serving longer term career needs and interests.

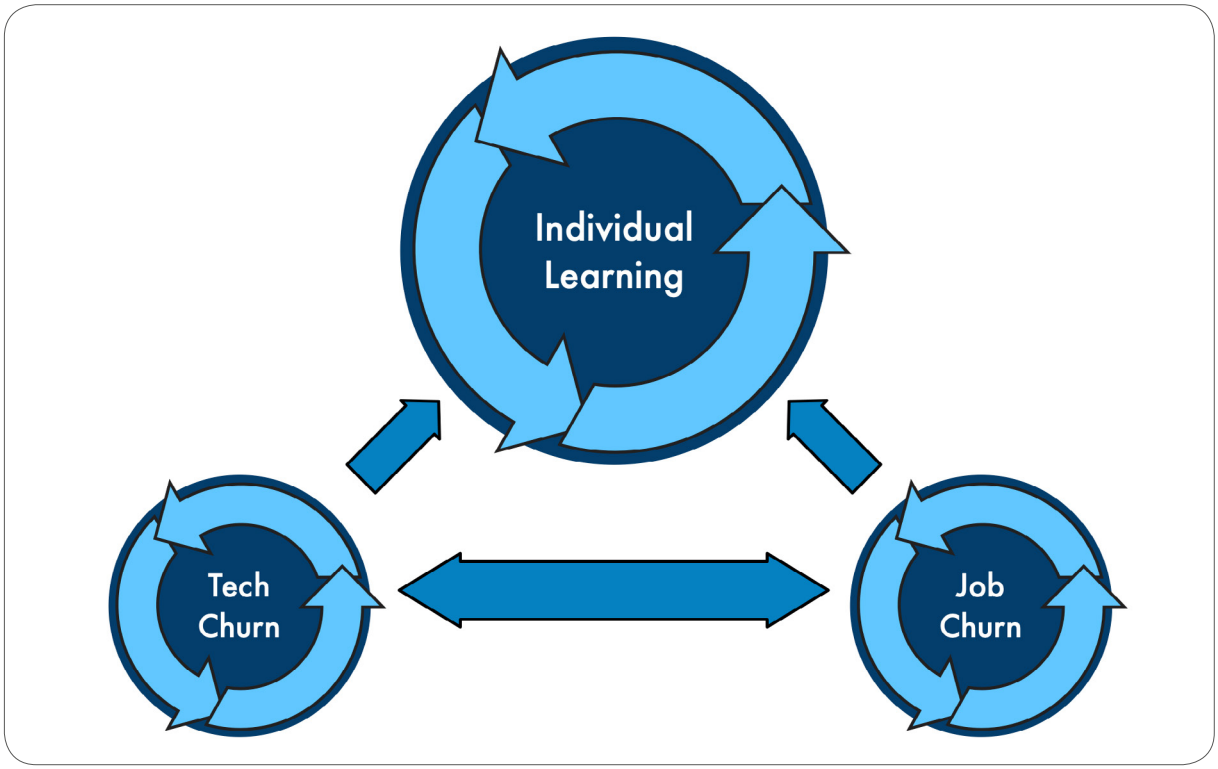


Figure 10. Dual disruption and lifelong learning

Today's reality is that many of the things we would like to do have never been done before - and demand new skills and approaches from the technologically skilled individuals who will bring them to life. These are the skills to operate in complex environments, to adapt to change, to imagine, to foresee, shape, and react to new capabilities and solutions and to navigate uncertainty in constructive / productive team relationships.

Looking more deeply at the World Economic Forum's work on 21st century skills, these themes are strongly apparent:

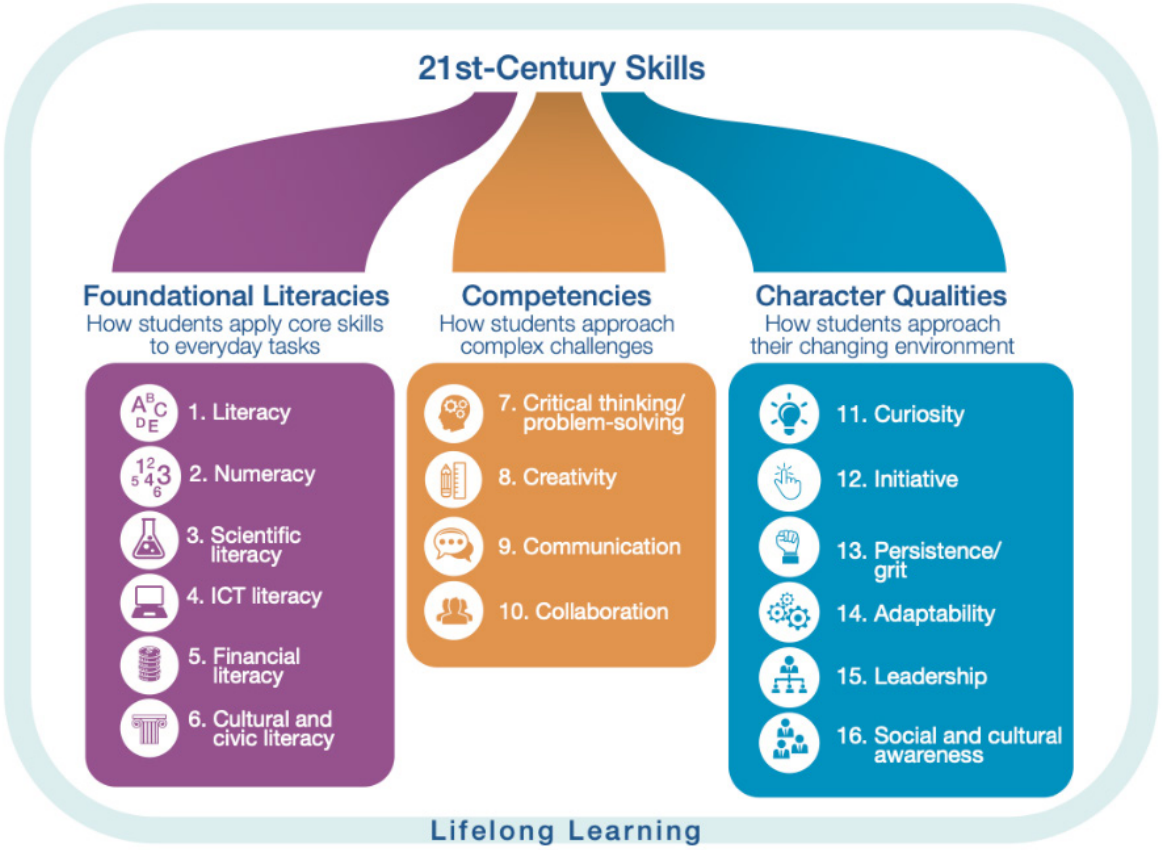


Figure 11. Students require 16 skills for the 21st century. *Source*: World Economic Forum

They can also be clearly identified in the widely adopted 'Skills Framework for the Internet Age', which provides a taxonomy of the skills relevant to modern information workers.

Of six categories consisting of 102 skills, only two are directly "technical" in a common usage sense, and a rough count suggests that approximately three quarters of the skills require a significant element of interpersonal or organisational capability - and, reinforcing the industry feedback that senior skill-sets are particularly hard to source, fully three quarters of the capability levels identified within those skill sets require independence at some level - i.e. the capacity to work with autonomy, advise, assure, initiate, influence and direct.

The modern IT worker clearly needs to be much more than a technical subject matter expert, and above and beyond the increasing complexity of the technology landscape itself, a key challenge for technical education is to address the gap in these interpersonal and organisational skill-sets.

Again, Kevin Kelly supplies useful insight, arguing that in a world of constant change, the capability of individuals and organisations to adapt over time becomes a critical competitive differentiator.

6. Stakeholder Research

Despite this clear need to adapt, change itself is not progress - and to establish direction requires an understanding of the landscape.

To map the features of the local ICT education environment, SIGNAL conducted a survey of stakeholders. Views were canvassed across five key areas relating to the delivery of the SIGNAL mission:

1. **Tech Developments**
2. **Industry Objectives**
3. **Student's Skills and Needs**
4. **Teaching and Service Delivery**
5. **Developing New Zealand's Social fabric**

Respondents were asked to allocate points to represent the future significance of the five headline topics, and to sort a short list of options within each area by perceived importance. They were also asked to assess the expected future significance of a list of specific technical skills and associated disciplines. The responses were aggregated into the overall prioritisations presented in the following sections.

Survey response was unfortunately limited at only 17 respondents, and results can only be considered indicative, Nonetheless, the messages align well with the themes discussed above. Of the 17 respondents, 15 indicated their current relationship to SIGNAL:

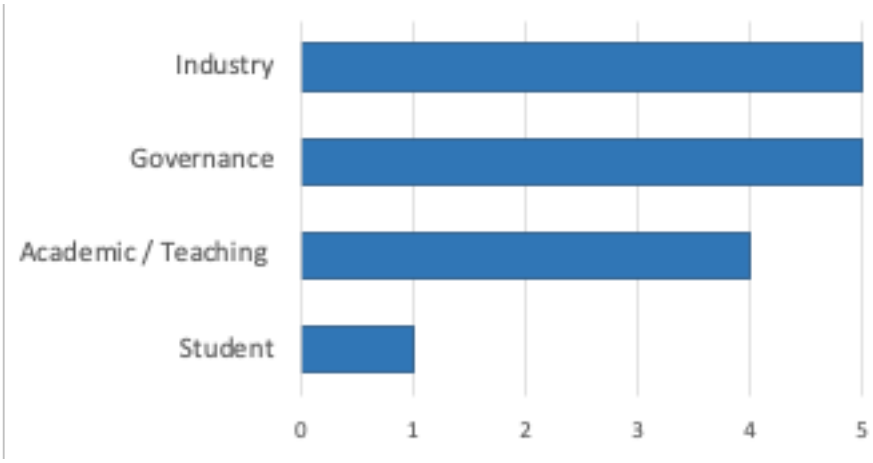
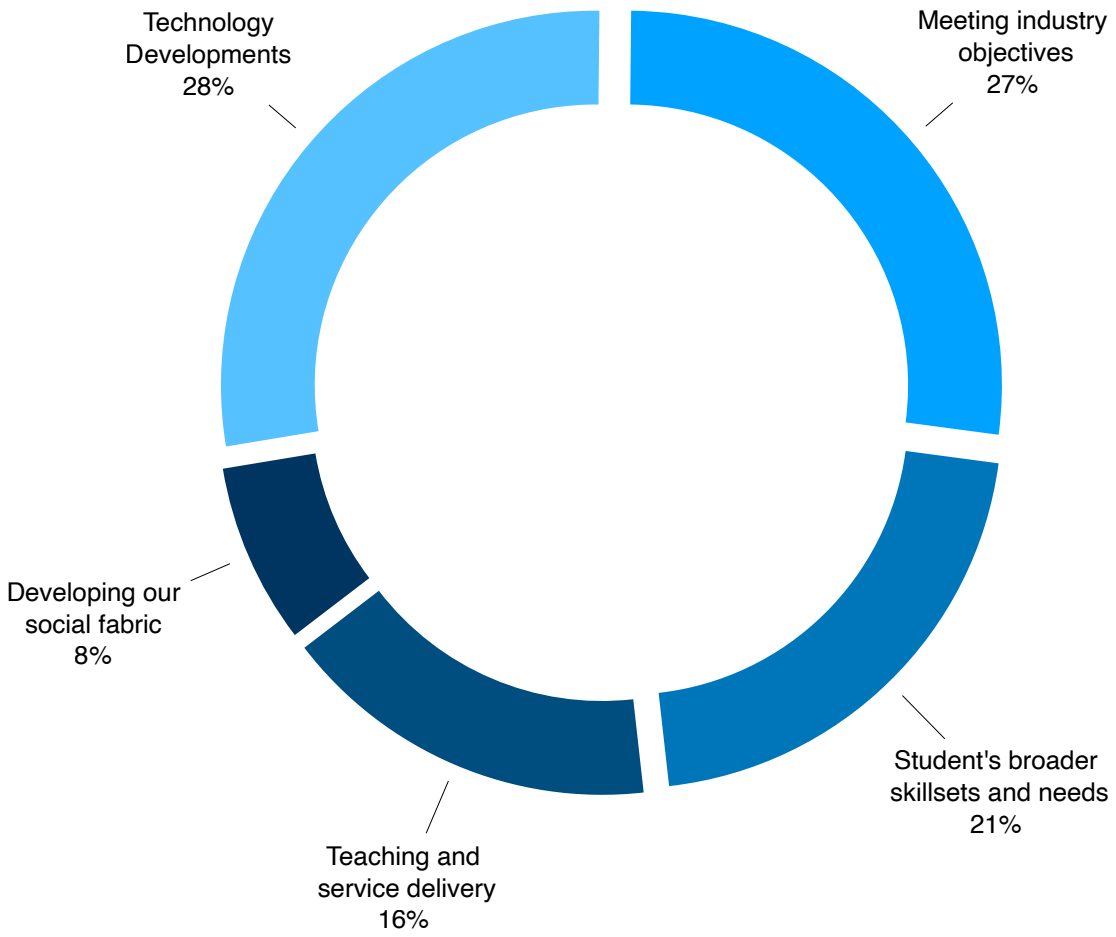


Figure 12. Relationship to SIGNAL survey response

Correspondingly, the results do not represent a meaningful indicator of student views, and given the importance of a flow of successful and satisfied students to SIGNAL's overall success, future emphasis should be placed on gathering additional student input.

High Level Priorities



Total Score / Relative importance

Technology Developments	Meeting industry objectives	Student's broader skillsets and needs	Teaching and service delivery	Developing our social fabric
500	485	380	295	140

Figure 13. High level priorities

The survey indicated high level priorities a near dead heat between tech developments and meeting industry needs as the most important future issues - perhaps not surprising given the respondent mix, but well aligned with the discussion above. Again, given the low student response rate, the 3rd and 4th rankings (Student Needs and Teaching / Delivery) are unsurprising. Perhaps more surprising is the low priority placed on the wider needs of the country as a whole - especially given the robust and ongoing debate on the impacts of technology on the workings of society, politics and the economy as a whole, and the current skills gaps, particularly at executive and board levels of many organisations[1]. Each of these areas is discussed further in the sections following.

[1] In hindsight at April 2020, this perspective may be changed by the Covid-19 crisis.

6.1 Tech Developments

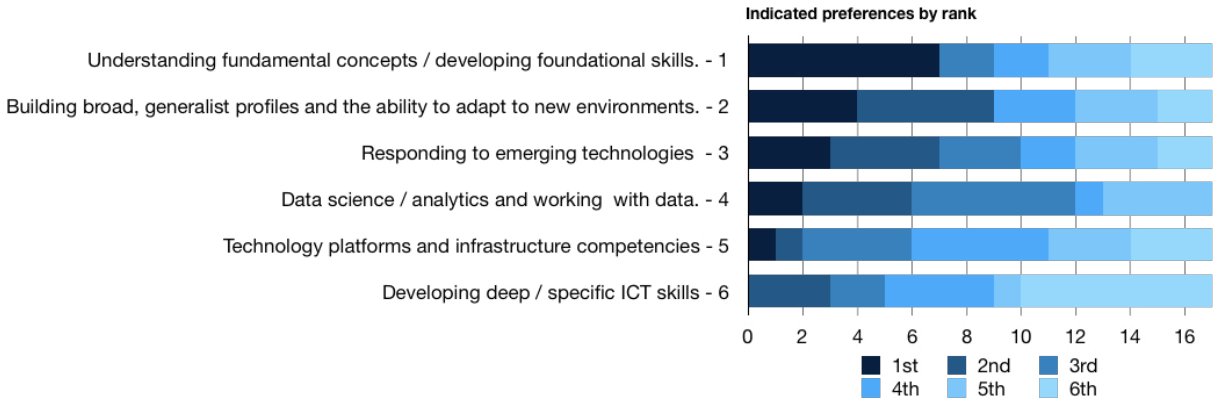


Figure 14. Tech developments

The rapid expansion and churn of technology challenges industry, learner and educator alike as they cycle repeatedly through choices of which technology to focus on next, how much scarce resource to invest and how to these new competencies can be integrated with existing skills to maintain and present a coherent whole.

Tech educators need to develop approaches to managing these uncertainties as they plan future content, in particular to accommodate the nuances needed to address technologies at differing penetrations, maturity, and certainty of existing in the future.

Given that each new technology builds upon earlier technologies, it is likely that the longer a technology has been in active use, the longer it's likely to be around in future. Rather like sand pouring onto a pile, some slips off, while some becomes the buried foundation of the growing heap.

This suggests an emerging continuum between core foundational skills which serve as the basis of career long capabilities and point learning to address a short term need - which may or may not be useful in the long term. At the foundational end of this continuum are skills like computational and design thinking, analytical capabilities and skills in core technologies such as widespread languages, security and networking. At the other, we need tools to undertake point look ups or solve specific challenges - for example Stack Overflow, or O'Reilly Safari, as well as generic competencies like the problem analysis, vendor and platform selection skills to find viable solutions for specific needs.

This pattern is clear in the survey result, showing emphasis on the complementary needs of providing the foundational capabilities and equipping students with the skills to iterate their own capabilities over time, rather than attempting to address the broad scope of technology capabilities in detail.

This divergence suggests stratification of courses into levels aligned with technology maturity, and tools such as the Thought Works Tech Radar provide a useful model for this, publishing a regular classification of emerging technologies by maturity levels.

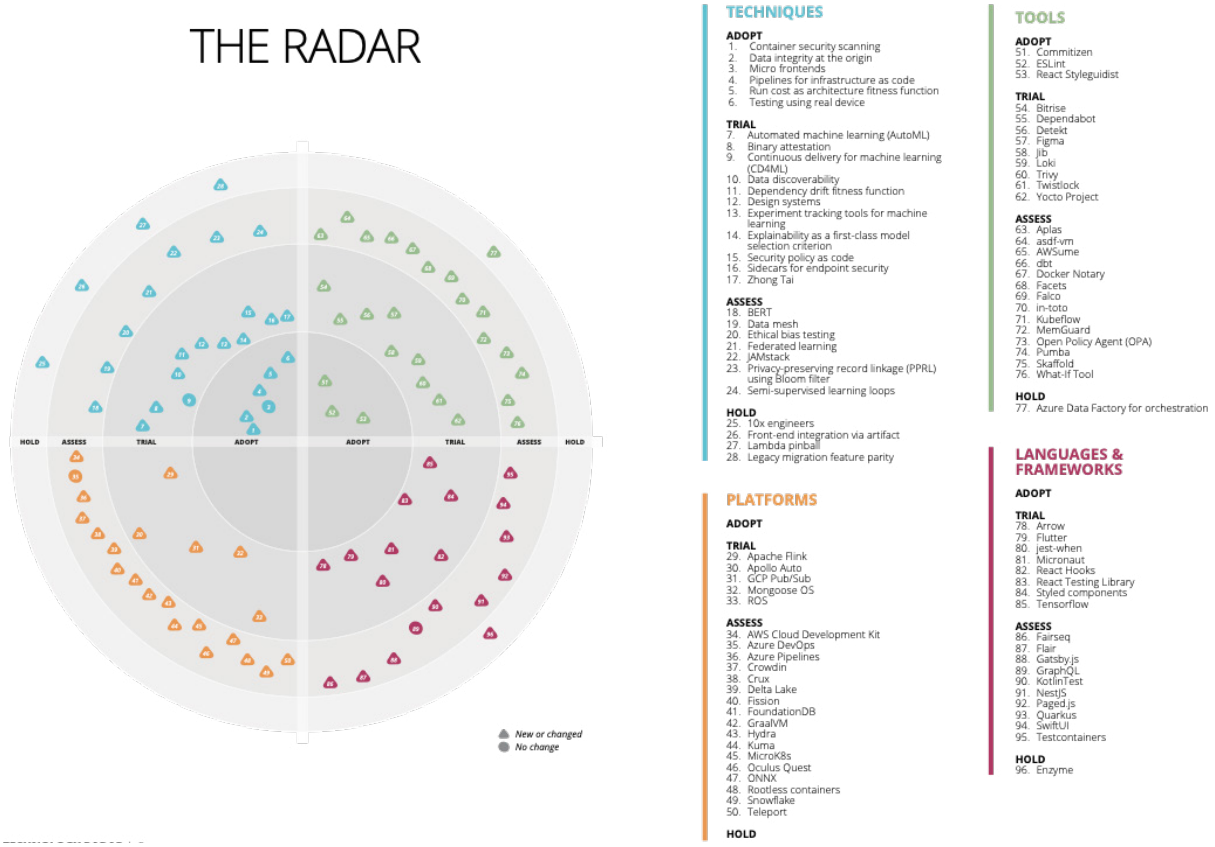


Figure 15. Technology Radar. *Source*: TechRadar 21 - [Nov-2019] https://www.thoughtworks.com/radar

Funnel, pipeline or matrix approaches to course development may also provide useful planning models, and responding to the short term churn of new developments also implies the need to work out how to shorten course preparation cycles – and the institutional structures needed to support the additional speed while maintaining the quality of content.

Ranking for Specific Skills

Respondents were also asked to rank the perceived future importance of a large list of specific skills – both specific technical skills and more generalist interpersonal, organisational or managerial skills.

Ranks were assigned by computing a score for each skill choice. Respondents were requested to rate their expectation of the future importance of each entry in the skill list as either “Critical (1)”, “High (0.5)”, “Medium (0.25)” or “Low (-0.1)“. Scores were then calculated by multiplying the total number of votes in each category for each skill by the weights indicated after each option. No answer from a survey respondent was treated as a zero score and the list was then ranked in order by the sum of the weighted votes. The relative rankings are presented in Figure 15.

While a detailed analysis of these ranking is beyond the capacity of this report (and realistically, of the data to support a robust conclusion), it is worthwhile to note some specific points:

- There is a healthy mix of technical and non-technical skills in the top ranks, supporting the ideas around of fundamental skill-sets which include a balance of complementary capabilities.
- In particular, there is a focus on the interpersonal skills required to engage and execute work in modern team environments - such as Communication, agile and project management, working with clients and change management skills.
- The highest ranked technical skills all speak to the current industry focus on data driven solutions facilitating distributed / integrated systems and leading towards AI / ML deployment.

These findings reinforce the message that tech education must increase it's focus on producing graduates with effective interpersonal and work management capabilities.

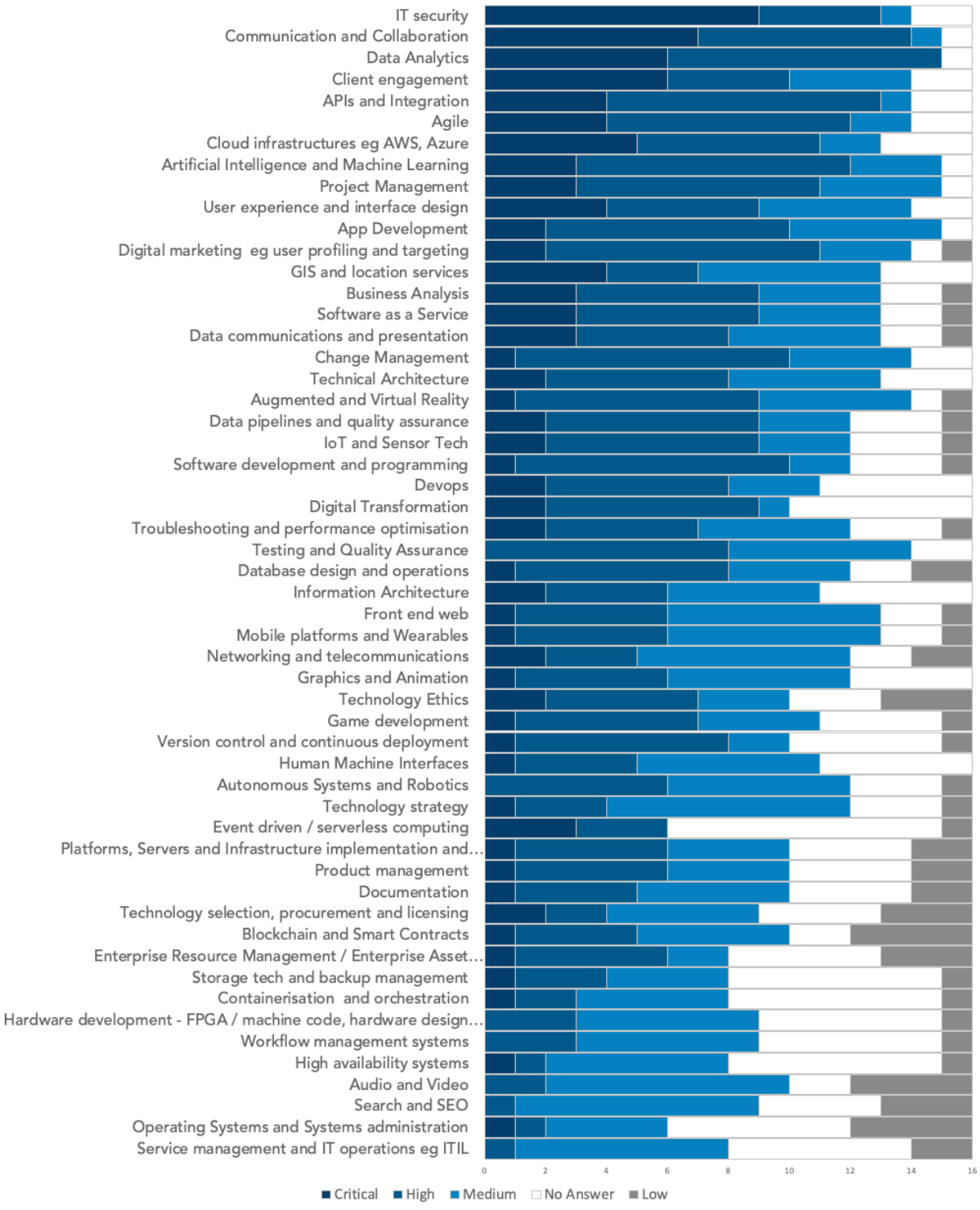


Figure 16. Ranking for specific skills

6.2 Industry Objectives

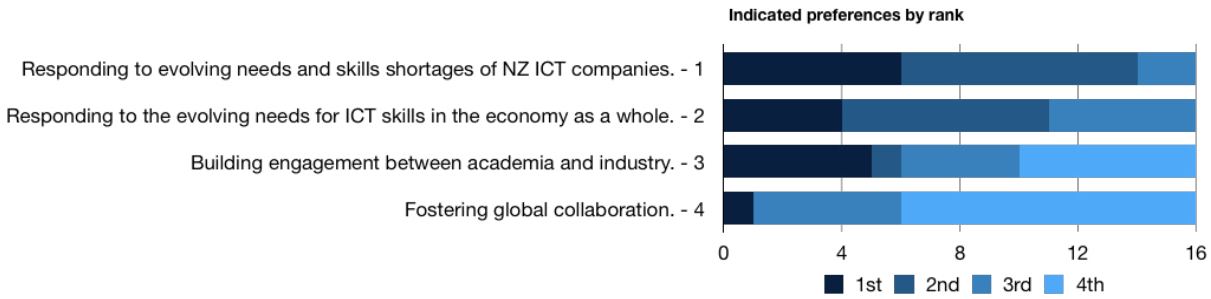


Figure 17. Industry objectives

Given respondents are primarily industry participants, it is unsurprising that the first ranked option in this section is the needs of ICT companies, but the tight clustering of respondents' 1st ranked choices among the top three options indicates a broader appreciation of the complex position of ICT skills in the modern economy.

Many of the discussion points above also apply to the topic of skill shortages, and these is a similar need to address multiple dimensions and perspectives:

- How to respond to short / medium / long term market movements.
- The complementary skill-sets required to successfully operate in a business environment.
- The establishment of effective structures to support lifelong learning, 'in post' education and professional development.
- Understanding the areas of future tech skills need from business.

Addressing these areas is complicated by the structural nature of NZ as a small, isolated economy - the existing lack of mid to high grade skills is playing out globally, but the impact of this is likely to be amplified by a small labour pool, and implies a further challenge - how can we educate a pipeline of the new capability we need if we are missing the advanced capabilities? And how do we create and access these skills if we do choose to address these issues?

Current industry responses focus on contract labour and international hiring, but this can be seen as managing a symptom rather treating a cause. In the long term, rather like NZ rugby, there is need to create a robust feeder ecosystem to provide a flow of future IT 'All Blacks'.

In this context, it is also relevant to consider selected feedback from SIGNAL's Industry reference group partners at the group meeting in June 2019.

- Participants indicated skill sets their tech organizations find it most difficult to hire for included: developers, business analysts, data scientists, business intelligence, DevOps, and cyber security.
- All the participants had hired junior or graduate staff over time. Common barriers to hiring graduate ICT staff are the overhead of coaching and development, and the generally more limited technical skill-set and life experiences of graduates.

These are core systemic issues which require long term vision, consistent stewardship and close institutional / industry collaboration to address. They are not trivial matters to address, but as illustrated by examples such as the partnerships between Siemens and academia, the right investments have potentially large pay-offs.

6.3 Student's Skills and Needs

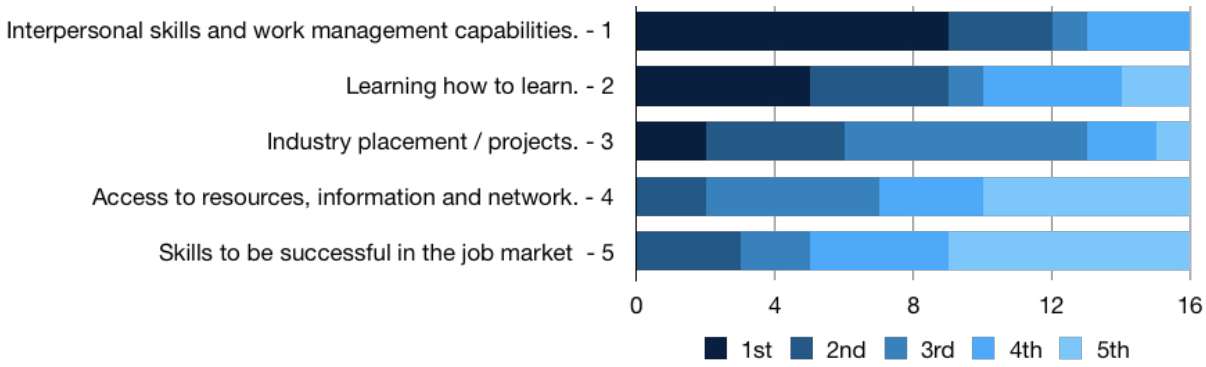


Figure 18. Student's skills and needs

Given the low representation of students in the survey population, this section should be seen as the desires from other participants for student outcomes, and is no less useful for students because of that. Nevertheless, further investigation of these areas would be valuable.

As expected, the need for 'rounded' capabilities features strongly again, and will not be discussed further here.

The 2nd focus on learning how to learn raises a number of interesting considerations. Developments in understanding of the neurological basis of learning indicate potentially significant benefits in creating aligned teaching systems, and in particular collaborative learning environments.

A study of completion rates for Massive Open Online Courses (MOOC) indicates dropout rates up to 93%. These limitations are addressed by feedback from young learners discussing the future of education at the SingularityU exponential youth camp in 2014, who identified 6 key desires - recast below to draw out the essential themes.

- Personalisation of learning
- Active learning
- Collaborative learning
- Expert coaching and guidance
- Developing grounded, real world skills
- Developing confidence and growth mindsets

In the SIGNAL context these themes imply the need to consider how to build on the industry placement programme and existing collaborative learning schemes - both of which provide the varied, grounded, application oriented learning environments required to develop true skill fluency and the practical environments for developing the broad skill-sets emphasised elsewhere in the discussion.

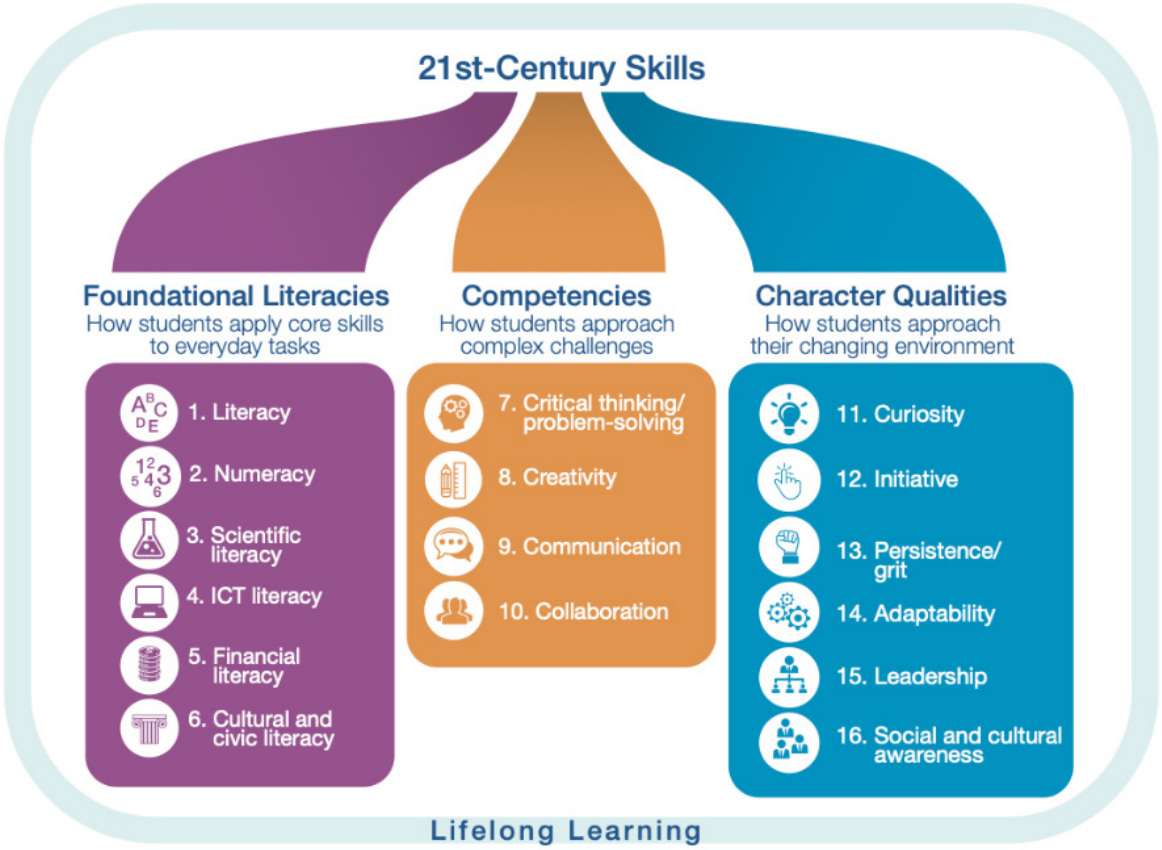


Figure 19. Students require 16 skills for the 21st century. *Source*: World Economic Forum

Demographics

Another important area to consider are the forecast changes in New Zealand's demographic mix, particularly growing Māori, Pacific and Asian populations forecast in the Statistics NZ population projections over the next 20 years.

While these changes are gradual, the role of education in supporting long term success in an appropriate cultural context for individual students must be a factor in institutional and national planning. Key this will be to address the significant forecast growth in the proportion of young people from Māori, Pacific and Asian ethnic backgrounds over the coming years.

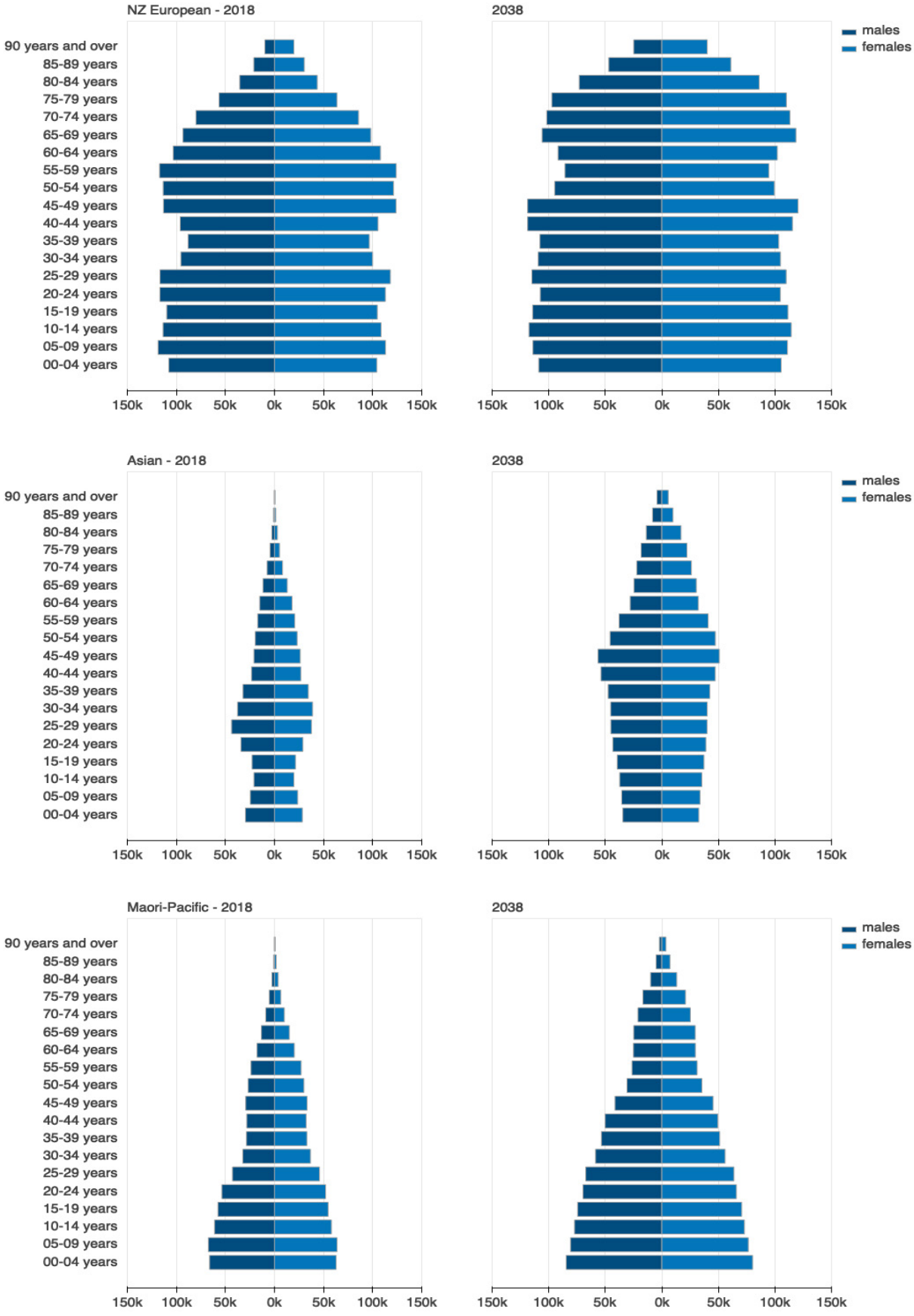


Figure 20. New Zealand demographics forecast growth: 2018 / 2038

6.4 Teaching and Service Delivery

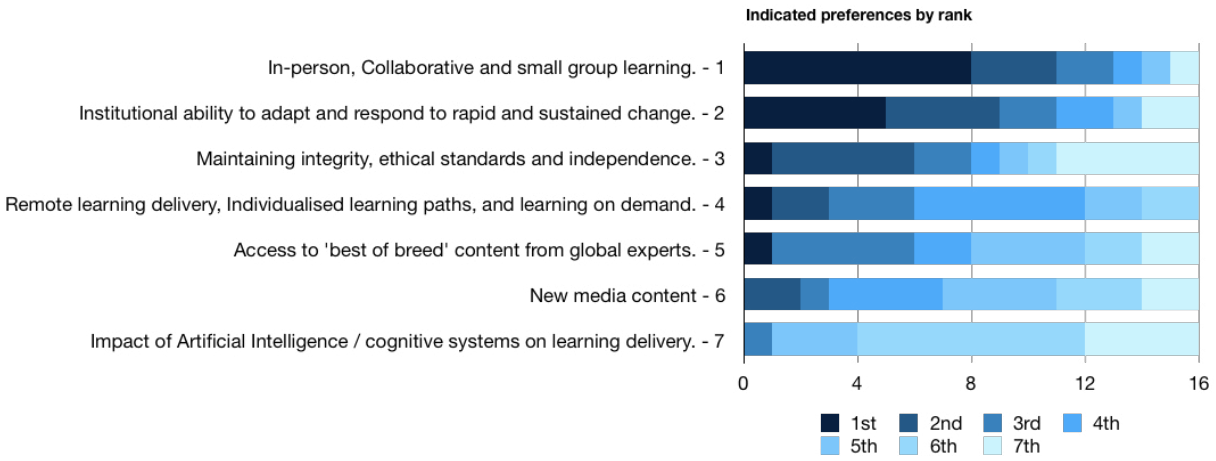


Figure 21. Teaching and service delivery

This evolving environment places significant challenges on institutions themselves, disrupting existing models in exactly the same manner as other sectors.

The rapid development in student and industry stakeholder needs and the tech landscape challenge education providers to develop the internal / organisational capacities and processes to respond in effective and timely ways, and an increasing need to further develop experiential and active learning strands throughout the program portfolio.

Critical to successfully navigating these complex changes will be a clear and common understanding of organisational purpose and focus. This will support effective prioritisation, coherent branding and communication and the important decisions on what not to do. Given the vast potential scope at play, specialisation is inevitable, and if an organisation can't cover everything, it must establish a basis for deciding what not to address.

Even for an organisation with a clear intent, the unpredictability of the current environment means that establishing the "right" way forward is neither a trivial matter nor one that can be guaranteed to stay “right” for any significant period of time.

These challenges imply that teaching institutions also need to be effective learning institutions, able to apply continuous improvement techniques such as agile to adjust their own delivery to the changing needs of their customers. Iterative tools such as the EFQM Excellence model can be valuable in designing systemic approaches to these challenges.

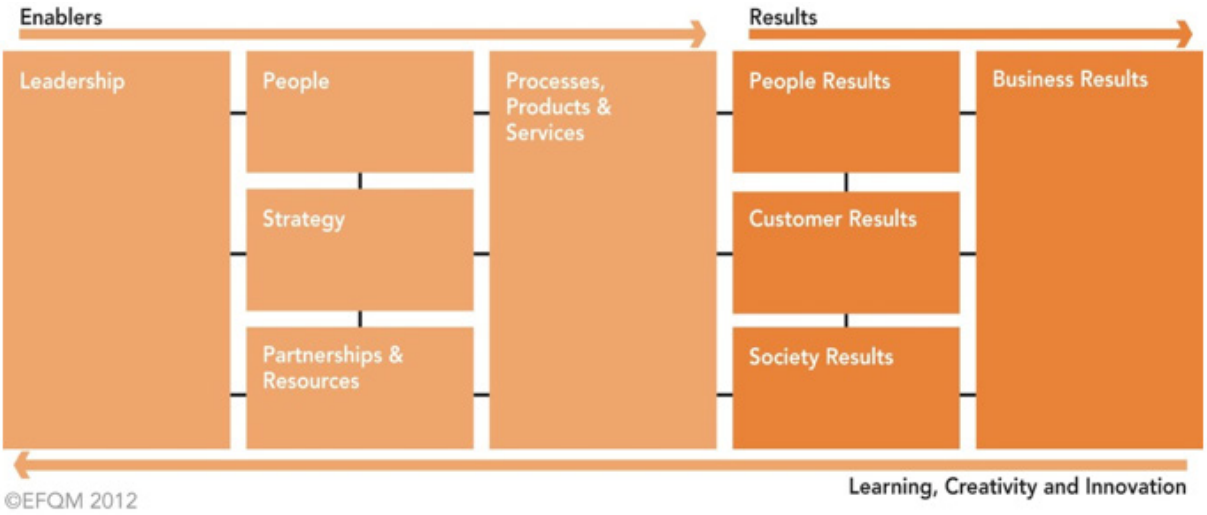


Figure 22. Learning, Creativity and Innovation Excellence model. *Source*: EFQM 2012

Education sector stakeholders observe that intuitions are at different stages of this "digital transformation", with higher education seen to be lagging early education and secondary institutions– however, considering the clear signs that our current systems are not meeting the needs of industry or student, the need to accelerate change is increasingly apparent.

While issues such as sunk cost, regulation, maintaining quality delivery and institutional momentum are very real, the experience of many other sectors should serve as a warning that ultimately the consumer will seek alternative solutions should their needs not be adequately served.

Learning Delivery

A key aspect of the evolution of education delivery is the question of how education providers leverage ed-tech in their own activities – or perhaps how ed-tech threatens the existing institutional solutions. The market for online learning software and apps and educational content is advancing rapidly, and the illustration below of the top 500 education apps gives some sense of the variety available to the modern learner.

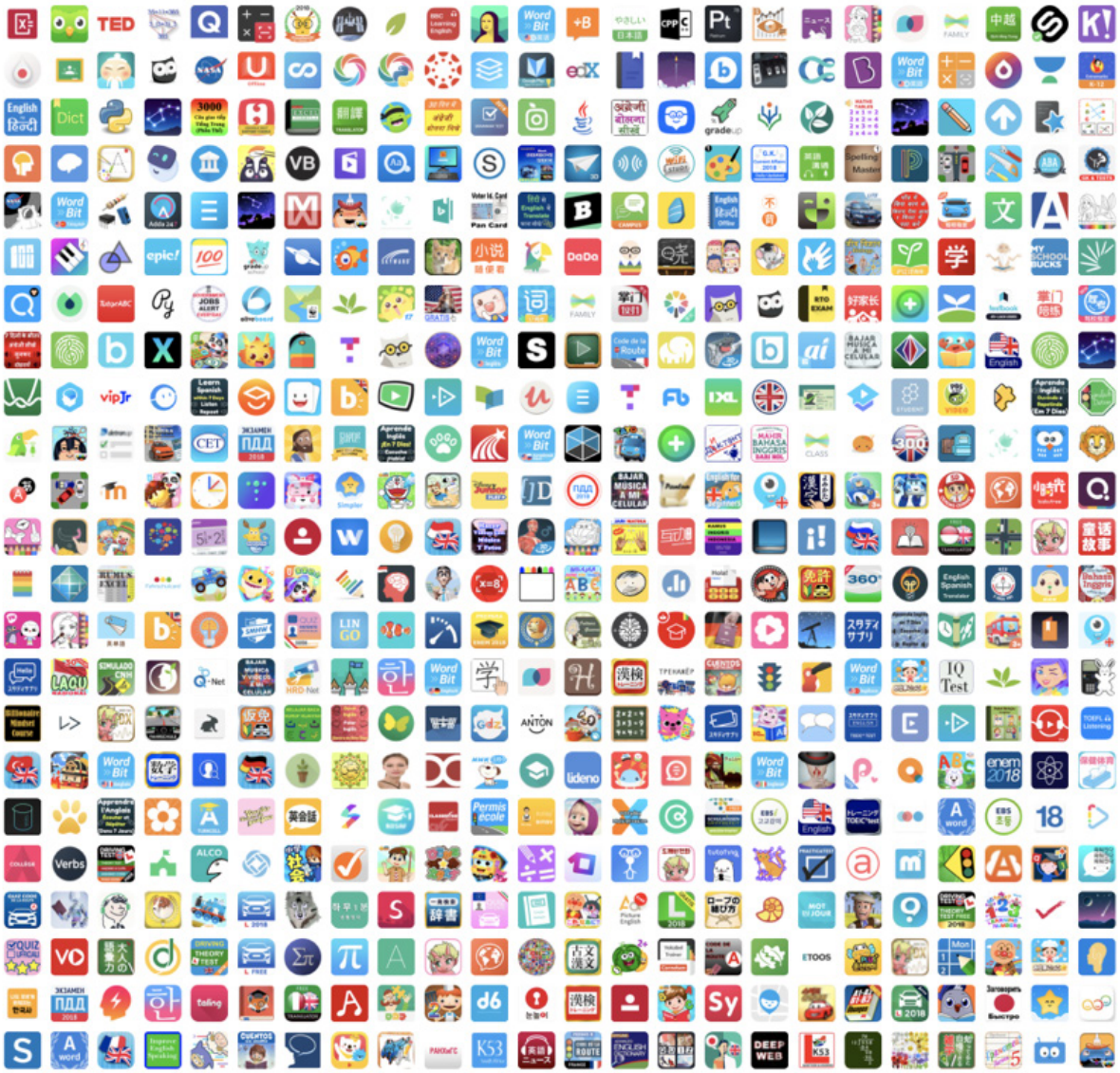


Figure 23. Top 500 education apps. *Source*: https://interactive.holoniq.com/global-education-apps/

To remain relevant in this environment, institutions will need to consider how they differentiate their services, expertise and their additional value add to consumers - and to consider these themes in relation to the collaboration / active learning and real world capability development requirements identified above.

6.5 Developing New Zealand's Social Fabric

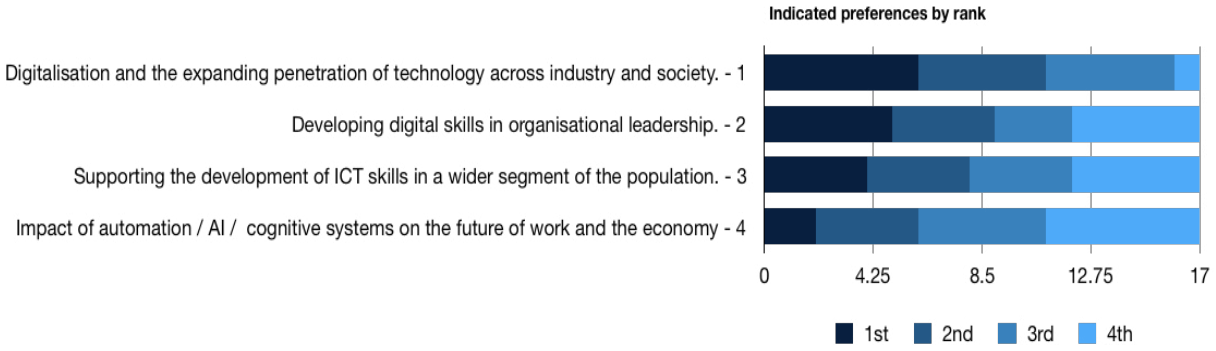


Figure 24. Developing New Zealand's social fabric

While survey respondents rated this area as the least important[1] of the five aspects, the expanding role and influence of tech is the object of much debate in media and political institutions, and this is an area that institutions dismiss at their own risk.

The diagram below gives a sense of the complexity and scope of the dynamics digital technologies are creating in society. These reach many areas – recent legislation and debates on topics as varied as the publishing standards for social media, the licensing of transport platforms such as Uber and Lime, digital privacy issues, cyberbullying, deep fakes, predatory use of gambling (loot boxes) in games marketed at the young and the linkages between mental health issues and the use of tech, all speak to the critical importance of grounding technology development and decision making in the real world.

The DQ Istitute's framework for Digital IQ gives an excellent sense of the scope and complexity of these issues:

Figure 25. LearnTech Lab and the Future of Learning conference. *Source*: https://www.dqinstitute.org

[1] Again, there is potential for this result to be impacted by the Covid-19 Crisis.

Closely associated with these areas is a need to consider the impact of the products that coders produce, and the integrity of their operation in the real world as we strive to deliver a world where our users can operate in confidence, security and safety.

Education providers have an important role to play in this regard, given the skills gaps that exist - it should be of concern to everyone that the recent NZ Institute of Directors Sentiment Survey of NZ Board Directors found that '*Only 33% of directors agreed that their board has the right capability to lead their digital future. This has remained consistently low over the past four years, hovering between 30-35%.*'

These risks are also impacting on the willingness to lead: '*This year 40% of directors (up from 33% in 2018) agreed that the scope of director responsibilities is more likely to deter them from taking on a governance role now than 12 months ago.*'

Given the material risks relating to IT Security and business continuity (to select just two important examples), as well as emerging risks such as security of automated control systems, "Internet of Things" installations and Artificial Intelligence / Machine Learning, it is increasingly pressing that decision makers at all levels have the relevant skills to execute wisely.

6. In Conclusion: Where to From Here? - Considerations for a Future Programme

Technology education has reached a nexus. A range of indicators point to mismatch between the needs of education "consumers" and the systems currently in place to meet them, but the digitalisation of society rolls on regardless. When the Chief Special Adviser to British Prime Minister Boris Johnson uses his personal blog to advertise vacancies at Number 10 for "data scientists, project managers, policy experts, assorted weirdos", it is no stretch to state that technology skills are critical for the future economic and social health of New Zealand.

Trying to forge a path through this complex jungle, institutions that have operated in a fairly stable mode for many years find themselves faced with complex and interconnected challenges – to remain relevant in the face of subject matter flux, to maintain quality of teaching and validation across a tidal wave of material, to reinvent themselves from teaching technical subject matter to meet demand for "whole person" skill-sets and to equip students with the skills and confidence for lifelong learning and productivity – all in the context of rapidly advancing delivery channels, student expectations, budget pressure and competition from alternative sources of learning.

As a regulated environment, innovation in education is constrained, however the situation of "Millennials [who] are simultaneously overqualified and under-skilled" called out by Deloitte satisfies nobody.

The need to identify and implement effective new approaches is clear, but what exactly those approaches will be must still be conceived and implemented with the necessary quality - significant tasks in their own right. Nevertheless, as learning culture continues to be driven by the evolution of technology and work, institutional evolution will be necessary for survival - and the organisations who engage most effectively with the processes of change will come out ahead.

To navigate this journey, we will need a clear picture of where we want to go. Drawing together the threads of discussion, we can start to imagine some of the characteristics of the system we need to create - it is a system which:

- Delivers the foundational skills, confidence and mindset so students can continue to learn and grow themselves throughout their careers.
- Provides personalised learning supported by expert coaching and guidance.
- Is responsive to the developing technology environment and prioritises resources effectively towards the important developments.
- Educates students to be both technically skilled and effective interpersonal contributors
- Creates responsible technical citizens.
- Maintains and grows technical skill-sets within the NZ marketplace and begins to reduce the need and expense of importing offshore skills.
- Focusses on active, collaborative learning and practical, real world experiences, fostering fluency and real world capabilities.

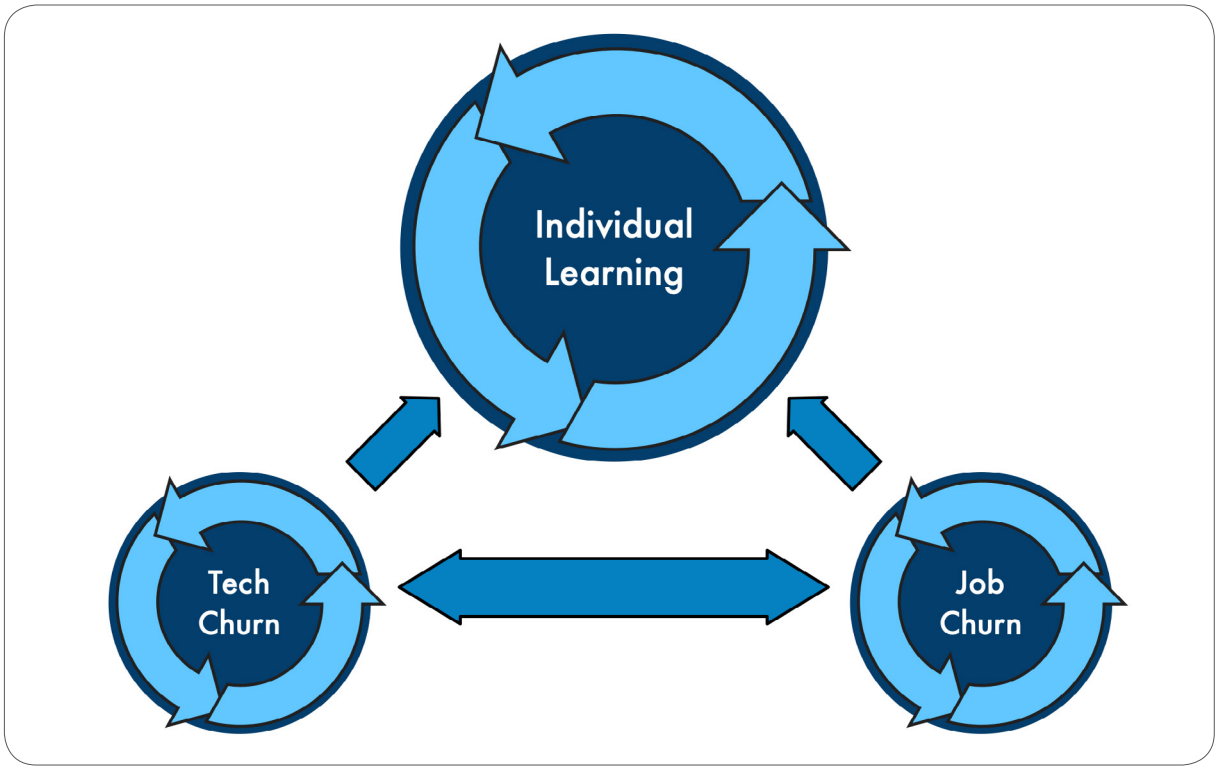


Figure 26. Dual disruption on lifelong learning

Meeting these objectives in the internet age will require a re-imagination of the role of the educator, moving ever further beyond traditional delivery and certification to take on additional roles:

- Curator and pathfinder to relevant, high quality content.
- Guide and sense maker to help students interpret and digest their learning.
- Business consultant, to help students to bring their learnings into real world work environments.
- Mentor and coach to assist when things are challenging.
- Motivator and challenger, to ensure students hold themselves to account.
- Networker and connector, bridging between students and businesses to make meaningful and valuable introductions for both.
- Agile optimiser, constantly assessing and improving content, tools, techniques and methods of delivery.
- Learning theorist, helping students to establish optimal learning skills and to manage the demanding task of maintaining focus in the modern attention economy.

Turning to the skills themselves, the future tech education organisation needs to develop skills and frameworks to address the stratified importance of skills and to strike the balance between fundamentals and transient skill-sets and technical and non-technical outcomes – all the while maintaining flexibility to meet the various needs of each student and the changing environmental context.

It's easy to see this as an increasingly modular “Lego brick” education, for example based around micro credentials, but equally possible that even these relatively new ideas may be quickly eclipsed - for example by AI powered “direct assessment” solutions measuring candidate suitability at the point of engagement – and in this fragmented environment, care is needed to ensure that the value of a “full” education is not lost, and that students are challenged and encouraged to go further than bite sized learning to solve a short term problem – returning to our balloon analogy, there is much value to be found in the interconnections between topics.

Maintaining the quality and integrity of education delivery whilst grappling with this evolving environment represents a highly complex institutional change management task akin to replacing the wings of a flying plane. The organisation that meets these needs does not fit comfortably in our current university – polytechnic systems, and yet these are inevitably the foundation from which any new reality will be built.

To be successful in this endeavour will require integration of many complex themes in a model which can itself respond in changing times and still manage to steer a steady best practice course through the volatility.

The delicate balance which must be struck between change and stability would be a challenge to any organisation,and the political status of education as a “high profile” policy item coupled with short election cycles only serves to complicate matters further – developing a successful long term collaboration between businesses, institutions and government will require time and stability. One could almost hope for NZ to revisit it's former courage and create the first independent education policy unit, akin to the appointment of an independent, goal oriented Reserve Bank. Such a solution might provide the environment for controlled experimentation that will be needed to home in on the best outcomes with the minimum disruption – and perhaps even for the system to catch up with the technology curve.

Whatever the solution, it's clear that we will inevitably need to move to a new paradigm, one which needs to provide a rich and engaging experience serving the individual needs of each student and to equip them not only with the skills they need today, but the tools to keep them sharp tomorrow and to use them effectively in the messy analogue environment of the real world.

Perhaps this is not a traditional 'student-institution-industry' technology education model after all, but instead a collaborative undertaking to facilitate and enable learning and discovery – with all participants teaching and learning to navigate this new landscape together.

Authors

Martyn Rivett

Lead Author

Martyn is an independent advisor, strategist and future thinker who has spent too much of his life in front of a screen. The only common threads of a varied 25 year career as a technology and management professional have been complementary obsessions for breaking new ground and hands on technology problem solving - in both senses of solving problems with tech.

After a late realisation that it's actually all about people, he now spends his time trying to make things a little better for humans by helping organisations choose, plan, implement and manage technology and processes in better ways.

He can be reached at:
https://www.linkedin.com/in/martynrivett/

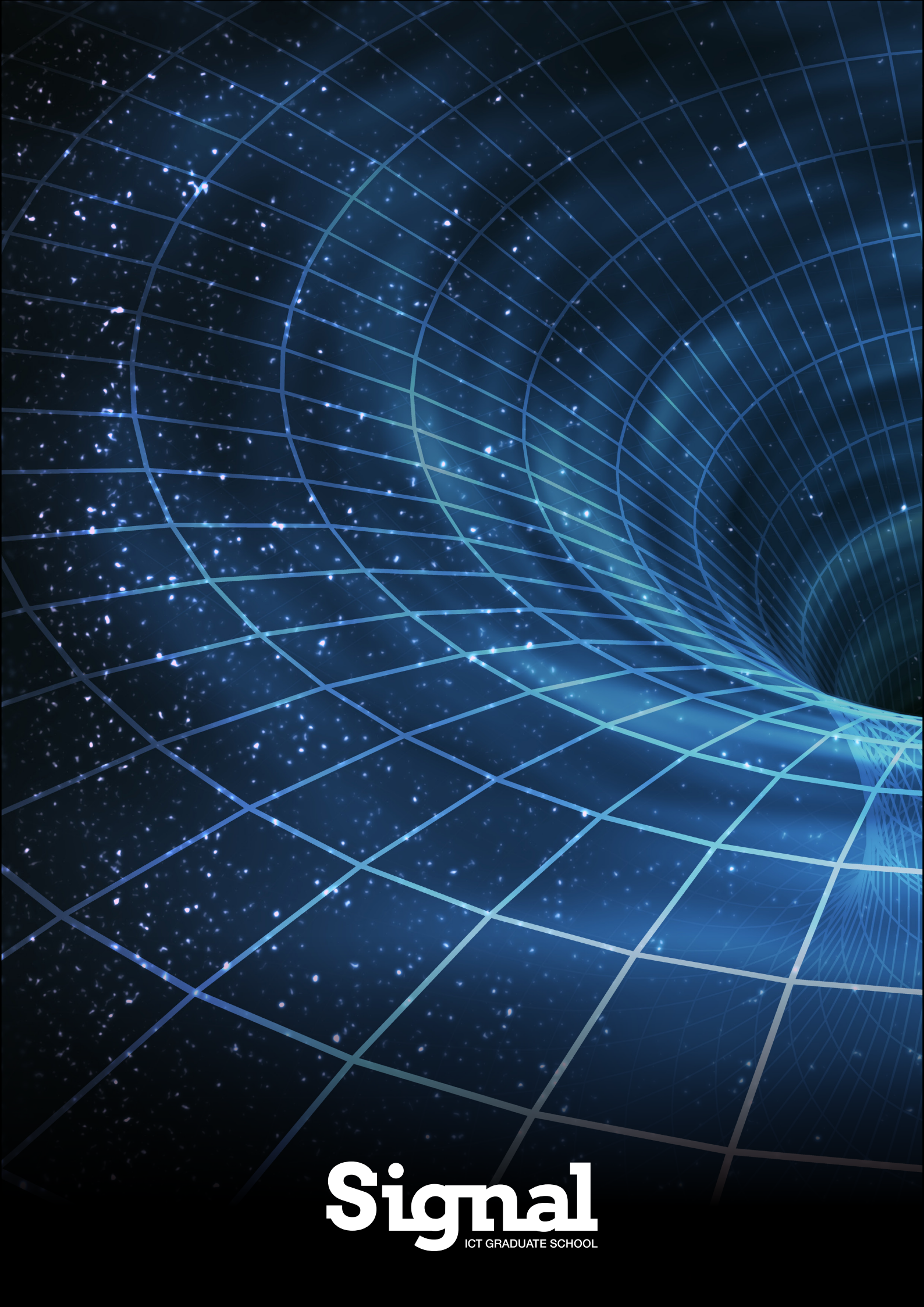
Stuart Charters

Contributing Author and Editor

Stuart is an experienced educator and academic who loves to tinker. He enjoys varied research interests broadly springing from his fascination with how humans use technology to solve problems.

As Director of SIGNAL ICT Graduate School, he has first hand experience of building an environment supporting students to learn collaboratively in an applied context - and the powerful impact that this can create. This has led him to understand that the value of tertiary education does not lie predominantly in content but in the opportunity to interact and apply those learnings.

He can be reached at:
https://www.linkedin.com/in/stuartcharters/


Signal
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