Growing researchers computational skills to meet future needs

Review and Analysis of NeSI's Training Strategy 2015-2017

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Contents

Foreword

NeSI grows the computational capability of New Zealand researchers to ensure New Zealand has the skills within its science organisations to meet future needs.

NeSI works as a catalyst alongside sector institutions and research communities in growing a national network of certified instructors, and on delivery of a range of foundational and advanced training events in research software and data engineering.

This review reflects on the first three years of NeSI's first training strategy. This strategy was put in place at the start of 2015, embodying a shift in focus to active engagement on building skills. This review informs NeSI's future plans, establishing a more strategic perspective on the role NeSI might play, informed by the insights gained across these first formative years.

The insights and observations of this review highlight a significant challenge ahead for the sector in equipping researchers for a digitally-intensive future. Historically the realm of research methods has been located deeply within any research community. Institutions have mostly played a passive role. With the embodying of an increasingly major proportion of research methods into software, software and data engineering practices are becoming essential capabilities for a high performing science system. Yet institutions and communities have struggled to recognise and respond to this implied challenge, with little incentive to upskill teams and develop shared computational capabilities.

There are signs of a change in posture both locally and internationally. Formalised programmes are now emerging which recognise and support changes to research software and data engineering practices and career paths. NeSI is actively engaged in advocating for this shift, including through its partnership with the Carpentries, its advocacy for career paths of Research Software Engineers, and its development of curriculum for advanced training in computational methods and HPC.

This review is timely to inform NeSI's future strategies and to recognise and build on the work of the many individual researchers who have championed this cause. Key foundations are in place within the community from which to build a broader programme of change. NeSI intends to continue to champion the cause, and looks forward to working alongside others in the sector to develop a more highly skilled computational research workforce to meet future needs.

Nick Jones, NeSI Director

Dr. Georgina Rae, Engagement Manager

Introduction

NeSI's training strategy, developed in 2014/15, set out to:

- Build working relationships within the New Zealand research sector to support a collaborative network of knowledge, skills, and behaviours across the country
- Align NeSI's training with the researchers' own view of their development
- Deliver useful and relevant training programmes to research communities, some in partnership with other institutions
- Promote models of training delivery

To achieve these goals, NeSI focussed on building partnerships with well-rounded, deeply committed researchers having a desire and ability to lead skills transfer within their communities. Most of the outputs discussed in this document were therefore achieved through collaborations.

A collaborative approach to training is consistent with NeSI's stated values:

> *"NeSI cooperates with researchers by providing superior computer power, support systems and training to underpin the integrity of their research." - NeSI Training Strategy 2015-2017* [1]

It is through this lens that NeSI's activities and achievements are described.

Training Strategy Review

In late 2017, NeSI contracted Dr. Fabiana Kubke to review NeSI's training strategy and provide:

- a snapshot of NeSI training activities over the years 2015-2017
- an estimate of the penetration of training activities in the research sector
- an estimate of the potential of NeSI training activities to provide direct or indirect support for researcher up-skilling
- a framework to guide how future NeSI training activities could/should be deployed - taking into account NeSI's capacity - to maximise impact

This document focuses primarily on the higher education (HE) sector and Crown Research Institutes (CRIs), and the direct training activities NeSI undertakes. It does not seek to address the informal acquisition of skills that lift researcher capabilities in our high performance digital environment.

[1] All subsequent quotes in this document are also from the NeSI Training Strategy 2015-2017 document linked below.
https://www.nesi.org.nz/file/nesi-training-strategy-2015-2017pdf

NeSI's Training Strategy

Collaborating with technologists and researchers for specialised training as mentors and subject matter experts

NeSI's training strategy recognised that the adoption of advanced computational skills depended on researchers' adoption and confidence in a set of basic skills. In addition to providing the necessary training in advanced skills, NeSI's strategy placed a strong emphasis on the deployment of foundational coding and data science skills, and the development of well-trained instructors able to increase the scalability of training in the research sector.

Three partially overlapping layers of training were part of this strategy:

1. **Training in basic skills to use tools, platforms, and services**
2. **Instructor training activities intended to grow the sector's ability to scale training delivery**
3. **Advanced skills training in applications and methods**

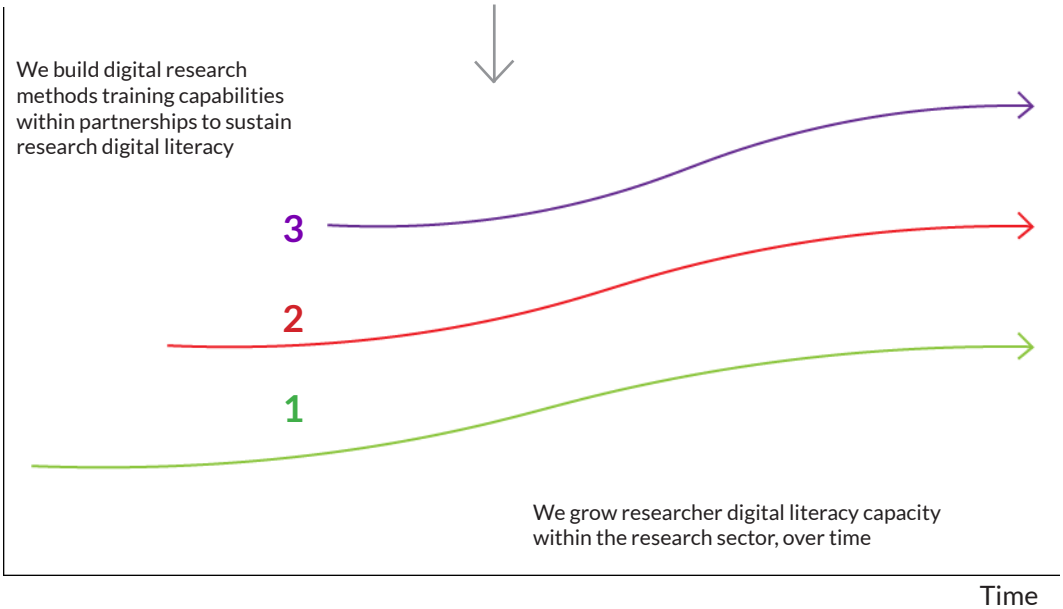

Figure 1. Overlapping layers of NeSI's training strategy

By its very nature, this strategy suggests that training leadership shifts from NeSI to the research sector over time, and provides an essential instructor training support to enable this shift. NeSI's strategy aims to build a network of people as a national community of practice in training.

Activities & Initiatives

"A NeSI-centred view of training enables us to build working relationships with New Zealand research communities over time. We establish training as a programme, looking beyond one-time events or engagement, viewing our activities as connecting an ecosystem of offerings and stakeholders to realise their potential. This helps us build a network of knowledge, skills and behaviours across New Zealand."

Over the period of 2016-2017 the large majority of NeSI training events were focussed on raising awareness and foundational skills, with a minority focussed on skills associated with the use of specific infrastructure.

Basic skills to use platforms tools and services

"NeSI takes an active role in leading and organising events, collaborating with local research communities and institutional hosts, building capacity and community using Software Carpentry and other approaches."

NeSI's basic layer of training aims to build NeSI's confidence in its reflective training strategy, and inform NeSI's strategy through engaging with researchers, their institutions, and communities of practice. Events in this layer include Research Bazars (ResBaz), training Bootcamps, community-led events, and Carpentries workshops (Software Carpentry, Data Carpentry, etc.). Thirty-one institutions or organisations (national and international) have engaged with some form of these basic skills training activities. See table 1 for the basic skills training planned and delivered by NeSI.

Basic Skills Training	Planned	Delivered
Research Bazaar / Bootcamps Carpentries Community-led events	24	33

Table 1. Basic skills training planned and delivered by NeSI

In the future, NeSI may be best suited to play a role coordinating teaching resources and quality control, supporting instructor training, and coordinating a national database of participants and instructors. This could help measure the impact these activities have in the research sector, how this impact aligns with the national science priorities, and fill in the gaps where the leadership may be lacking, or where organising institutions may limit access to the training events.

Ability to scale training

> *"NeSI adds train the trainer activities into the programme, enabling others to take a lead, to grow the scale of training activity across the sector. [...] the expectation is of a growing number of local community-led events with NeSI's initial help through mentorship, sponsorship and support."*

Through instructor training activities, NeSI staff share their practices as instructors, enabling institutions and communities to assume a lead role. This approach looks to build partnerships to sustain capabilities over time.

NeSI's instructor training activities are focussed primarily on the organisation and delivery of Software Carpentry instructor training sessions. Instructor training is a key element facilitating the deployment of Software Carpentry instructors across New Zealand. This set of activities has the largest potential to become community-driven, as these are supported and coordinated by a much larger international community.

Instructor Training	Planned	Delivered
Software Carpentry Instructor training	58	66

Table 2. Instructor training planned and delivered by NeSI

There were 4 instructor training sessions held between 2015 and 2017 (one of these was online, and another was reserved for NeSI staff). Participants from 15 organisations attended instructor training. The checkout process was completed by 55.7% of the attendees, which matches global values (~55%).

Aside from one participant from MBIE, all other instructors trained are associated with a University or a CRI. The distribution of instructor training participants across institutions indicates that NeSI is doing well in deploying trained instructors across the HE and CRI sector.

Advanced skills in applications and methods

> *"Leveraging successes from earlier work, NeSI shifts to provision of advanced, methods-aware training."*

The goal of this layer of training aims to support researchers with world-class digital literacies to approach challenging research problems. Training in advanced skills in applications and methods consists of, for example, workshops specific to High Performance Computing (HPC).

Advanced Skills Training	Planned	Delivered
HPC-specific workshops	6+	17

Table 3. Advanced skills training planned and delivered by NeSI

It is expected that this training layer will become a more important focus as train the trainer initiatives and basic skills training activities become primarily led by local communities. Table 3 shows that NeSI has delivered almost 3 times the planned advanced skills trainings.

[2] http://www.datacarpentry.org/blog/instructor-metrics/

Reach of NeSI's Training Activities

In order to understand the proportion of New Zealand's research workforce NeSI has supported through its training initiatives, we must first size the workforce[3].

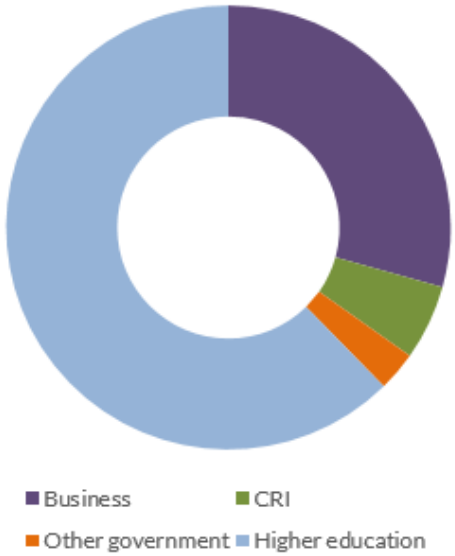

Figure 2. Proportion of the research workforce across different sectors

Role	HE	CRI
Researchers	10,700	1,860
Technicians	2,000	558
Students	16,400	0
Total	**29,100**	**2,557**
Percent	92%	8%

Table 4. Proportion of research workforce in HE and CRI

The large majority of the workforce is in the HE and business sectors (see figure 2), and less than half of the HE sector is supported by permanent staff[4]. Due to the lack of data to describe the distribution of researchers in the business sector, it is mostly excluded from this report. The share of the research workforce in HE institutions and CRIs is shown in table 4 above.

[3] The research workforce in higher education institution or discipline were estimated based on the number of funded Evidence Portfolios in the 2012 PBRF round for each institution/discipline and normalised to the size of the researcher workforce reported in the 2016 R&D survey. Student numbers are the sum of TEC reported Masters and PhD students, normalised to the 2016 R&D survey totals.

[4] Note: it is expected that many students may be working either in the business sector or in CRIs, but, as they must be registered within a tertiary education institution for their degrees, the numbers are hence associated with the HE workforce.

Reach of instructor training

Workers at all universities, with the exception of Unitec, and workers at all CRIs have participated in NeSI's training activities. Within the HE sector, the Universities of Otago and Auckland have the largest share of learners. This is not surprising as these institutions have clear leadership involved in promoting and organizing Carpentries and ResBaz-like events. There is an observable increase in the number of trained instructors over 2016/2017, which reflects NeSI's strength in ability to train instructors within New Zealand. Figure 3 below shows this trend, per institution.

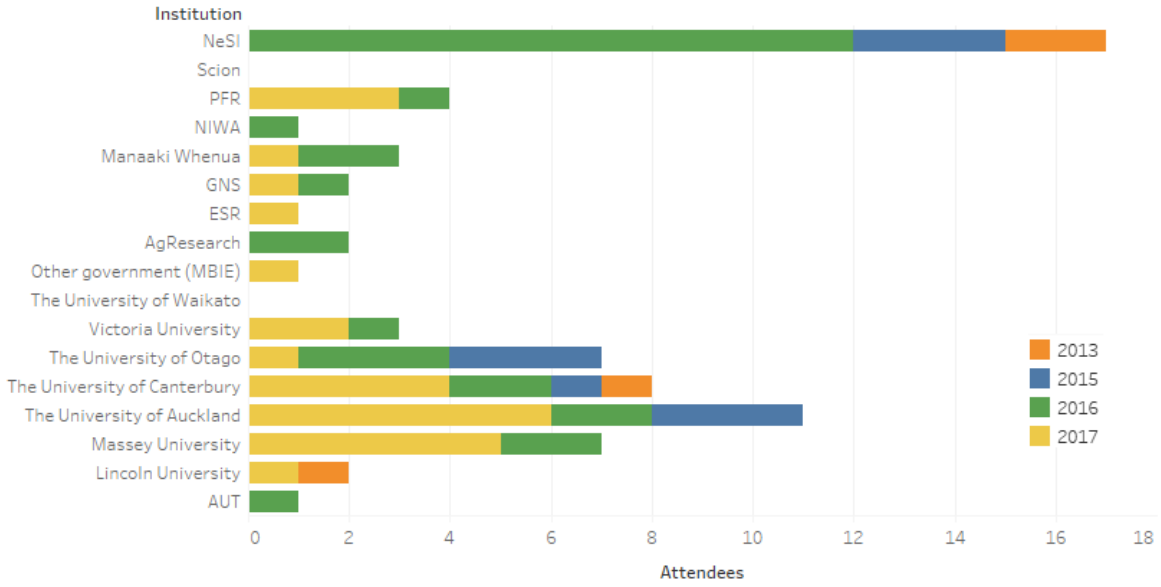

Figure 3. Graph showing the number of trained instructors per institution

	Total Learners	% of workforce
HE	513	1.76
CRIs	129	5.05
Other	32	N/A

Table 5. Learners across different sectors

It is worth noting that the number of trained instructors per institution does not parallel the institutional share of the workforce. Most participants (95%) in NeSI training activities are affiliated with universities and CRIs, although the penetration of training in the CRI sector is larger when normalised to the size of the workforce as shown on table 5 above.

Under the Carpentries training model, researchers that have undertaken instructor training are expected to contribute to future Carpentries training activities. More longitudinal tracking will be needed to understand where NeSI-trained instructors are currently located and how this asset is (or is not) being exploited locally to support the deployment of skills.

There would be value in having a New Zealand database of trained instructors, and to reflect on the possible benefits of having motivated instructors associated with key institutions or geographical locations. Trained instructors could be encouraged to lead local support activities, such as Hacky Hours, or help organise and promote Carpentry workshops.

See Appendix A for further breakdown of learners vs % workforce, and also the comparison between the number of instructors and learners for each institution.

Researcher Workforce Penetration

While NeSI has delivered a large number of training events, the penetration of training (percentage of total researcher workforce) that has attended these events is important to consider when assessing success of a national training initiative. This is considered in the graph shown in figure 4.

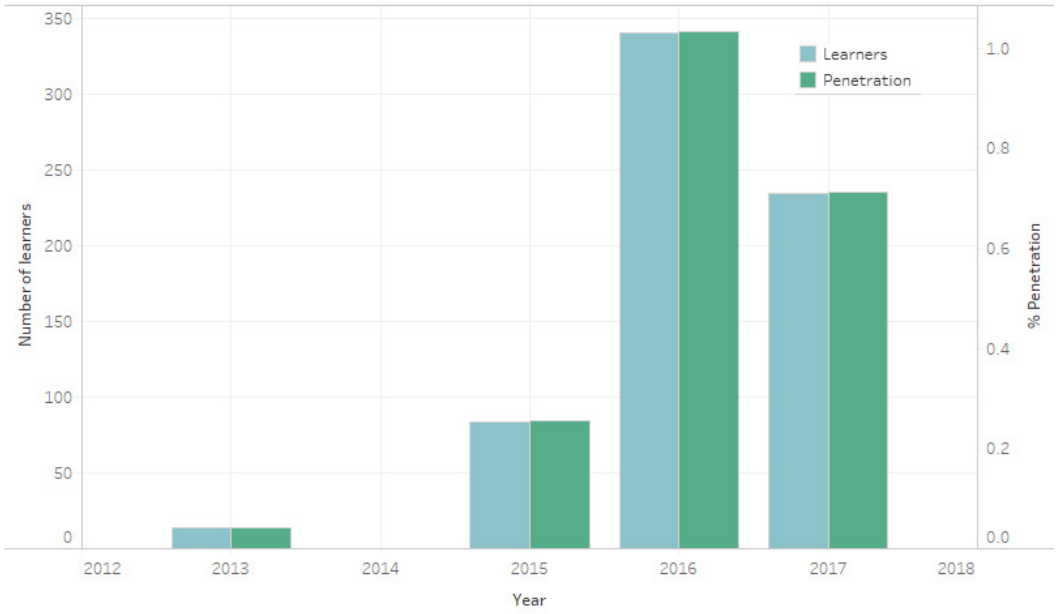

Figure 4. Graph showing the number of learners who have attended NeSI training (blue) and the penetration (percentage of researcher workforce) of these numbers (green) by year.

NeSI's training activities had the most penetration in 2016, however in no year did NeSI train more than 1% of the research workforce. This raises the question, what level of penetration would be required in order to get a noticeable step-change in the digital capability of New Zealand researchers?

In order to have a real impact of the New Zealand research workforce, there is likely a scale-up required in terms of amount of training opportunities made available. See Appendix B for a further breakdown of the scale of NZ's research workforce. The purpose of this analysis is to scope the demand for research digital practices training across New Zealand.

Building a National Community of Practice

Building a national community of practice in training has underpinned the strategy's delivery and success. NeSI has modelled a national leadership role, bringing a planned approach to developing and facilitating communities of practice in training and related events and activities.

NeSI's current community of practice tactics include:

- **eResearch NZ Conference** - a conference series founded by NeSI, with NeSI facilitating and contributing to sessions on training practices
- **The Carpentries** - training instructors, facilitating completion rates for instructors, certification, and support for delivery of subsequent carpentry events
- **Science Coding Conference** – a conference series founded within the CRIs and now run by NeSI, encouraging emergence of a community of Research Software Engineers
- **ResBaz** - a community event developed with colleagues in Australia and promoted by NeSI in NZ, with NeSI facilitating national coordination of local activities with participation by all local hosts, to share practice
- **Hacky Hours** - advocating for Hacky Hours / Study Groups within local disciplinary or institutional communities focussed on digital research practices

NeSI continues taking a leadership role in delivering the eResearch NZ and Science Coding Conferences annually. NeSI has been the nationwide coordinator for Software and Data Carpentry training since 2013, and in New Zealand Software Carpentry instructors have now formed a strong community of their own and the number of workshops have been steadily growing.

NeSI contribution

NeSI has delivered the targets set out in their training strategy, and its activities have provided training efficiently. The overall impact and hence effectiveness of the training, however, cannot be assessed confidently with the current data. Due to limited resources, NeSI has been challenged to sustain its community of practice tactics, with a drop in late 2017 and through 2018.

Table 6 below shows an estimate of the national FTE contribution across institutions and communities to deliver the training activities discussed in this report, with comparison to the level of resource made available by NeSI (NeSI FTE).

	2011	2012	2013	2014	2015	2016	2017
Total FTE estimate for training activities	0.088	1.086	1.003	0.501	1.090	3.263	2.420
NeSI FTE contributed to training	0.050	0.050	0.050	0.050	0.050	0.600	0.300
% NeSI contribution	57%	4.61%	4.98%	9.98%	4.59%	18.39%	12.40%

Table 6. National FTE estimates and NeSI FTE contributions to training per year

Of note, is the increase in NeSI FTE through 2016 and 2017 which corresponds to a noticeable increase in training activity.

Key learnings from the community of practice activities include:

- Formalise these tactics and considering how they're scaled across communities and over time
- Support mechanisms that maximise the cross-hybridisation across different training events
- Ensure that different training events have the right geographical and institutional coverage
- Support mechanisms that enable communities to run their own events, freeing NeSI staff to step in where local expertise is unavailable

Strategy Measurement & Evaluation

Participant information (including number of participants, affiliation, role, discipline, etc.) is not always readily available across all NeSI training activities. This makes follow-up data capture limited, and makes it difficult to measure the impact of the past training activities. As NeSI considers its next training strategy, it would be of value to capture data that make it possible to evaluate the extent to which these offerings are:

- growing HPC capabilities,
- promoting innovation,
- supporting research priorities,
- keeping up with international trends.

A well-thought set of evaluation forms and follow up interviews may provide some insight about the effectiveness of these offerings. It is in this area of training where NeSI's efforts directly translate to the growth of advanced computational capabilities. This is important not just for the growth of research in New Zealand, but also the sustainability of NeSI as an infrastructure provider.

Here are some suggestions on how NeSI could better measure the impact:

- work with key organisations to address the limitations of data about the research workforce
- include measures of impact for its training strategy evaluation targets
- collect data about training events that supports the evaluation of NeSI's training goals and training effectiveness, and how these may translate to uptake of infrastructure use
- work with training collaborators to share data across different training initiatives and measure the breadth and quality of training activities to:
    - identify gaps and opportunities
    - inform how different organisations can assume leadership roles in different areas
    - ensure that training efforts are not duplicated at the expense of other needed training support
    - share methods for quality delivery and evaluation of training activities, to promote engagement as a community of practice

Summary

For this document, a thorough evaluation of NeSI training strategy was done for the periods from 2015 to 2017. Here are the 5 main observations.

1 NeSI has built a training strategy in 2014/2015 recognising the 3 partially overlapping layers of types of training activities.

a. Training in basic skills to use tools, platforms and services
b. Instructor training activities intended to grow the sector's ability to scale training delivery
c. Advanced skills training in applications and methods

2 NeSI has set clear goals within limited resources to start delivering. From 2015 to 2017, NeSI has achieved and exceeded these goals and have come away with valuable learnings.

3 Upon the analyses of NZ researcher workforce, the reach of training activities by NeSI was very small at less than 1 percent of the total workforce. Some in-depth analyses were done to get better understanding of impact areas and resourcing required for bigger reach.

4 NeSI has taken a leadership role in building a national community of training practices that include eResearch NZ, Carpentries, Science Coding Conference, ResBaz, and Hacky Hour. These communities, in varying degrees, are thriving on their own and becoming more self sustaining.

5 It was understood that training is a complex problem where benefits of activities are not immediate. NeSI needs to improve the process of capturing the training data to enable better evaluation and more strategic measurement of progress.

The information provided in this document will be used to guide the NeSI 3 business case. People in the sector have expressed a strong desire for a noticeable step-change in the digital capability of New Zealand researchers. This will require a scale-up in terms of amount of training opportunities made available, the amount dedicated resources allocated, and collaborative efforts from the sector, including NeSI and the institutions.

Appendix A: Detailed analysis of NeSI training impact

When the number of learners is normalised to the estimated size of the workforce, training activity appears to have a bigger penetration in CRIs than in HE institutions (see figure 5).

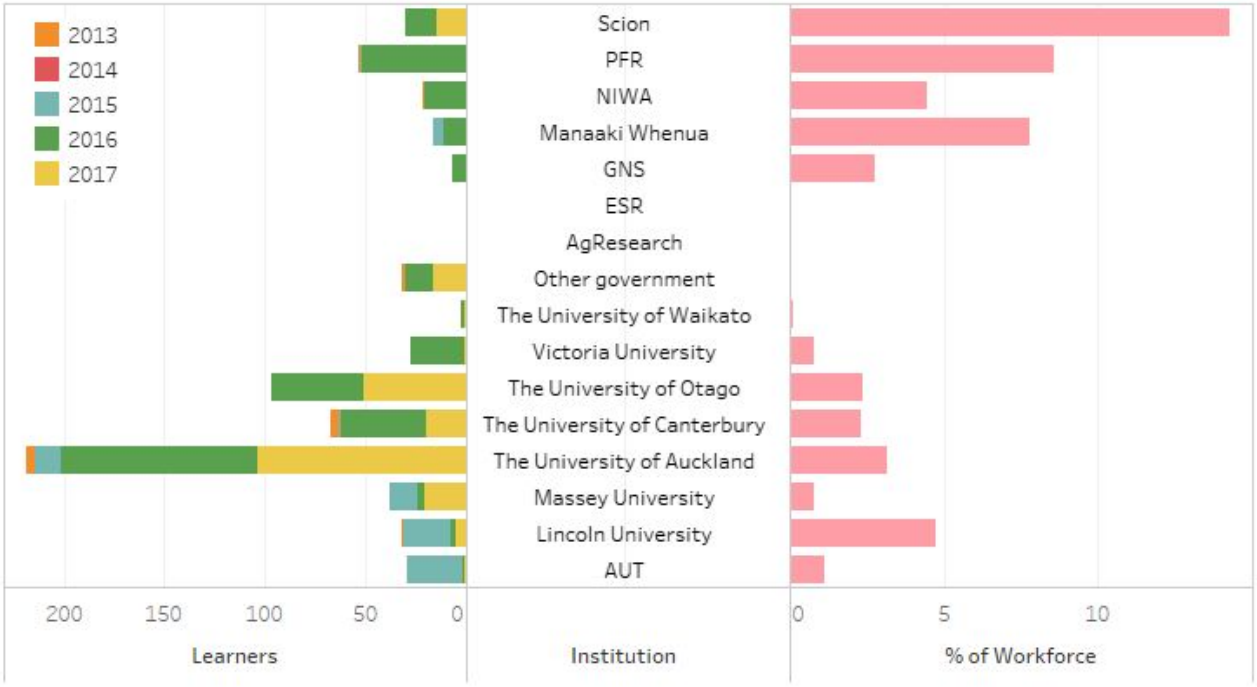

Figure 5. Graphs showing the distribution of learners in HR and CRIs, either by number of learners (left) or as a percentage of the workforce (right).

The current data does not provide sufficient information to identify the distribution of learners across specific offerings, which would be necessary to evaluate training participation against the training strategy roadmap.

There is no one-to-one mapping between the institutional membership of trained instructors and of individuals participating in training activities, with some institutions (e.g., ESR and AgResearch) having participated in instructor training, but not in other training activities. This is more apparent in the CRI sector. See figure 6 for the comparison.

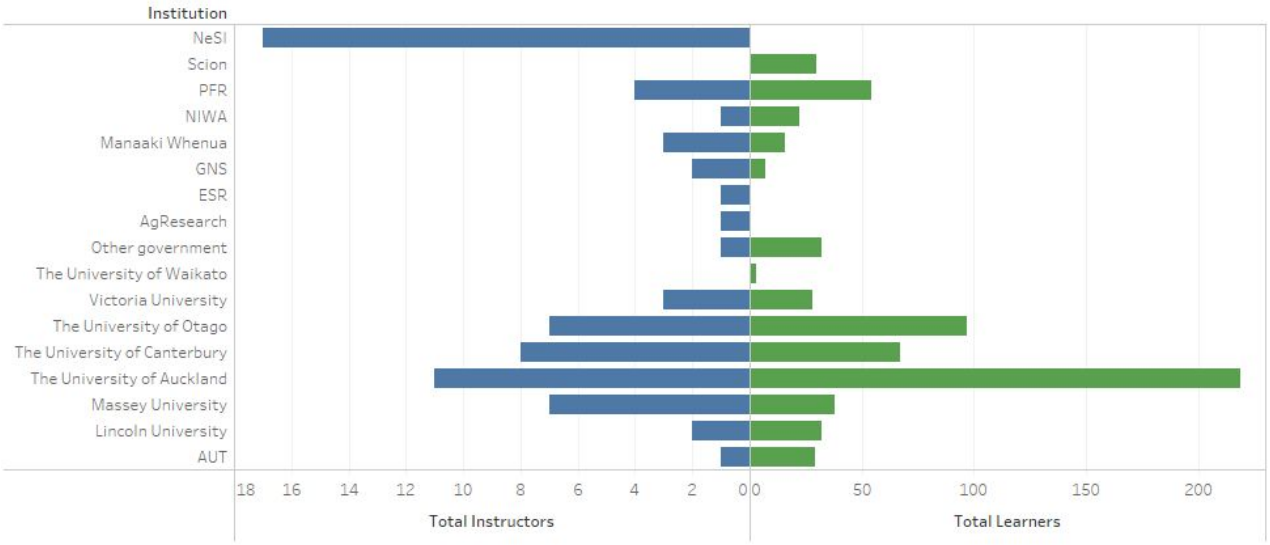

Figure 6. Graph showing the number of trained instructors and learners by institution.

Appendix B: Scale of NZ research workforce

New Zealand's researcher population can be broken down by career stage as well as by the type of organisation the researcher is hosted by[1].

Total research population

	HED	CRI	Other Gov	Business	TOTAL
Student[2]	16,400	N/A	N/A	N/A	16,400
Researcher + Tech	12,700	2,557	1,343	13,700	30,300
TOTAL	29,100	2,557	1,343	13,700	46,700

Table 7. Research population across different sectors and across career stages

Total population numbers alone are not indicative of the scale of demand for training as people spend varying amounts of time in any stage. Instead, adjusting the population to include turnover allows us to understand the scale of demand on a year-by-year basis[3]. See table 8 for the estimated turnover per year.

	Universities				Gov + Business[4]	TOTAL	TOTAL - RES ONLY
	Undergrad[5]	non-PhD res students[6]	PhD[7]	Research Staff[8]			
#	146,535	7,330	9,070	12,700	17,600	193,235	46,700
# per year (turnover per year)	48,845	7,330	3,023	378	378	59,954	11,109

Table 8. Research population turnover per year

[1] R&D Survey 2016, Stats NZ. Distribution of workforce are estimates based on numbers obtained from R&D 2016 survey, student enrolment, normalised to 2016 R&D, and CRI annual reports.
[2] While there are students working in CRIs, and other places, they are counted in Universities as they must be enrolled there.
[3] For example, it is assumed that undergraduates spend three years in this stage so there are actually only 48,845 students who could require training (146,535/3) each year if training initiatives are run continuously.
[4] Only 25% of PhD graduates continue in research
[5] Assumes a 3 year undergraduate programme
[6] Assumes 1 year, non-PhD research students (note that some of these are undergraduates therefore will be double-counted)
[7] Assumes a 3 year PhD programme
[8] Research Staff: Permanent research staff, ECRs and Technical staff; assumes research staff are 0:50 split between universities and other sectors

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