GRATTAN Institute

October 2013

The teaching-research nexus in higher education

Background paper supporting the
Taking university teaching seriously report

Ittima Cherastidtham, Julie Sonnemann and Andrew Norton

Grattan Institute Support

Founding members

Australian Government

State Government Victoria

The University of Melbourne

bhpbilliton resourcing the future

Program support

Higher Education Program

The Myer Foundation

Affiliate Partners

National Australia Bank

Google

Senior Affiliates

Wesfarmers

Stockland

GE Australia and New Zealand

PricewaterhouseCoopers

Affiliates

Arup

Urbis

The Scanlon Foundation

Lend Lease

Origin Foundation

Sinclair Knight Merz

EY

Grattan Institute Report No. 2013- 12, October 2013

This report was written by Andrew Norton, Grattan Institute Higher Education Program Director, and Grattan Institute Associates Ittima Cherastidtham and Julie Sonnemann.

Ling Tan, Daniel Edwards, Hamish Coates and Alexandra Radloff from the Australian Council for Educational Research analysed results from the Australasian Survey of Student Engagement and provided Staff Student Engagement Survey data.

Grattan Institute is an independent think-tank focused on Australian public policy. We aim to improve policy outcomes by engaging with both decision-makers and the community.

For further information on the Institute's programs, or to join our mailing list, please go to: http://www.grattan.edu.au/

This report may be cited as:
Cherastidtham, I., Sonnemann, J., and Norton, A., 2013, *The teaching-research nexus in higher education,* Grattan Institute, Melbourne.

ISBN: 978-1-925015-45-4

Overview

The *Taking university teaching seriously* report published by the Grattan Institute in July 2013 analysed the quality of teaching in Australian universities. It included a chapter on whether university research activity was an advantage or a disadvantage for teaching. That chapter was based on new empirical research into the teaching-research relationship in Australian universities. This paper expands on that chapter, providing more detail on statistical methods and results.

Many academics believe that there is a strong and positive relationship between teaching and research. The relationship is described as a 'teaching-research nexus'. Belief in the teaching-research relationship is backed by regulation that requires all universities to both teach and research.

A teaching-research nexus has not to date received much support from empirical studies. Typically, the international published research finds no relationship between teaching and research performance, or small negative or positive relationships.

Grattan's study makes a new contribution to the debate by exploring specific aspects of the nexus. For example, it analyses whether students in highly-rated research academic environments are more academically challenged than students in low-research academic environments, or receive more feedback from teachers. Results are reported at the detailed discipline level, which has not been done before in Australia.

These empirical results give us little reason to believe that teaching is improved when it is undertaken with research. The hypothesis that students would be more academically challenged in a high-research environment was not supported. Equally, these results do not strongly support the opposite hypothesis: that research is bad for the student experience. Overall, the level of research just doesn't seem to systematically affect teaching quality either way.

This paper also presents new findings comparing teacher characteristics in high and low-research environments. It finds teacher traits do not vary significantly between the two groups. Most universities hire people with limited teacher training. They mostly fill on-going academic jobs with roles that involve dual functions of teaching and research. Most universities are happy for temporary staff to do much of the teaching.

This paper shows that high- and low-research departments have similar teaching practices. As *Taking university teaching seriously* emphasises, the key to improving teaching is neither to remove research nor to promote a teaching-research nexus. It is a focus on practices and technologies known to improve teaching. The nexus should be left to rest.

Table of contents

Figures

Tables

1. Theories about the relationship between teaching and research

By law, every Australian university is a teaching and research institution.[1] The law codifies a strong belief in universities that their two main activities are positively linked. Yet this view has never been universally supported. There are theories and empirical evidence that can be used to support either case.

1.1 Common theories

Common positive and negative theories about the teaching-research relationship are outlined below.[2]

Positive theories

- Academics are better at developing advanced, up-to-date curricula. Research active staff may be better at designing curriculum involving student research projects.
- Students hold research-active teachers in high regard and are more engaged and challenged to learn from them.
- Researchers are passionate about the disciplines they teach, and will better motivate students.
- Researchers are better at instilling critical thinking and research skills in students, given these are skills they need in their research.
- Researchers are better placed to self-reflect on what teaching approaches work well, given their academic disposition to critique and review.
- Effective researchers are also likely to be effective teachers. Individuals who excel in any given field are likely to excel in other fields as well.

Negative theories

- Researchers may have less time and energy to devote to students. They may invest less effort in giving student feedback, class preparation, curriculum design or assessment.
- Students may be less engaged if they perceive academics to be less interested in teaching compared to research.
- Researchers don't necessarily have good presentation skills.
- Researchers may not be able to explain concepts clearly.
- Researchers may teach their research interests, rather than material that is more relevant to an undergraduate curriculum.

[1] DIICCSRTE (2012a)
[2] Drawn from Brew (2010), Zaman (2004), Trigwell (2005), Pascarella and Terenzini (2005), Marsh and Hattie (2002), Jenkins (2004), Hattie and Marsh (1996), Stappenbelt (2013)

Negative and positive theories may not always be mutually exclusive. Some claimed advantages and disadvantages could both be true. For example, the curriculum in research-intensive universities may be better, but academics may devote less time and effort to teaching it well. Students could be more motivated, but have teachers who are worse at explaining key concepts to them. Or there could be positive effects on teaching from research up to a point – such as designing a good course – but the relationship becomes negative if staff spend too much time on research.

Analysing the overall effect of the teaching-research relationship is difficult. The impact may vary between disciplines and subjects. In some subjects, the complexity of staff research may be so far ahead of the undergraduate curriculum that making strong connections with student learning is very difficult.[3] Some subjects may be more inquiry based than others, and have a greater need for inquiry based teaching.

Student perceptions also vary. Students in some courses may want a practical curriculum and view the teacher's research as a hindrance.[4] For academically-oriented students, a research-intensive department may be the right place even if its academics devote less time and energy to teaching.[5] For less academic students, access to cutting-edge research is likely to be a lower educational priority than a clear understanding of the basics.

1.2 Empirical evidence

The teaching-research nexus has been examined in a significant number of studies. Qualitative studies tend to report positive findings. This may reflect the fact that experts often strongly believe that teaching and research are positively related.[6]

Three major surveys of empirical research in the 1980s and 1990s find an overall correlation close to zero, or only a slightly positive relationship.[7] Some recent single-university studies continue the pattern of varied results. One found a positive relationship between the research productivity of academics and student performance on a standardised test.[8] However, another study found that weaker students achieved better grades if taught by non-tenure track academics, who are typically not paid to research.[9]

Results from the American National Survey of Student Engagement (NSSE) are consistent with a conclusion that the relationship is mildly negative. Figure 1 shows survey responses of students in 20 high-research doctoral-granting universities with those of students in 81 baccalaureate (undergraduate) colleges

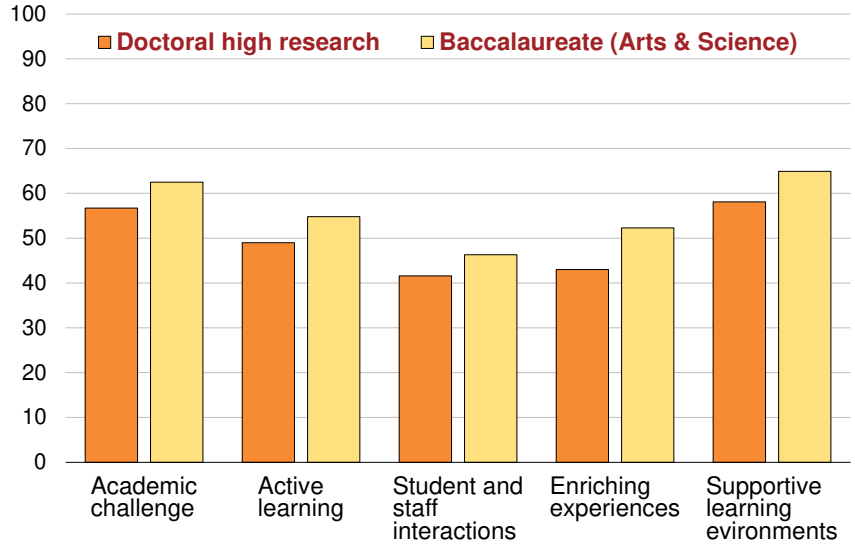
[3] Jenkins (2004)
[4] Jenkins and Healey (2005)
[5] For example, high ATAR students have high course completion rates, suggesting that they can overcome any difficulties caused by poor teaching: Norton (2013a), p. 7.

[6] Witte, *et al.* (2012)
[7] Hattie and Marsh (1996), Allen (1996), Feldman (1987), Faia (1976). However many studies use simple correlation estimates that do not control for other factors.
[8] Galbraith and Merrill (2012)
[9] Figlio, *et al.* (2013)

focusing on arts and sciences. The latter group is typically teaching-focused, though many academics who teach in these colleges are published researchers. As can be seen, the colleges out-perform the research universities on every scale.

Australian evidence on this issue is less common. A study published in the early 1990s found no or a negative relationship at both the individual academic and departmental level, with the exception of some former colleges of advanced education (which were later turned into or merged with universities).[10] A study published in 2002 of a large urban Australian university found a close to zero relationship.[11] A more recent Australian study found a negative correlation between research quality and teaching.[12]

Figure 1: Comparing high and low-research institutions, USA 2012



Source: NSSE (2012)

.

[10] Ramsden and Moses (1992)
[11] Marsh and Hattie (2002)
[12] Barrett and Milbourne (2012)

2. New Australian empirical work on the teaching-research relationship

The Grattan Institute has conducted new empirical work on the teaching-research relationship in the Australian context. Our research extends recent empirical work but differs in several ways.[13] It goes to the narrowest subject level the available data will permit. Earlier work uses only broad groupings that do not enable detailed discipline comparisons. Our research looks at individual questions in student surveys to more specifically explore various hypotheses about the teaching-research nexus. Finally, our work uses data from the Australasian Survey of Student Engagement (AUSSE), which has not previously been used to examine the teaching-research relationship.

2.1 Student survey data

Ideally, research into the teaching-research relationship would compare objective measures of student learning between academics or departments with different levels of research activity. However, such data is rare in higher education. Like much of the international literature on the teaching-research relationship we instead examine student survey results.

Although these surveys do not directly measure learning outcomes, the survey questions are based on research into what constitutes an effective learning environment.[14]

Two nationwide student surveys of undergraduates or recent bachelor-degree graduates are used:

- The AUSSE (2010, 2011), which includes first and later year undergraduate students.
- The Course Experience Questionnaire (CEQ) (2009, 2010), which surveys recently qualified graduates.

These are the best available Australian datasets at present. Further information on the AUSSE and CEQ surveys is included in Appendix G.

2.2 Identifying high and low-research groups

Initially we sought to assess the impact of research by comparing research-*free* to research-*rich* environments. However as most departments in Australian universities have at least some

[13] We refer to the recent study by Barrett and Milbourne (2012)

[14] For discussion of using student surveys to measure the learning environment see Carini, *et al.* (2006); Coates (2006); Kuh, *et al.* (2008); Pascarella, *et al.* (2010)

research activity, we compare high- and low- research departments.[15]

We use three criteria to identify high- and low-research departments:

- *Research excellence.* We use the Excellence in Research for Australia (ERA) ratings (2010) as a proxy. High-research departments must have an ERA rating of three or above (on a one to five rating scale). A rating of three means 'at world class standard'. Low-research departments must have an ERA rating showing 'insufficient research volume' i.e. less than 50 research publications over a six-year period.

  For our dataset, it was necessary to match ERA ratings reported at the 'field of research' level to corresponding 'field of education' categories (for details of the concordance of these categories, see Appendix A).[16]

- *Research activity*. We assess the level of research activity at the field of education level. High-research groups must have at least ten research students, and low-research groups must have fewer than ten research students.

- *Teaching activity*. We check there is a sufficient number of teaching students at the field of education level, as an indicator that the department has a substantive teaching role.

These criteria are summarised in table 1.

Table 1: Criteria for high and low-research groups

Criteria	High-research group	Low-research group
Research rating	ERA rating is 3 or above	ERA rating of insufficient volume
Research activity *(a)*	At least 10 research students	Fewer than 10 research students
Teaching activity *(b)*	More than 225 EFTSL	More than 225 EFTSL

(a) Research students are those in Doctorate by Research and Masters by Research.
(b) Taught students comprise EFTSL students in a bachelor, associate degree, other undergraduate, enabling courses, non-award courses. The average number of students by 4-digit field of education was 225 EFTSL, using DEEWR (2010) data.

2.3 The regression model

Regression analysis was used to assess the effect of research on teaching and learning. We used a mixed effects model which helps to identify discipline-specific effects. The model included both 'fixed' and 'random' components. The fixed component showed the effect of research that is constant across disciplines. The random component captured the differing effects of research by discipline. For further information on the mixed effects model

[15] The analysis is based on 'fields of education' which do not map perfectly onto departments. However, departments are a reasonable approximation in most case and the language of 'department' is more familiar.
[16] 'Fields of education' is an Australian Standard Classification of Education (ASCED), which defines the subject matter of educational activity. 'Fields of research' is an Australian and New Zealand Standard Research Classification (ANZSRC) which allows for the categorisation of research activity. Both classifications have three levels (2 digits, 4 digits, 6 digits code levels).

see Appendix B. To interpret the model's log-odds ratio, see Appendix F.

For our analysis, we transformed survey responses to binary variables. This was necessary for a mixed regression model with ordered multinomial dependent variables (see Appendix B for a discussion of the regression model).[17] For a given survey question, if the student survey raw score was greater than the median score, the outcome was coded to 1, and 0 otherwise. We then estimated the extent to which being in a high or low-research environment predicted being above or below the median score.

We ran a regression for each survey question. This gave us detailed information on whether student responses in high and low-research environments showed any differences for given survey items. In total, we examined 66 questions from both the AUSSE and the CEQ (see Appendix H for the list of questions). Our analysis spanned 37 universities and 22 disciplines overall (disciplines detailed in Appendix C).

For some questions there were no variations between disciplines, after controlling for other factors. In these cases, the disciplines were analysed together when estimating the effect of research (i.e. only the fixed effects were estimated).[18]

To isolate the effect of research, the analysis controls for other factors that influence teaching and learning. These are called explanatory variables, seen in table 2.

At the individual student level, we control for age, gender, citizenship, language background, part-time/full-time study, live on/off campus, level of qualification, double/single degree and disability.

We also include the median Australian Tertiary Admission Rank (ATAR) for the field of study in each university.[19] Potential differences in university populations were controlled for by creating five groupings relating to university prestige, geography and mission. Universities were classified as one of the following; Group of Eight, Australian Technology Network, gumtree, older regional or new generation (see Appendix E for more detail).

The modelling strategy for the AUSSE and CEQ is similar in technique but differs according to available data. Detailed descriptions are presented in Appendix D.

The sample size varies for each question and discipline. Sample sizes average around 2000 for CEQ and 350 for AUSSE.[20] We test significance at the 15% level, rather than the more common 5% or 10%. The benefit is that groups with smaller sample sizes could be included in the study. Testing at this level increases the

[17] The AUSSE 4 point scale is: 'very little', 'some', 'quite a bit' and 'very much'. The CEQ 5 point scale is: 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree', 'strongly agree'.
[18] For details on specific questions, see Appendix L

[19] We did not have individual student information on ATAR, and so used the median data collected by DIICCSRTE.
[20] This is the average sample size for each question by discipline. A minimum sample size of 20 responses was required as a threshold.

risk of a false positive. However, we consider this to be a conservative approach as it maximises our chances of finding a teaching-research relationship.

Table 2: Dependent and explanatory variables

Dependent	Explanatory variables		
	Individual	Department	University
CEQ questions / AUSSE questions	Age Gender On campus Full time / part-time Indigenous English as first language Born in Australia International Double degree Level of qualification Disability	High / low research ATAR Discipline	Grouped by prestige, location, mission

Further information is available on:

- The full list of variables used in AUSSE regressions (table 5 and table 6) and CEQ regressions (table 7 and table 8).
- The full list of questions in our study (table 12).
- The mean, median, standard deviation, maximum and minimum of outcome variables and independent variables for AUSSE regressions (table 14, table 15) and CEQ regressions (table 16 and table 17).
- The missing values strategy (Appendix I).
- Issues considered when jointly analysing AUSSE and CEQ results (Appendix J).

3. Findings from the Grattan teaching-research analysis

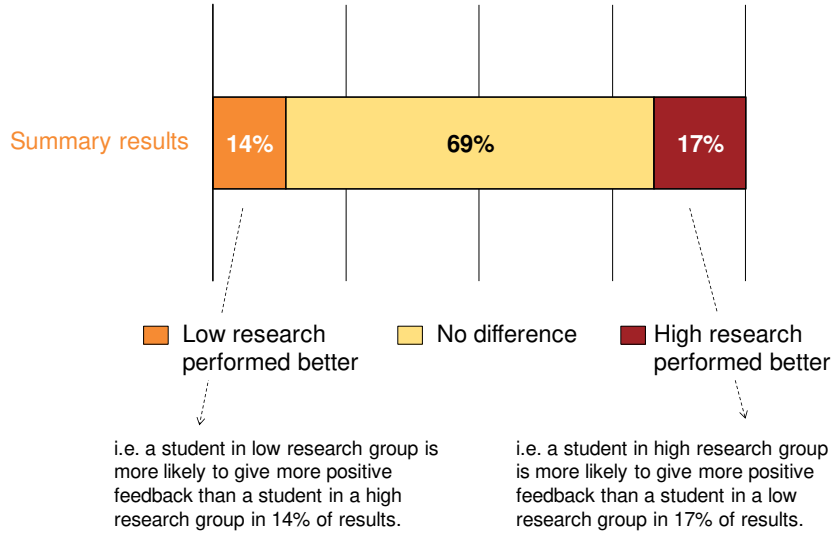
Overall, our empirical analysis shows that learning in a high-research environment is typically neither a negative nor a positive for students. There is no difference in 69 per cent of student survey results analysed, as seen in figure 2.

'No difference' does not necessarily mean that responses are identical. Rather, it means that after controlling for other factors, any observed gaps were sufficiently small that they were likely to occur by chance.

A small proportion of results show some difference between high- and low-research groups. Figure 2 shows that high-research environments perform better in 17 per cent of results, and low-research environments perform better in 14 per cent of results. Box 1 explains what a 'result' means in our analysis.

The next section provides a more detailed discussion of results. Appendix K includes all bar charts, and Appendix L includes results for individual survey questions by discipline. [21]

Figure 2: Summary of results from high and low-research groups



Note: 905 results were analysed across 66 questions and 22 disciplines. A 'result' is the estimated impact of research on students' survey responses to each question, by discipline.

[21] Estimates for control variables are not reported as they differ for different questions. Given we analyse 66 questions, it would be an onerous amount of data to report.

Box 1: What is a 'result'?

In our analysis, we run a regression for each of the 66 student survey questions. Each regression produces a series of 'results'; which are the estimated impacts of research for given disciplines. *One* result is the impact of research for a specific survey question and discipline.

If the result is positive, high-research departments perform better for that discipline and question. If it is negative, low-research departments perform better. If it is insignificant, there is no difference between the two groups.

When a high- or low-research group 'performs better', this means that students in that group are more likely to be more satisfied than students in the other group (for a particular question and discipline).

Our bar charts show the aggregated results. The charts highlight the proportion of results where high- or low-research groups perform better / worse / equally. Results for each question are weighted equally in the bar chart for simplicity. This assumes that survey questions have equal importance in terms of the student experience, which is not always the case. However, this approach is preferable to making many subjective judgments on the relative importance of each question.

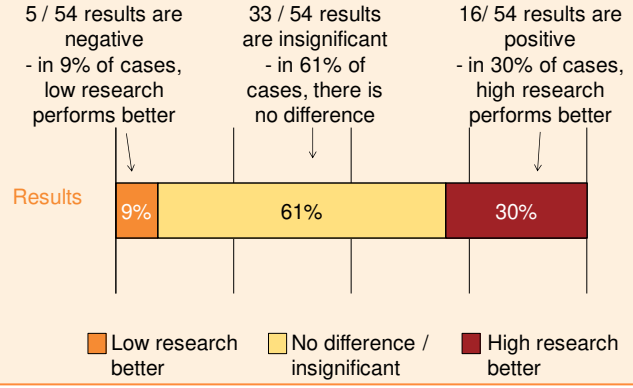
	Q1	Q2	Q3	Q4	Q5
Mathematical Sciences				0.3	
Biological Sciences				0.3	0.4
Information Systems				0.3	
Mechanical and Industrial Eng and Tech	0.2		0.1	0.3	
Electrical and Electronic Eng and Tech				0.3	-0.2
Building				0.3	
Environmental Studies				0.3	0.1
Medical Studies				0.3	
Nursing				0.3	
Rehabilitation Therapies				0.3	0.3
Teacher Education	-0.2	-0.3	-0.4	0.3	-0.3

A regression is run for each of the 66 questions

Each box is a 'result' - the estimated impact of research, for a given question and discipline

Insignificant estimate - no difference
Positive estimate - high research performs better
Negative estimate - low research performs better
Insufficient sample size

Of the 54 results (boxes) in the table above:



3.1 Detailed results

We analyse the summary results by organising questions into four topics;

i. Student engagement

ii. Skills development

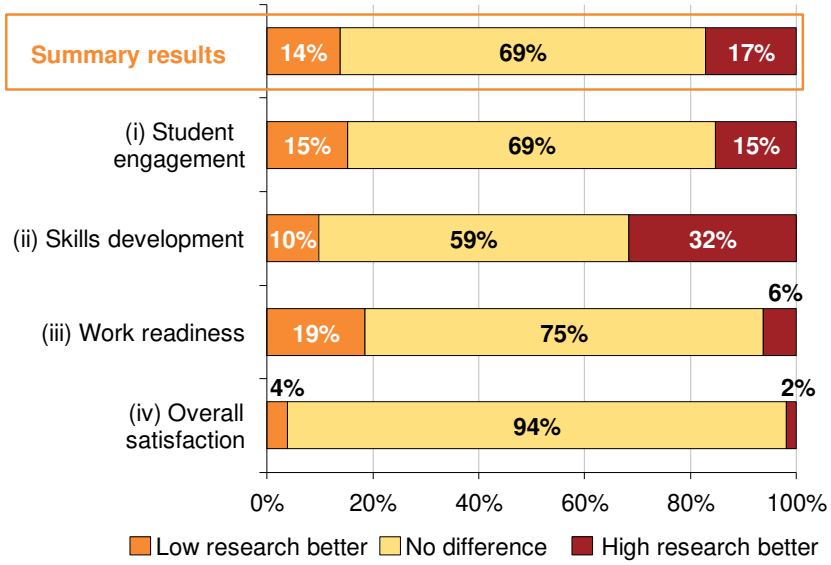
iii. Work readiness, and

iv. Overall satisfaction.

Across each of the four categories, the majority of results show no difference between high- and low-research departments. This is seen in figure 3.

Examining these four aspects of learning gives some nuance to the overall finding of mostly no difference. In skills development, high-research environments performed better in 32 per cent of results, compared to only 10 per cent for low-research environments. Low-research environments perform better in work readiness in 19 per cent of results, compared to only 6 per cent of results in high-research environments. For student engagement, low and high-research each performed better than the other in 15 per cent of results. Almost all (94 per cent) results on overall student satisfaction show no difference between the two groups.

Figure 3: Summary results across four topics



3.1.1 Student engagement

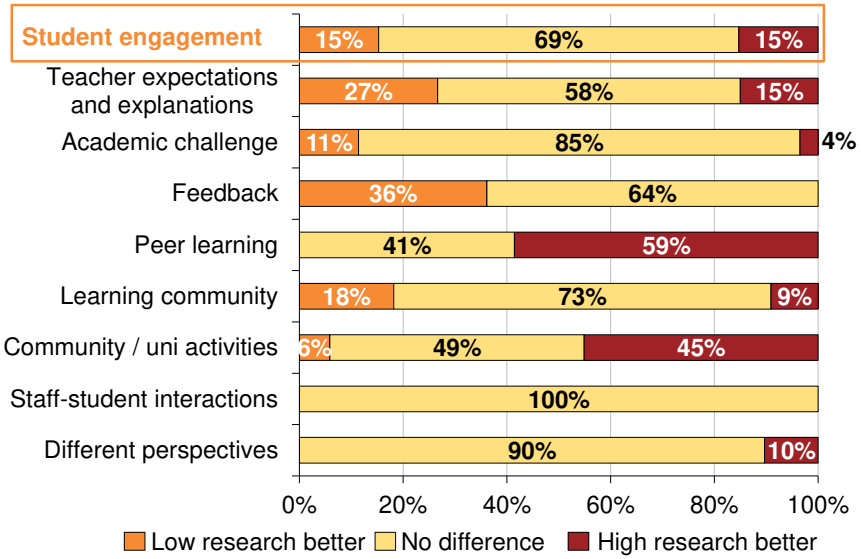
The AUSSE and CEQ questions on student engagement allow us to test some specific hypotheses about how teaching and research might interact. Academics in high-research departments may expect more of students due to their own expertise. They may also have more authority in the eyes of students due to their research achievements, or through their enthusiasm for inquiry inspire their students. If so, we would expect stronger results for high-research departments on measures of academic challenge.

Yet the data in our survey does not support this hypothesis. In a group of questions related to academic challenge, students in high-research environments scored more highly than those in low-research environments in only 4 per cent of results figure 4. The questions asked students whether they worked hard to meet teacher expectations, how much they were required to read for their course, and how much time they spent studying. A similar result was found for a question on whether teaching staff motivated students to do their best work.

A negative hypothesis about the teaching-research relationship is that more research means less time for students. Conversely, academics in departments with few research students and little research output should have more time available for students.

Questions regarding feedback on work give some support to this hypothesis. No results favoured high-research departments. By contrast, low-research departments out-performed high-research departments in 36 per cent of results. This outcome was largely driven by an AUSSE question about whether students "received prompt oral and written feedback...on academic performance." The low-research group performed better on this item in every discipline examined.

Figure 4: Student engagement results



Note: 419 results were analysed in the student engagement cluster.

However, in the student-staff interaction cluster, which also examines academic time use, there were no significant differences between high- and low-research groups. These

questions cover topics to do with discussing academic work with teachers outside class, or work with teachers on projects or other activities.

Students in high-research environments gave the most positive results in the "peer learning" cluster of questions. Nearly 60 per cent of results based on these questions favour the high-research group. They were more likely to say that they "worked with other students outside class to prepare assignments." Teachers in high-research environments may better incorporate group-based assignments into coursework, perhaps reflecting good practice to encourage peer learning, or employer feedback that they want graduates to have teamwork skills.[22] Yet this result may be due to time-constraint factors: possibly academics in high-research environments encourage peer assessment to reduce their own work, or students turn to each other because academic staff are less helpful.

[22] GCA (2012)

3.1.2 Skills development

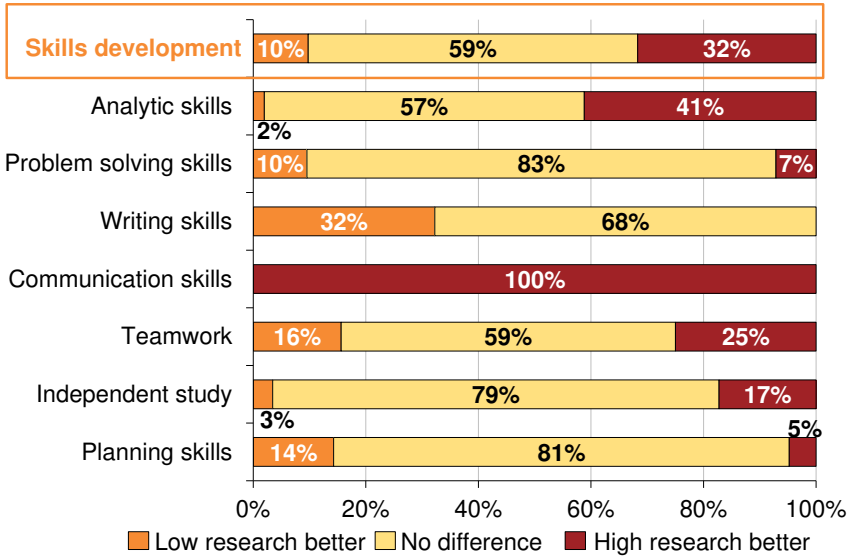
Students go to university to develop skills. These include cognitive skills and general personal skills valued by employers. Our surveys have questions on skills, but they should be treated with more caution than the student engagement questions. Skills questions typically ask students or graduates to evaluate their own development, a subject on which they may take an overly positive view.

The majority of results on skills development (59 per cent) show no difference between the high- and low-research environments (see figure 5). However, the high-research departments did better in this cluster of questions than in any other. In the remaining results, high-research environments perform better in 32 per cent of results, and low-research environments in 10 per cent of results.

On communication skills, the high-research group reported more development in all results.[23] The questions asked about speaking clearly and effectively and developing communication skills relevant to their discipline. High-research groups also reported strong development of their quantitative skills. Perhaps students admitted to universities that offer high-research environments have greater self-confidence than other students, which could result in over-optimistic beliefs about personal development. Further research would be needed to confirm this.

[23] This involved two survey questions, each comparing high- and low-research departments overall rather than by discipline.

Figure 5: Skills development results



Note: 246 results were analysed in the skills development cluster

There were no differences between the high- and low-research groups on a question about "thinking critically and analytically." The only skills development area in which low-research groups reported substantially more progress was on writing skills, coming out ahead on nearly a third of these questions.

3.1.3 Work readiness

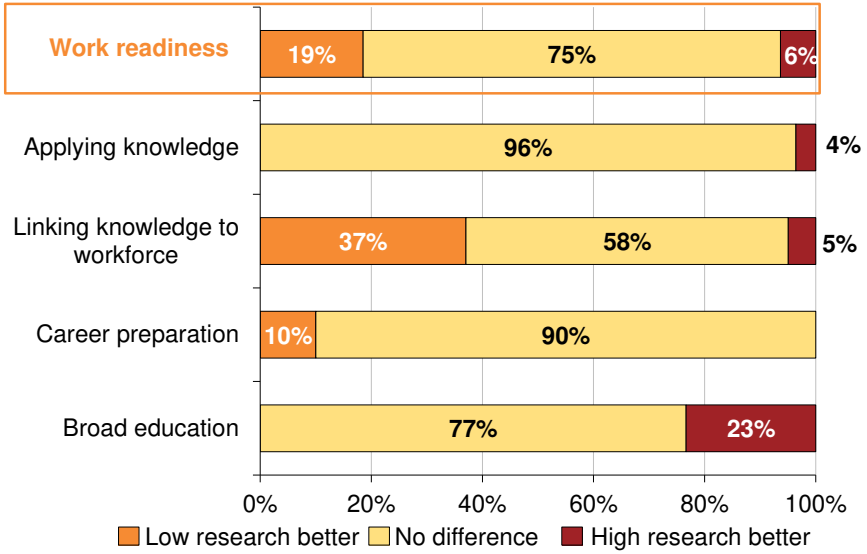
In Australia, most bachelor-degree graduates (about three-quarters) give a job-related reason as the main reason for study.[24] Low-research environments performed better in 19 per cent of work-readiness results, compared to only 6 per cent of results for high-research environments. Again, however, the vast majority of results (three quarters) show no difference in work readiness, as seen in figure 6.

The stronger result for low-research environments is largely driven by a question on "blended academic learning with workplace experience", where low-research performs better across all disciplines. This matches the common perception that low-research environments are more practical and work-oriented. Teachers in low-research environments may integrate work placements into their courses more often, or alternatively, their students may be more enthusiastic about work experience.

High-research environments performed better in providing a broad education in 23 per cent of results. This is also in line with a belief that high-research environments provide a broader, more rounded education which is valued by some employers.

[24] ABS (2010)

Figure 6: Work readiness results

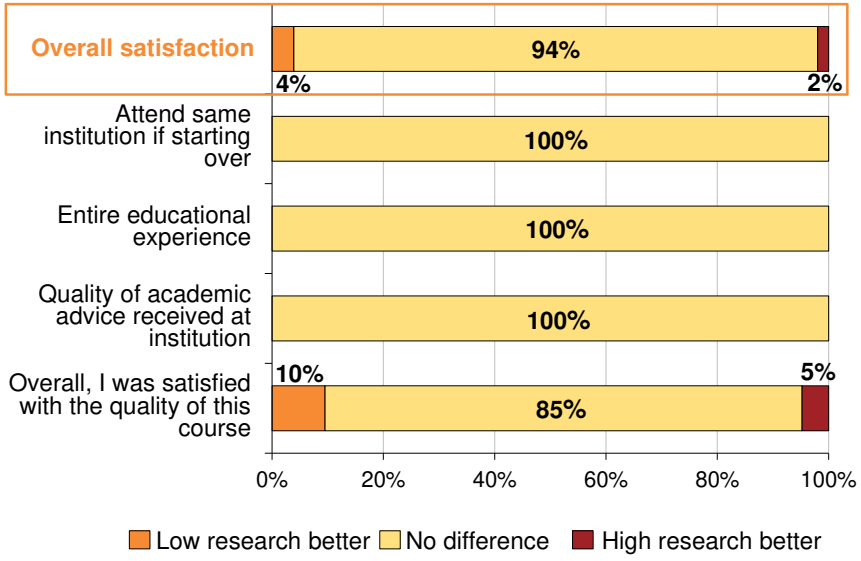


Note: 189 results were analysed in the work readiness cluster

3.1.4 Overall student satisfaction

Our results show little difference in overall student satisfaction between high and low-research groups, holding other factors constant (figure 7). In almost all results (94 per cent) there is no difference. There is no difference in 100 per cent of results in: whether students would attend the same institution starting over, satisfaction with the entire educational experience, and the perceived quality of academic advice received at the university.

Figure 7: Overall satisfaction results



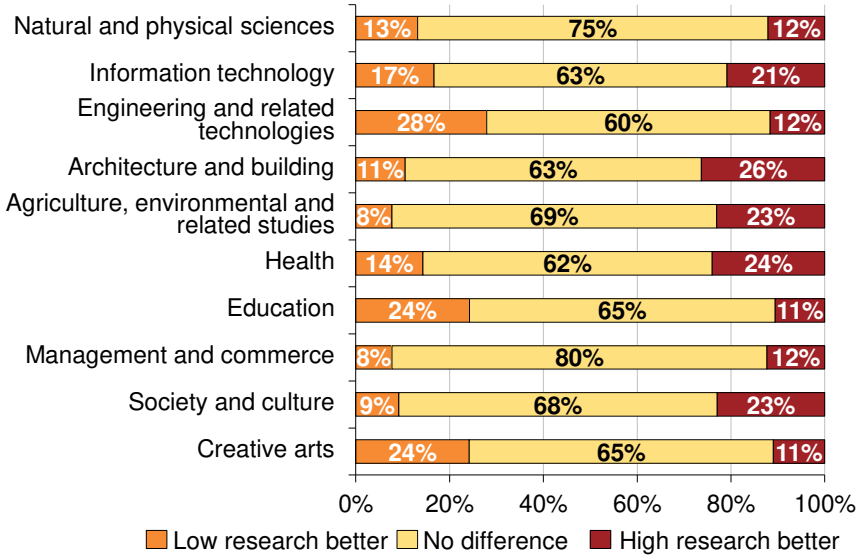
Note: 51 results were analysed in the satisfaction cluster

3.2 Discipline level results

Does the research nexus have different effects on disciplines? Figure 8 shows the results for each broad field of education. In every field at least 60 per cent of the results show no difference between high- and low-research groups.

Every field of education has a small percentage of results where high- and low-research environments perform better. While some fields of education have more positive results for high- or for low-groups than others, there is no obvious pattern to them. For example, high-research environments perform better in some more vocationally-oriented fields (such as architecture and building) but not others (such as management and commerce). Other discipline-specific factors not directly related to research intensiveness may be at play here. This could include, for example, differences in teacher quality or curriculum design between disciplines not directly controlled for in our study.

Figure 8: Results by broad field of education



Note: Results are presented across ten broad fields of education, composed of 22 disciplines.

4. Teacher characteristics in high- and low-research environments

The empirical findings in chapter 3 suggest that research intensiveness and the learning experience are not strongly related. Differences in research activity do not translate into reliable differences in teaching and learning. One possible reason for this is that teaching staff characteristics of the two groups do not differ greatly.

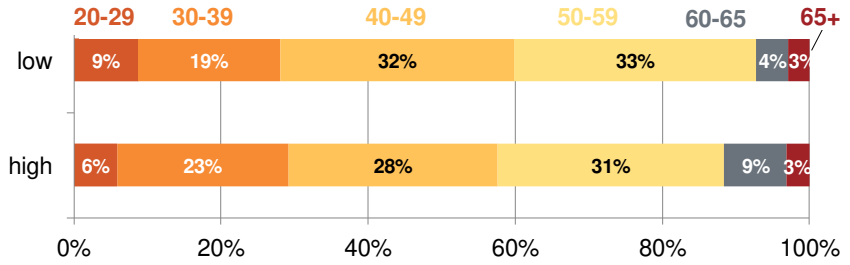
Our datasets do not connect individual students to individual academics. But the AUSSE has a parallel survey of staff, the Staff Student Engagement Survey (SSES), which gives information on staff age, seniority, working conditions, and views on teaching effectiveness. We use the SSES to compare the characteristics of teachers in the high- and low-research groups, using 600 staff responses in 2010.

4.1 Teacher age and seniority

Our dataset shows that teachers in high- and low-research groups have similar age profiles. Figure 9 shows the ages are largely skewed toward older teachers in both groups, with the majority of staff are between 40-49 and 50-59 years old. However in general there is a decent spread across all age groups. Research into the sessional academic workforce shows that staff are spread across most ages.[25]

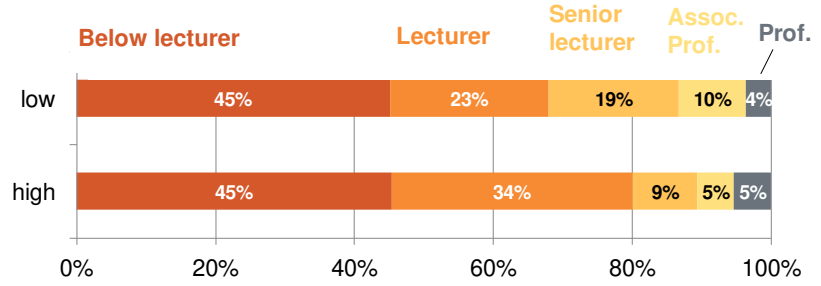
[25] Bexley, *et al.* (2011), p. 38

Figure 9: Age of teachers in high- and low-research groups, 2010



Note this excludes research-only staff. T-tests show the means are statistically significant at the 5% level. Source: ACER (2010)

Figure 10: Career level in high- and low-research groups, 2010



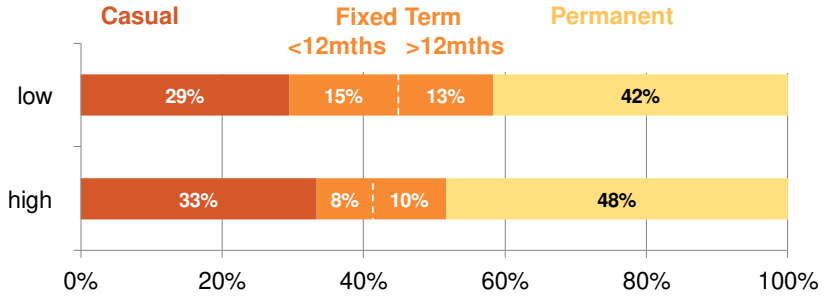
Note this excludes research-only staff. T-test shows the means are statistically significant at the 5% level. Source: ACER (2010)

Figure 10 shows that most teachers are either tutors, assistant lecturers and lecturers. Only a minority of teachers are professors, even in the high-research group. The most senior researchers do a small amount of teaching work.

Despite differences in research activity, both groups show a similar split of work duties. Around two-thirds of respondents are in mixed teaching and research roles, and about one third in teaching only roles.[26]

In addition, both groups have high levels of casual and fixed teaching staff. Less than half are permanent staff, as seen in figure 11. Across the sector, teaching seems to be treated as a low priority activity that can be delegated to temporary staff. However casual employment contracts do not necessarily mean that teaching staff have short-term relationships with their university. Another staff survey found that a third of sessional staff had worked for their university for four years or more.[27]

Figure 11: Teacher contracts in high and low-research groups, 2010



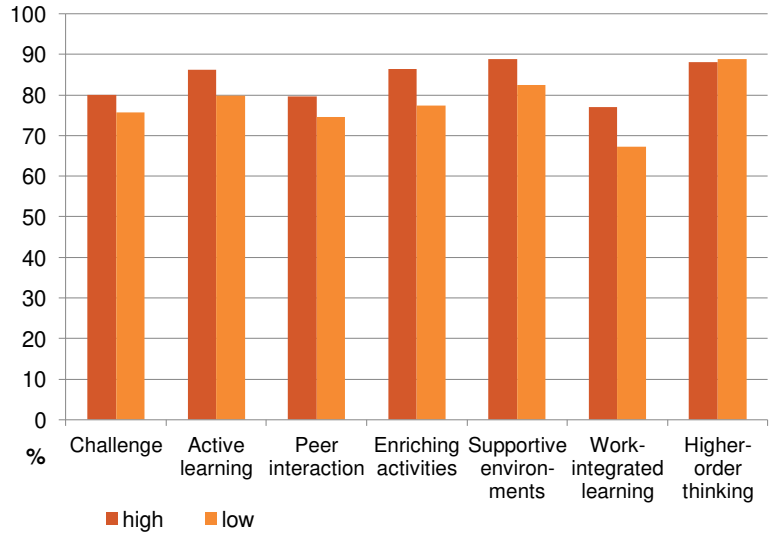
Note t-test shows the means are not statistically significant at the 5% level.
Source: ACER (2010)

4.2 Teacher views

Teachers in high- and low-research environments seem to share similar views on what matters for effective learning, as seen in figure 12. Respondents in the high-research group place slightly more importance on most factors, possibly showing a greater awareness or understanding. Except possibly for peer interaction, the student data in our analysis does not however provide evidence that this understanding translates into student experience.

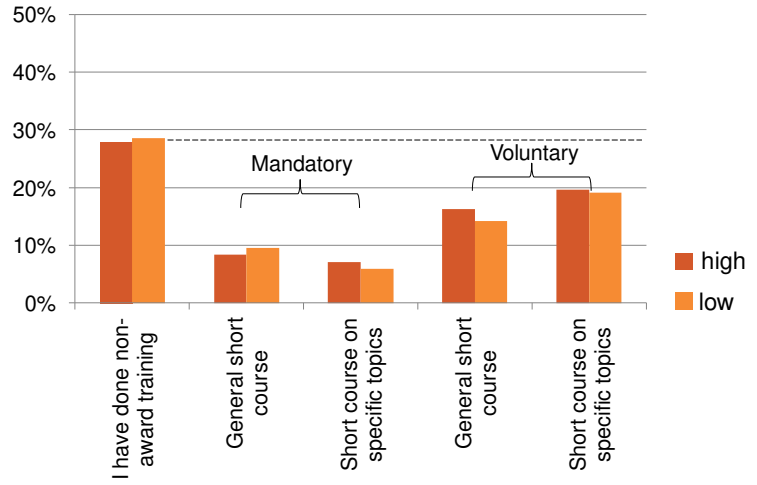
[26] This does not include Research-only roles. Only teachers are surveyed.
[27] Bexley, *et al.* (2011), p. 38

Figure 12: Teacher views on "importance" of certain behaviours



Note: Mean scores are rated on a 100 point scale. T-test shows the means are statistically significant at the 5% level, except for higher order thinking scale.
Source: ACER (2010)

Figure 13: Teacher training in high and low-research groups, 2010

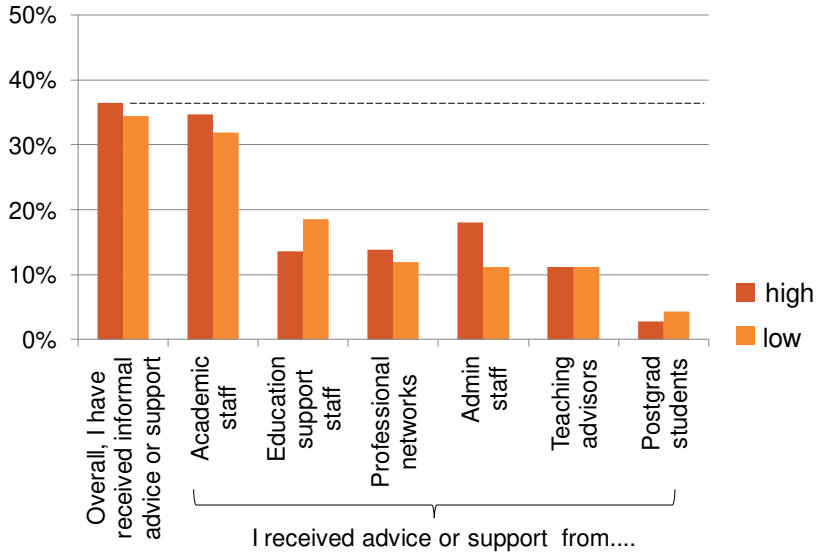


Source: ACER (2010)

4.3 Teacher training and support

Teacher training appears to be largely ad hoc in both groups. As seen in figure 13, less than 10% of staff have done mandatory short courses. Many teachers also appear to work in isolation throughout the sector. Figure 14 shows that in both groups, only one third of staff report receiving advice or support on teaching. It appears neither group has seriously sought to professionalise teaching.

Figure 14: Teacher advice and support, 2010



Source: ACER (2010)

5. Trends in research productivity and student satisfaction

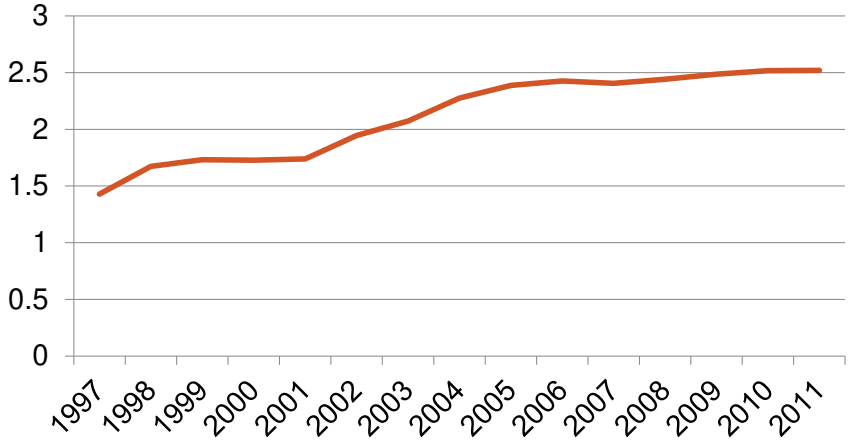
If a direct trade-off existed between time spent on teaching and research, we would expect their productivity measures to diverge. Better teaching would come at the expense of research, and more research would come at the expense of teaching. In practice, the relationship seems to be more complex than that.

5.1 Trends in research output

From the late 1980s, research funding has been linked to measures of research productivity, including numbers of publications.[28] As seen in figure 15, annual publications per academic trended up between 1997 and 2006, with slower growth from 2008. The numbers have been weighted to reflect the non-research responsibilities of academic staff.

Rewards for numbers of publications are sometimes criticised as promoting quantity over quality. The value of academic publications is inherently difficult to measure. Numbers of publications in prestigious journals, major awards, and frequency of citations are some of the proxy measures used. These measures are used by international university rankings. Since 2004, the number of Australian universities in the top 500 globally has increased from 14 to 19, and in the top 100 from 2 to 5.[29] Quantity does not seem to have crowded out quality.

Figure 15: Annual publications per researcher, 1997-2011



Source: DIICCSRTE (2012b); (various years).
Note: Academics often have multiple roles. Academics with teaching and research roles have been weighted at .4, to take account of their teaching, engagement and administrative responsibilities. Research-only academics have been weighted at .8.

[28] See Larkins and Croucher (2013) for the history, Norton (2013b) p 45-49 for current policy.

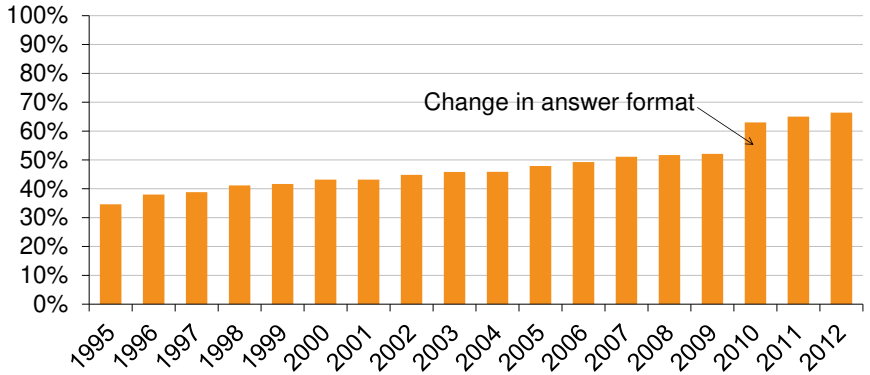
[29] ARWU (2013)

5.2 Trends in student satisfaction

Apart from a brief period between 2006 and 2009, there has been no government performance funding linked to student satisfaction. However, since 1996 reported student satisfaction with teaching has increased steadily, as seen in figure 16. This has occurred despite an increase in the number of students per teaching academic, and despite an overall increase in research publications.

Experience since the mid-1990s suggest that it is possible to simultaneously improve research and teaching performance. This points to the conclusion that university policies and practices are the key drivers of teaching and research performance.

Figure 16: Student satisfaction with teaching trends, 1995-2012



Notes:

1. *A student is interpreted as satisfied if they chose one of the top two points on a five-point scale. They are interpreted as dissatisfied if they choose on the lower two points on the scale. The overall good teaching scale averages student responses to six questions.*
2. *In 2010 a mid-point in a five-point scale, which had previously been unlabelled, was described as "neither agree nor disagree" with the proposition being offered (for example, "the staff put a lot of time into commenting on my work.") Possibly this means that satisfaction using the top two point definition was understated for previous years. However, CEQ respondents may have interpreted "neither agree nor disagree" as meaning they have no opinion, while they could have interpreted the unmarked mid-point as representing a view, such as 'middling' or 'mediocre' but not unsatisfactory.*

Source: GCA (1995-2013), Good teaching scale of the Course Experience Questionnaire.

6. Conclusion: the teaching-research relationship

The empirical results in this study give little reason to believe that teaching is improved by co-producing it with research. The hypothesis that students would be more academically challenged in a high-research environment was not supported by relevant questions in the AUSSE and CEQ. The hypothesis that academics in low-research environments might spend more time and effort on their students received partial support.

The relatively good results in some areas for students in high-research environments may be due to factors not directly related to research activity. Social connections among the students are more likely than academic research to cause greater involvement in the university community and more group study. Students in high-research environments report good results on skills development, but these are the questions most vulnerable to biased responses.

In some disciplines, access to the latest research may improve the curriculum. However, academics do not need to be active researchers to keep up with research activity. Scholarship involves "keeping abreast of the literature and new research...and using that knowledge to inform learning and teaching."[30] This can be done by teaching-focused academics, just as professionals in many other occupations keep up to date with research relevant to their work.

In the many degrees preparing students for future work, professional admission requirements limit differences between what universities teach. Universities can also buy advanced course content. This is one potential business model for massive open online course (MOOC) providers such as Coursera and edX.[31] They sell course materials developed by some of the world's leading research universities.

Although this study finds no evidence that research activity leads to a better teaching environment, equally it does not strongly support the opposite hypothesis: that research is bad for teaching. In some disciplines, students in high-research areas report less feedback than their contemporaries in low-research areas. But in many other disciplines this does not seem to be a problem. Overall, the level of research just doesn't seem to systematically affect teaching quality either way.

The likely reason is that Australia's universities have a common culture, which does not vary significantly with the level of research activity. They have similar approaches to staff recruitment and teaching. Although in theory universities with less research activity have the potential to devote more resources to improving teaching, in practice this opportunity has not been consistently taken up.

[30] TEQSA (2012), p. 37

[31] Norton, *et al.* (2013), p. 6-7. Even high-research universities are interested in doing this, with UWA replacing lectures in one its subject with a Stanford MOOC: Dodd (2013)

Grattan's *Taking university teaching seriously* report argues that these cultural and organisational factors are the key to improving teaching.[32] Fortunately, changes since the 1990s have seen student satisfaction with teaching improve slowly but steadily. That research productivity also improved through much of the same period demonstrates that there is no simple choice between good teaching and good research. With good management, teaching-research universities can improve teaching without compromising their research mission.

[32] Norton, *et al.* (2013)

Appendix A: Concordance

Table 3: Corresponding 'fields of research' and 'fields of education', Grattan analysis

Field of research, 4-digit level		Field of education, 4-digit level	
0101	Pure Mathematics	0101	Mathematical Sciences
0102	Applied Mathematics	0101	Mathematical Sciences
0103	Numerical and Computational	0101	Mathematical Sciences
0104	Statistics	0101	Mathematical Sciences
0105	Mathematical Physics	0101	Mathematical Sciences
0199	Other Mathematical Sciences	0101	Mathematical Sciences
0201	Astronomical and Space Sciences	0103	Physics and Astronomy
0202	Atomic, Molecular, Nuclear, Particle and Plasma Physics	0103	Physics and Astronomy
0203	Classical Physics	0103	Physics and Astronomy
0204	Condensed Matter Physics	0103	Physics and Astronomy
0205	Optical Physics	0103	Physics and Astronomy
0206	Quantum Physics	0103	Physics and Astronomy
0299	Other Physical Sciences	0103	Physics and Astronomy
0301	Analytical Chemistry	0105	Chemical Sciences
0302	Inorganic Chemistry	0105	Chemical Sciences
0303	Macromolecular and Materials Chemistry	0105	Chemical Sciences
0304	Medicinal and Biomolecular Chemistry	0105	Chemical Sciences
0305	Organic Chemistry	0105	Chemical Sciences
0306	Physical Chemistry (Incl. Structural)	0105	Chemical Sciences
0307	Theoretical and Computational Chemistry	0105	Chemical Sciences
0399	Other Chemical Sciences	0105	Chemical Sciences

Field of research, 4-digit level		Field of education, 4-digit level	
0401	Atmospheric Sciences	0107	Earth Sciences
0402	Geochemistry	0107	Earth Sciences
0403	Geology	0107	Earth Sciences
0404	Geophysics	0107	Earth Sciences
0405	Oceanography	0107	Earth Sciences
0406	Physical Geography and Environmental Geoscience	0107	Earth Sciences
0499	Other Earth Sciences	0107	Earth Sciences
0501	Ecological Applications	0509	Environmental Studies
0502	Environmental Science and Management	0509	Environmental Studies
0503	Soil Sciences	0501	Agriculture
0599	Other Environmental Sciences	0599	Other Agriculture, Environmental and Related Studies
0601	Biochemistry and Cell Biology	0109	Biological Sciences
0602	Ecology	0109	Biological Sciences
0603	Evolutionary Biology	0109	Biological Sciences
0604	Genetics	0109	Biological Sciences
0605	Microbiology	0109	Biological Sciences
0606	Physiology	0109	Biological Sciences
0607	Plant Biology	0109	Biological Sciences
0608	Zoology	0109	Biological Sciences
0699	Other Biological Sciences	0109	Biological Sciences
0701	Agriculture, Land and Farm Management	0501	Agriculture
0702	Animal Production	0501	Agriculture
0703	Crop and Pasture Production	0503	Horticulture and Viticulture
0704	Fisheries Sciences	0507	Fisheries Studies
0705	Forestry Sciences	0505	Forestry Studies

Field of research, 4-digit level		Field of education, 4-digit level	
0706	Horticultural Production	0503	Horticulture and Viticulture
0707	Veterinary Sciences	0611	Veterinary Studies
0799	Other Agricultural and Veterinary Sciences	0599	Other Agriculture, Environmental and Related Studies
0801	Artificial Intelligence and Image Processing	0201	Computer Science
0802	Computation Theory and Mathematics	0201	Computer Science
0803	Computer Software	0201	Computer Science
0804	Data Format	0201	Computer Science
0805	Distributed Computing	0201	Computer Science
0806	Information Systems	0203	Information Systems
0807	Library and Information Studies	0913	Librarianship, Information Management and Curatorial Studies
0899	Other Information and Computing Sciences	0299	Other Information Technology
0901	Aerospace Engineering	0315	Aerospace Engineering and Technology
0902	Automotive Engineering	0305	Automotive Engineering and Technology
0903	Biomedical Engineering	0399	Other Engineering and Related Technologies
0904	Chemical Engineering	0303	Process and Resources Engineering
0905	Civil Engineering	0309	Civil Engineering
0906	Electrical and Electronic Engineering	0313	Electrical and Electronic Engineering and Technology
0907	Environmental Engineering	0399	Other Engineering and Related Technologies
0908	Food Sciences	0303	Process and Resources Engineering
0909	Geomatic Engineering	0311	Geomatic Engineering
0910	Manufacturing Engineering	0301	Manufacturing Engineering and Technology
0911	Maritime Engineering	0317	Maritime Engineering and Technology
0912	Materials Engineering	0303	Process and Resources Engineering
0913	Mechanical Engineering	0307	Mechanical and Industrial Engineering and Technology
0914	Resources Engineering and Extractive Metallurgy	0303	Process and Resources Engineering

Field of research, 4-digit level		Field of education, 4-digit level	
0915	Interdisciplinary Engineering	0399	Other Engineering and Related Technologies
0999	Other Engineering	0399	Other Engineering and Related Technologies
1001	Agricultural Biotechnology	0199	Other Natural and Physical Sciences
1002	Environmental Biotechnology	0199	Other Natural and Physical Sciences
1003	Industrial Biotechnology	0199	Other Natural and Physical Sciences
1004	Medical Biotechnology	0199	Other Natural and Physical Sciences
1005	Communications Technologies	0313	Electrical and Electronic Engineering and Technology
1006	Computer Hardware	0313	Electrical and Electronic Engineering and Technology
1007	Nanotechnology	0105	Chemical Sciences
1099	Other Technology	0399	Other Engineering and Related Technologies
1101	Medical Biochemistry and Metabolomics	0199	Other Natural and Physical Sciences
1102	Cardiovascular Medicine and Haematology	0601	Medical Studies
1103	Clinical Sciences	0199	Other Natural and Physical Sciences
1104	Complementary and Alternative Medicine	0619	Complementary Therapies
1105	Dentistry	0607	Dental Studies
1106	Human Movement and Sports Science	0617	Rehabilitation Therapies
1107	Immunology	0601	Medical Studies
1108	Medical Microbiology	0199	Other Natural and Physical Sciences
1109	Neurosciences	0109	Biological Sciences
1110	Nursing	0603	Nursing
1111	Nutrition and Dietetics	0699	Other Health
1112	Oncology and Carcinogenesis	0601	Medical Studies
1113	Ophthalmology and Optometry	0609	Optical Science
1114	Paediatrics and Reproductive Medicine	0601	Medical Studies
1115	Pharmacology and Pharmaceutical Sciences	0605	Pharmacy

Field of research, 4-digit level		Field of education, 4-digit level	
1117	Public Health and Health Services	0613	Public Health
1199	Other Medical and Health Sciences	0699	Other Health
1201	Architecture	0401	Architecture and Urban Environment
1202	Building	0403	Building
1203	Design Practice and Management	1005	Graphic and Design Studies
1204	Engineering Design	0399	Other Engineering and Related Technologies
1205	Urban and Regional Planning	0401	Architecture and Urban Environment
1299	Other Built Environment and Design	0401	Architecture and Urban Environment
1301	Education Systems	0703	Curriculum and Education Studies
1302	Curriculum and Pedagogy	0703	Curriculum and Education Studies
1303	Specialist Studies in Education	0701	Teacher Education
1399	Other Education	0799	Other Education
1401	Economic Theory	0919	Economics and Econometrics
1402	Applied Economics	0919	Economics and Econometrics
1403	Econometrics	0919	Economics and Econometrics
1499	Other Economics	0919	Economics and Econometrics
1501	Accounting, Auditing and Accountability	0801	Accounting
1502	Banking, Finance and Investment	0811	Banking, Finance and Related Fields
1503	Business and Management	0803	Business and Management
1504	Commercial Services	0803	Business and Management
1505	Marketing	0805	Sales and Marketing
1506	Tourism	0807	Tourism
1507	Transportation and Freight Services	0899	Other Management and Commerce
1599	Other Commerce, Management, Tourism and Services	0899	Other Management and Commerce
1601	Anthropology	0903	Studies in Human Society

Field of research, 4-digit level		Field of education, 4-digit level	
1602	Criminology	0999	Other Society and Culture
1603	Demography	0903	Studies in Human Society
1604	Human Geography	0903	Studies in Human Society
1605	Policy and Administration	0901	Political Science and Policy Studies
1606	Political Science	0901	Political Science and Policy Studies
1607	Social Work	0905	Human Welfare Studies and Services
1608	Sociology	0903	Studies in Human Society
1699	Other Studies in Human Society	0999	Other Society and Culture
1701	Psychology	0907	Behavioural Science
1702	Cognitive Sciences	0907	Behavioural Science
1799	Sciences	0907	Behavioural Science
1801	Law	0909	Law
1802	Maori Law	0911	Justice and Law Enforcement
1899	Other Law and Legal Studies	0911	Justice and Law Enforcement
1901	Art Theory and Criticism	1099	Other Creative Arts
1902	Film, Television and Digital Media	1007	Communication and Media Studies
1903	Jouralism and Professional Writing	1007	Communication and Media Studies
1904	Performing Arts and Creative Writing	1001	Performing Arts
1905	Visual Arts and Crafts	1003	Visual Arts and Crafts
1999	Other Studies in Creative Arts and Writing	1099	Other Creative Arts
2001	Communication and Media Studies	1007	Communication and Media Studies
2002	Cultural Studies	0903	Studies in Human Society
2003	Language Studies	0915	Language and Literature
2004	Linguistics	0915	Language and Literature
2005	Literary Studies	0915	Language and Literature

2099	Other Language, Communication and Culture	0999	Other Society and Culture
2101	Archaeology	0903	Studies in Human Society
2102	Curatorial and Related Studies	0913	Librarianship, Information Management and Curatorial Studies
2103	Historical Studies	0903	Studies in Human Society
2199	Other History and Archaeology	0903	Studies in Human Society
2201	Applied Ethics	0917	Philosophy and Religious Studies
2202	History and Philosophy of Specific Fields	0917	Philosophy and Religious Studies
2203	Philosophy	0917	Philosophy and Religious Studies
2204	Religion and Religious Studies	0917	Philosophy and Religious Studies
2299	Other Philosophy and Religious Studies	0917	Philosophy and Religious Studies

Based on Grattan analysis, using the Australian Standard Classification of Education (ASCED) manual

Appendix B: Mixed Logit Model

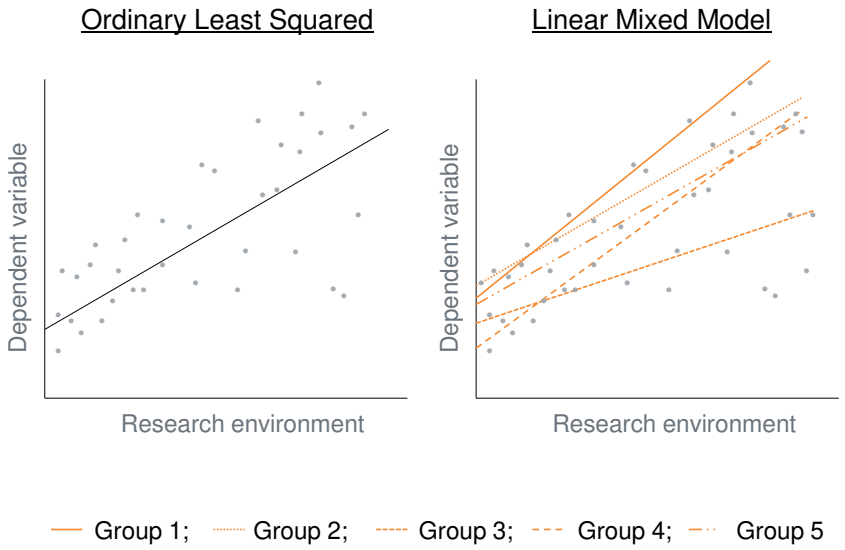
The Mixed Logit Model (MLM) is one of the most promising discrete choice models available.[33] The model accommodates various hierarchies often present in datasets, offering greater flexibility in regression analysis.

In classical statistics, a typical assumption is that observations are randomly drawn from the population and are independent and identically distributed. However, this is unrealistic for clustered data. In most social sciences study, data consists of hierarchical framework. Observations between levels or clusters are independent, but observations within each cluster are correlated as they belong to the same sub-population. The MLM allows the presence of correlation between subjects. It does not require the highly restrictive assumption of irrelevant alternatives, a characteristic of the MLM.

The MLM contains both 'fixed' and 'random' components, which allow for the inclusion of random deviation other than those associated with overall error term. The random component reflects the correlation amongst the observations from the same group.

Figure 17 shows a comparison between an identical data set using different Ordinary Least Squared (OLS) versus Linear Mixed Model. Clearly, the benefit of multiple intercepts and slopes allow for better representation of the data and therefore improves the accuracy of inferences.

Figure 17: Comparison between OLS and LMM



[33] Hensher and Greene (2003)

Mixed Models may be expressed in different but inherently equivalent forms. However, the formal generalized representation is as follows. [34]

$$y_{i,t} = \beta_1 x_{1,i,t} + \cdots + \beta_P x_{P,i,t} + \mu_1 z_{1,i,t} + \cdots + \mu_Q z_{Q,i,t} + \varepsilon_{i,t}$$

$$b_{i,j} \sim N(0, \varphi_j^2)$$
$$Cov(b_j, b_{j'}) = \varphi_{jj'}$$

$$\varepsilon_{i,l} \sim N(0, \sigma^2 \lambda_{i,l,l})$$
$$Cov(\varepsilon_{i,l}, \varepsilon_{i,l'}) = \sigma^2 \lambda_{i,l,l'}$$

where:

- $y_{i,t}$ is the value of the response variable
- $\beta_1, \cdots, \beta_P$ are the fixed-effect coefficients, which are identical for all groups
- $x_{1,i,t}, \cdots, x_{P,i,t}$ are the fixed-effect regressors, including a constant
- $\mu_1, \cdots, \mu_Q$ are the random-effect coefficients, which vary between groups. They are assumed to be multivariately normally distributed.
- $z_{1,i,t}, \cdots, z_{Q,i,t}$ are the random-effect regressors
- φ_j^2 are the variances and $\varphi_{jj'}$ are the covariance matrix for random effects. It is assumed to be constant across groups
- $\varepsilon_{i,l}$ is the error of observation l in group i
- $\sigma^2 \lambda_{i,l,l'}$ are the covariance matrix of errors in group i
- Note that once the model is estimated, an log-likelihood test is used to evaluate the significance of $high\_research$. If the test results in insignificance, the $high\_research$ variable is removed from the Z matrix.

Equivalently, the model can be presented in matrix form below.[35]

$$\boldsymbol{Y}_{i,t} = \boldsymbol{X}_{i,t}\boldsymbol{\beta} + \boldsymbol{\mu}_i \boldsymbol{Z} + \boldsymbol{\varepsilon}_{i,t}$$

where the matrices symbol correspond to the generalised representation of the last model.

We tested our analysis for the presence of multi-collinearity. Multi-collinearity is a common problem arising from the presence of covariance/correlation between the independent variables. A severe multi-collinearity problem violates a classical assumption of Multiple Linear/Non-linear Regressions, which is no perfect collinearity. Severe multi-collinearity problem does not bias the estimates, but it inflates the variance, which results in over acceptance of the null hypothesis for individual parameters. Further, it can also decrease the stability of the model.

[34] Laird and Ware (1982)

[35] Fox and Weisberg (2002)

Variance Inflation Factor (VIF) is a way to diagnose potential problem of multicollinearity. The VIF represents how much the standard errors have been inflated due to the collinearity of variables. We estimated the VIF with our sample data and found no significant issues with multi-collinearity.

Appendix C: Fields of education

Table 4: Fields of education used in Grattan study

	2-digit level	4-digit level
1	natural and physical sciences	mathematical sciences
1	natural and physical sciences	biological sciences
2	information technology	information systems
3	engineering and related technologies	mechanical and industrial engineering and technology
3	engineering and related technologies	electrical and electronic engineering and technology
4	architecture and building	building
5	agriculture, environmental and related studies	environmental studies
6	health	medical studies
6	health	nursing
6	health	rehabilitation therapies
7	education	teacher education
8	management and commerce	accounting
8	management and commerce	sales and marketing
8	management and commerce	banking, finance and related fields
9	society and culture	studies in human society
9	society and culture	human welfare studies and services
9	society and culture	behavioural science
9	society and culture	language and literature
9	society and culture	philosophy and religious studies
9	society and culture	economics and econometrics
10	creative arts	graphic and design studies
10	creative arts	communication and media studies

Appendix D: Model specifications

The modelling strategy for each survey is similar in technique but differs according to the available data. Detailed descriptions are presented below.

AUSSE

The regression model can be described using the equation below, (with variables described in table 5 and table 6).

$$logit\left(\boldsymbol{AuSSE}_{ID,t}\right) = \boldsymbol{X}_{ID,t}\boldsymbol{\beta} + Z_{ID}\, U_{ID} + \boldsymbol{\varepsilon}_{ID,t}$$

ID represents four-digit Fields of Education

t represents student call identification for a 4-digit Field of Education

$\boldsymbol{\beta} = [\beta_1 \quad \dots \quad \beta_{25}]$ are the fixed-effect coefficients (including the intercept), which are identical for all groups of disciplines (ID)

$\boldsymbol{X}$ contains 24 variables which are described in table 5.

$high\_research$ is the high-research dummy, which is part of Z.

Z is an $N \times 1$ covariate matrix for the random effects U

U is the vector of random-coefficients for each group of disciplines

Once the model is estimated, an log-likelihood test is used to evaluate the significance of $high\_research$. If the test results in insignificance, the $high\_research$ variable is removed from the Z matrix.

Table 5: AUSSE regression variables

$\boldsymbol{AuSSE}_{ID,t}$			$\boldsymbol{X}_{ID,t}$		$\boldsymbol{Z}_{ID}$
EF_AC1	EF_SI4	LO_GL3	age		high_research
EF_AC2	EF_SI5	LO_GL4	age_squared		
EF_AC3	EF_SI6	LO_GL5	multilingual		
EF_AC4	EF_EE3	LO_GL6	male		
EF_AC5	EF_EE11	LO_GL7	disab		
EF_AC6	EF_WL1	LO_GL8	atsi		
EF_AC7	EF_WL2	LO_GL9	FT_study		
EF_AC8	EF_WL3	LO_GD4	on_campus		
EF_AC9	EF_WL4	LO_GD6	Auspermres		
EF_AC10	EF_WL5	LO_CR1	ATAR		
EF_AC11	EF_WL6	LO_CR2	Go8		
EF_AL1	LO_HT1	LO_CR3	ATN		
EF_AL2	LO_HT2	LO_CR4	Gumtree		
EF_AL4	LO_HT3	LO_CR5	Old_regional		
EF_AL5	LO_HT4	LO_OS1	New_gen_regional		
EF_AL6	LO_GL1	LO_OS2	Size		
EF_SI3	LO_GL2	LO_OS3	PE1	SL2	
			PE2	LE1	
			ED1	LE2	
			SL1	SL2	
			high_research		

Table 6: AUSSE regression variables - values

Variable name	Correspondence	Values
age	Age of respondents	Continuous
multilingual	Multilingual	1 for multilingual respondent, 0 for monolingual respondent
male	Sex	1 for male, 0 for female
disab	Disability	1 for disabled respondent, 0 for otherwise
atsi	Aboriginal and/or Torres Strait	1 for Aboriginal and/or Torres Strait Islander, 0 for otherwise
FT_study	Full time study	1 for Fulltime student, for otherwise
on_campus	On campus	1 for on campus student, 0 for otherwise
Auspermres	Australian permanent residence	1 for Australian permanent resident respondent, 0 for otherwise
ATAR	Australian Tertiary Admission Rank	Continuous
Go8	Group of Eight universities	1 if the respondent attends a Group of Eight university, 0 otherwise
ATN	Australian Technology Network of universities	1 if the respondent attends an Australian Technology Network of university, 0 otherwise
Gumtree		1 if the respondent attends a Gumtree university, 0 otherwise
Old_regional	Old regional universities	1 if the respondent attends an Old Regional university, 0 otherwise
New_gen_regional	New generation regional universities	1 if the respondent attends a New Generation Regional university, 0 otherwise
Size	Number of students taught	Continuous
PE1	How often the respondent discusses ideas from their readings or classes with others outside class	1 for never, 2 for sometimes, 3 for often, 4 for very often
PE2	Relationships with other students	1 for Unfriendly, unsupportive, sense of alienation, 2-6 represent the scale between 1 and 7 7 Friendly, supportive, sense of belonging
ED1	How well do you know about study group or learning community	1 for do not know about, 2 for have not decided, 3 for do not plan to do, 4 for plan to do, 5 for done

Variable name	Correspondence	Values
SL1	How well the university provides the support the respondent needs to socialise	1 for very little, 2 for some, 3 quite a bit, 4 very much
SL2	How well the university provides the support the respondent needs to succeed academically	1 for very little, 2 for some, 3 Quite a bit, 4 very much
LE1	Relationship with administrative personnel and services	1 for unfriendly, unsupportive, sense of alienation, 2-6 represent the scale between 1 and 7, 7 friendly, supportive, sense of belonging
high_research	Is the respondent studying in a high-research environment	1 for high-research environment, 0 otherwise

CEQ

The regression model can be described using the equation below (with variables described in table 7 and table 8).

$$logit(\boldsymbol{CEQ}_{ID,t}) = \boldsymbol{X}_{ID,t}\boldsymbol{\beta} + Z_{ID}\, U_{ID} + \boldsymbol{\varepsilon}_{ID,t}$$

where:

- ID represents four-digit Fields of Education
- t represents student call identification for a specific four-digit Fields of Education
- $\boldsymbol{\beta} = [\beta_1 \quad \dots \quad \beta_{25}]$ are the fixed-effct coefficients (including the intercept), which are identical for all groups of disciplines (ID)
- $\boldsymbol{X}$ contains variables described in table 7 and table 8.
- $high\_research$ is the high-research dummy variable, which is part of Z.
- Z is an $N \times 1$ covariate matrix for the random effects U
- U is the vector of random-coefficients for each group of disciplines

Table 7: CEQ regression variables

$\boldsymbol{CEQ}_{ID,t}$	$\boldsymbol{X}_{ID,t}$	$\boldsymbol{Z}_{ID}$
ceq101	age	high_research
ceq103	age_squared	
ceq127	male	
ceq115	disab	
ceq110	atsi	
ceq108	FT_study	
ceq139	on_campus	
ceq146	bornaust	
ceq106	ATAR	
ceq114	Go8	
ceq123	ATN	
ceq142	Gumtree	
ceq132	Old_regional	
ceq143	New_gen_regional	
ceq111	double_degree	
ceq117	size	
ceq136	high_research	
ceq140		
ceq148		
ceq149		
ceq118		
ceq131		

Table 8: CEQ regression variables - values

Variable name	Correspondence	Values
age	Age of respondents	Continuous
age_squared	Age of respondents squared	Continuous
male	Sex	1 for male, 0 for female
disab	Disability	1 for disabled respondent, 0 for otherwise
atsi	Aboriginal and/or Torres Strait	1 for Aboriginal and/or Torres Strait Islander, 0 for otherwise
FT_study	Full time study	1 for fulltime student, for otherwise
on_campus	On campus	1 for on campus student, 0 for otherwise
bornaust	Born in Australia	1 for born in Australia, 0 for otherwise
ATAR	Australian Tertiary admission rank	Continuous
Go8	Group of Eight universities	1 if the respondent attends a Group of 8 universities, 0 otherwise
ATN	Australian Technology Network of universities	1 if the respondent attends an Australian Technology Network of universities, 0 otherwise
Gumtree		1 if the respondent attends a gumtree universities, 0 otherwise
Old_regional	Old regional universities	1 if the respondent attends an old regional universities, 0 otherwise
New_gen_regional	New generation regional universities	1 if the respondent attends a new generation regional universities, 0 otherwise
size	Number of students taught	Continuous
double_degree	Enrolled in a double degree	1 for double degree, 0 otherwise
high_research	Studied in a high-research environment	1 for high-research environment, 0 otherwise

Appendix E: University groupings

Table 9: University groupings for our study

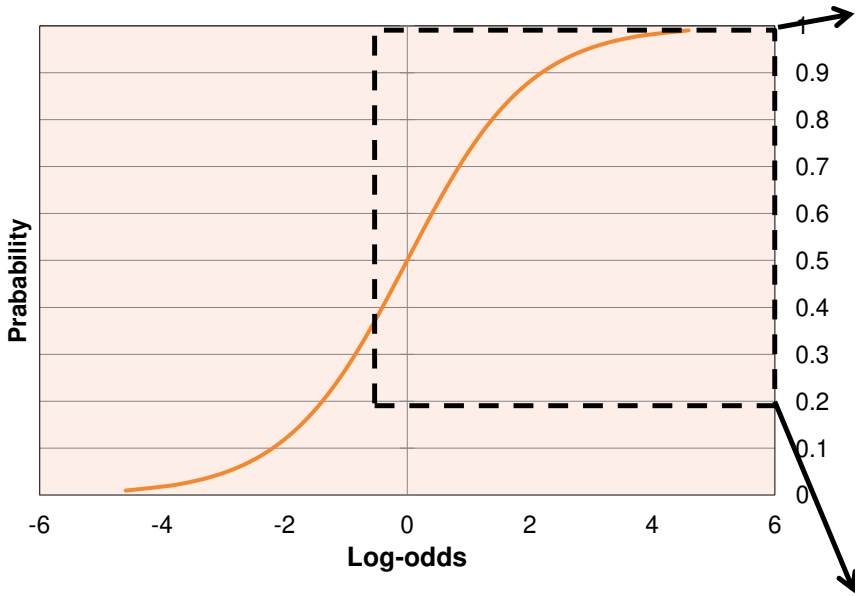
Group of 8	The University of New South Wales	Old regional	Charles Sturt University
	The University of Sydney		The University of New England
	Monash University		The University of Newcastle
	The University of Melbourne		University of Wollongong
	The University of Queensland		Deakin University
	The University of Western Australia		James Cook University
	The University of Adelaide		Charles Darwin University
	The Australian National University		University of Tasmania
Australian Technology Network	University of Technology, Sydney	New generation (regional)	Southern Cross University
	RMIT University		University of Ballarat
	Queensland University of Technology		Central Queensland University
	Curtin University of Technology		University of Southern Queensland
	University of South Australia		University of the Sunshine Coast
Gumtree	Macquarie University		Bachelor Institute of Indigenous Tertiary Education
	La Trobe University	(metro)	University of Western Sydney
	Griffith University		Swinburne University of Technology
	Murdoch University		Victoria University
	The Flinders University of South Australia		Bond University
			Edith Cowan University
			The University of Notre Dame Australia
			University of Canberra
			Australian Catholic University

Appendix F: Marginal odds-ratio

The logistic model requires a different approach in interpreting results. The accurate way of interpreting the Logit model is to use 'log-odds' or 'odd-ratio'. The marginal odd-ratio value of β can be interpreted as "high-research environment is β more likely to be satisfied (outcome variable) than low-research environments."

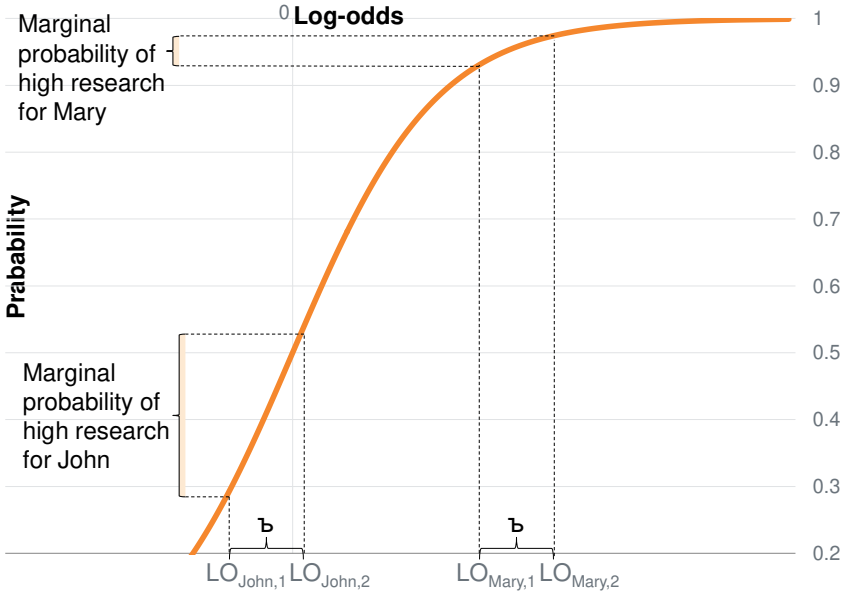
Another option is to use marginal probability interpretation, however it is not appropriate in this case. The marginal probability represents an overall probability change as a result of being in high-research environments, compared with low-research environments. That is, for an average person, what is the marginal effect of being in a high-research environment? This approach is problematic as the marginal effect differs amongst different respondents. Figure 18 shows the relationship between probability and log-odds. Clearly it is a non-linear relationship. Depending on a person's original position on the log-odd (horizontal) scale, the resulting marginal effect on probability differs.

Figure 18: Relationship between probability and log-odds



As an example, figure 19 shows John who is studying Accounting at 29yrs of age, and has an initial log-odds value of $LO_{John,1}$. Mary, who is studying Law at 18, has an initial log-odds value of $LO_{Mary,1}$. The effect of being in a high-research environment in terms of log-odds is represented by 'ъ'. However, the corresponding marginal probability of high-research differs substantially depending on the person.

Figure 19: Effects of being in a high-research environment between Mary and John



Appendix G: Surveys

AUSSE

The Australasian Survey of Student Engagement (AUSSE) is developed and managed by the Australian Council for Educational Research (ACER).[36] Within the AUSSE, we use data from the Student Engagement Questionnaire (SEQ).

The AUSSE involves cross-sectional data. The survey is administered in both online and in paper formats. It takes approximately 15 minutes to complete. The AUSSE clusters related questions into groups to explore different aspects of the student experience, such as the level of academic challenge or how students and staff interact. Our study uses the AUSSE's five different aspects of student engagement, as well as the five student outcomes scales, as shown in table 10.

We use 37 universities with results in the 2010 and 2011 AUSSE data. Non-university higher education providers in the AUSSE were excluded due to low numbers of respondents. New Zealand institutions were also excluded.

Table 10: AUSSE student engagement and student outcomes scales

Student engagement	Academic challenge	The extent to which expectations and assessments challenge students to learn
	Active learning	Students' efforts to actively construct knowledge
	Student and staff interactions	The level and nature of students' contact and interaction with staff
	Enriching educational experiences	Students' participation in broadening educational activities
	Work integrated learning	Integration of employment-focused work experiences into study
Student outcomes scales	Higher order thinking	Participation in higher-order forms of thinking
	General learning outcomes	Development of general competencies
	General development outcomes	Formation of general forms of individual and social development
	Career readiness	Preparation for participation in the professional workforce
	Overall satisfaction	Students' overall satisfaction with their educational experience

Source: Student engagement at New Zealand Institutes of Technology and Polytechnics[37]

[36] For information on how the AUSSE was developed, see Coates (2009).

[37] Radloff (2010)

CEQ

The Course Experience Questionnaire (CEQ) is administered as part of the Australian Graduate Survey (AGS). Since 1993 it has been conducted annually by Graduate Careers Australia. The CEQ is a national census of recently qualified graduates from all Australian universities. It targets coursework, rather than research degree graduates. It intends to capture data on the quality of teaching and courses. It has 13 core questions and 36 optional questions. The questions span over 6 scales, shown in table 11.

Table 11: CEQ scales

Good Teaching	The nature of teaching experienced during a course
Generic Skills	The enhancement of selected generic skills
Clear Goals and Standards	The course structure was clear and meaningful
Graduate Qualities	The generated higher-order outcomes and perspectives related to lifelong learning by the course
Learning Community	The social experience of learning at university
Overall Satisfaction	Overall satisfaction with course quality

Source: GCA (2012)

Appendix H: Survey questions in our study

Table 12: Survey questions from CEQ and AUSSE included in study

Student engagement				
Feedback	AUSSE	EF_SI4	In your experience at your institution during the current academic year, about how often have you done each of the following? Received prompt written or oral feedback from teachers/tutors on your academic performance	1' for never; '2' for sometimes; '3' for often; '4' for very often
	CEQ	ceq101	The staff put a lot of time into commenting on my work	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq103	The teaching staff normally gave me helpful feedback on how I was going	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq127	The staff made a real effort to understand difficulties I might be having with my work	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
Explaining and setting expectations	CEQ	ceq115	My lecturers were extremely good at explaining things	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq110	The teaching staff of this course motivated me to do my best work	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq108	It was always easy to know the standard of work expected	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq139	It was often hard to discover what was expected of me in this course	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq146	The staff made it clear right from the start what they expected from students	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
Peer learning	AUSSE	EL_AL1	In your experience at your institution during the current academic year, about how often have you done each of the following? Asked questions or contributed to discussions in class or online	1' for never; '2' for sometimes; '3' for often; '4' for very often
	AUSSE	EF_AL2	In your experience at your institution during the current academic year, about how often have you done each of the following? Made a class or online presentation	1' for never; '2' for sometimes; '3' for often; '4' for very often

Table 12 (continued)

Student engagement (continued)				
Peer learning (cont)	AUSSE	EF_AL4	In your experience at your institution during the current academic year, about how often have you done each of the following? Worked with other students outside class to prepare assignments	1' for never; '2' for sometimes; '3' for often; '4' for very often
Learning community		ceq118	I felt part of a group of students and staff committed to learning	'1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
University and community participation	CEQ	ceq131	I felt I belonged to the university community	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	EF_EE11	About how many hours do you spend in a typical seven-day week doing each of the following? Participating in extracurricular activities	1' for None; '2' for 1 to 5; '3' for 6 to 10; '4' for 11 to 15; '5' for 16 to 20; '6' for 21 to 25; '7' for 26 to 30; '8' for Over 30
	AUSSE	EF_AL5	In your experience at your institution during the current academic year, about how often have you done each of the following? Tutored or taught other university students (paid or voluntary)	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_AL6	In your experience at your institution during the current academic year, about how often have you done each of the following? Participated in a community based project as part of your study	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
Staff-student interaction	AUSSE	EF_SI3	Discussed ideas from your readings or classes with teaching staff outside class	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_SI5	Worked with teaching staff on activities other than coursework	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_SI6	Work on a research project with a staff member outside of coursework requirements	1' for Do not know about; '2' for Have not decided; '3' for Do not plan to do; '4' for Plan to do; '5' for Done
Academic challenge	AUSSE	EF_AC11	To what extent does your institution emphasise each of the following? Spend significant amounts of time studying on academic work	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_AC6	During the current academic year, about how much reading and writing have you done? Reading assigned textbooks, books or book-length packs of subject readings	1' for None; 2 for 1 to 4; '3' for 5 to 10; '4' for 11 to 20, '5' for More than 20

Table 12 (continued)

Student engagement (continued)				
Academic challenge (cont)	AUSSE	EF_AC1	At your institution during the current academic year, about how often have you done each of the following? Worked harder than you thought you could to meet a teachers/tutors standards or expectations	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_AC2	During the current academic year, how much has your coursework emphasised the following intellectual activities? Analysing basic elements of an idea	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_AC3	During the current academic year, how much has your coursework emphasised the following intellectual activities? Synthesizing and organizing ideas	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_AC4	During the current academic year, how much has your coursework emphasised the following intellectual activities? Making judgments about value of information	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_AC5	During the current academic year, how much has your coursework emphasised the following intellectual activities? Applying theories or concepts	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_AC7	During the current academic year, about how much reading and writing have you done? Written assignments fewer than 1000 words	1 for None; 2 for 1 to 4; '3' for 5 to 10; '4' for 11 to 20, '5' for More than 20
	AUSSE	EF_AC8	During the current academic year, about how much reading and writing have you done? Written assignments between 1000-5000 words	1 for None; 2 for 1 to 4; '3' for 5 to 10; '4' for 11 to 20, '5' for More than 20
	AUSSE	EF_AC9	During the current academic year, about how much reading and writing have you done? Written assignments more than 5000 words	1 for None; 2 for 1 to 4; '3' for 5 to 10; '4' for 11 to 20, '5' for More than 20
	AUSSE	EF_AC10	About how many hours do you spend in a typical seven-day week doing each of the following? Preparing for class	1' for None; '2' for 1 to 5; '3' for 6 to 10; '4' for 11 to 15; '5' for 16 to 20; '6' for 21 to 25; '7' for 26 to 30; '8' for Over 30
Different perspectives	CEQ	ceq148	My university experience encouraged me to value perspectives other than my own	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	EF_EE3	In your experience at your institution during the current academic year, about how often have you done each of the following? Conversations with students who are very different in terms of religious beliefs, political opinions or personal values	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often

Table 12 (continued)

Skill development				
Teamwork	CEQ	ceq106	The course helped me develop my ability to work as a team member	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_GL8	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Working effectively with others	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
Analytic skills	CEQ	ceq114	The course sharpened my analytic skills	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_GL5	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Thinking critically and analytically	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	LO_GL6	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Analysing quantitative problems	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
Problem solving skills	CEQ	ceq123	The course developed my problem-solving skills	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	CEQ	ceq142	As a result of my course, I feel confident about tackling unfamiliar problems	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
Writing skills	CEQ	ceq132	The course improved my skills in written communication	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_GL3	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Writing clearly and effectively	1 Very little; 2 Some; 3 Quite a bit; 4 Very much
Planning skills	CEQ	ceq143	My course helped me to develop the ability to plan my own work	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
Independent study	CEQ	ceq117	The course developed my confidence to investigate new ideas	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree

Table 12 (continued)

Skill development (continued)				
	AUSSE	LO_GL9	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Learning effectively on your own	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
Communication skills	AUSSE	LO_GL4	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Speaking clearly and effectively	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_WL3	During the current academic year, about how often have you done each of the following? Developed communication skills relevant to your discipline	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
Work readiness				
Broad education	CEQ	ceq111	The course provided me with a broad overview of my field of knowledge	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_GL1	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Acquiring a broad general education	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
Applying knowledge	CEQ	ceq136	I learned to apply principles from this course to new situations	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_GD4	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Solving complex real-world problems	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
Linking knowledge to workforce	CEQ	ceq140	I consider what I learned valuable for my future	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	EF_WL2	During the current academic year, about how often have you done each of the following? Improved knowledge and skills that will contribute to your employability	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_WL4	Which of the following have you done or do you plan to do before you graduate from your institution? Explored how to apply your learning in the workforce	1' for Do not know about; '2' for Have not decided; '3' for Do not plan to do; '4' for Plan to do; '5' for Done

Table 12 (continued)

Work readiness (continued)				
Linking knowledge to workforce (cont)	AUSSE	EF_WL6	To what extent has your experience at this institution contributed to your knowledge, skills and personal development in the following areas? Acquiring job-related or work-related knowledge and skills	1' for Very little; '2' for Some; '3' for Quite a bit; '4' for Very much
	AUSSE	EF_WL1	In your experience at your institution during the current academic year, about how often have you done each of the following? Blended academic learning with workplace experience	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	EF_WL5	Which of the following have you done or do you plan to do before you graduate from your institution? Industry placement or work experience	1' for Do not know about; '2' for Have not decided; '3' for Do not plan to do; '4' for Plan to do; '5' for Done
Career readiness	AUSSE	LO_CR1	During the current academic year, about how often have you done each of the following? Kept resume up to date	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	LO_CR2	During the current academic year, about how often have you done each of the following? Thought about how to present yourself to your employers	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	LO_CR3	During the current academic year, about how often have you done each of the following? Explored where to look for jobs relevant to your interests	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	LO_CR4	During the current academic year, about how often have you done each of the following? Used networking to source information on job opportunities	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often
	AUSSE	LO_CR5	During the current academic year, about how often have you done each of the following? Set career development goals and plans	1' for Never; '2' for Sometimes; '3' for Often; '4' for Very often

Table 12 (continued)

Overall satisfaction				
Satisfaction	CEQ	ceq149	Overall, I was satisfied with the quality of this course	1' for strongly disagree; '2' for disagree; '3' for neither agree nor disagree ; '4' for agree; '5' for strongly agree
	AUSSE	LO_OS1	Overall, how would you evaluate the quality of academic advice that you have received at your institution? Quality of academic advice received at institution	1' for Poor; '2' for Fair; '3' for Good; '4' for Excellent
	AUSSE	LO_OS2	How would you evaluate your entire educational experience at this institution? Entire education experience	1' for Poor; '2' for Fair; '3' for Good; '4' for Excellent
	AUSSE	LO_OS3	If you could start over again, would you go to the same institution you are now attending? Attend same institution if starting over	1' for Definitely no; '2' for Probably no; '3' for Probably yes; '4' for Definitely yes

Appendix I: Missing values strategy

Missing data is a common problem in any survey study. When data are collected by questionnaire, respondents may be unwilling or unable to answer some items. These types of responses are inevitable, but can have a significant effect on the conclusions.

There are four types of missing values:[38]

- Missing by definition - this occurs when data is missing by exclusion due to the sub-population focus of the study.
- Missing Completely at Random (MCAR) - occurs when the values are randomly distributed. With the right imputation approach, parameter estimates remain unbiased.
- Missing at Random (MAR) - occurs when the likelihood of missing data on the variable is not related to the value of the variable, after controlling for other factors in the study. If sufficient information is available, the missing cases can be ignored.[39]
- Not missing at random (NMAR) - occurs when the missing data pattern is related to data that is not available through the observed variables.[40] It is sometimes called "non-ignorable missingness", since if the problem is ignored, inferences will be biased.[41]

Traditional approaches to working with missing values include case-wise deletion, pair-wise deletion, and inclusion of an indicator variable. These approaches are sub-optimal except under highly specialised circumstances. This includes when the pattern of missing values correspond to MCAR. This can result in biases of estimates, an increase in type II errors, which causes failure to reject the null hypothesis, and underestimation of correlations.[42]

The 'single imputation' method is an important advance over traditional methods of dealing with missing values. It involves filling in a value for each missing datum using observed relationships of the variables. At the same time it injects a degree of random error to reflect uncertainty of imputation. However, it can omit sampling variability between multiple imputations, which results in under-estimation of standard error and an increase in type II error.[43] Therefore, our analysis uses a 'multiple imputation' (MI) method, an advanced development of single imputation.

Multiple imputation

To correct for the uncertainty, we need to take into account imprecision caused by the distribution of variables with missing

[38] Acock (2005)
[39] Gelman and Hill (2007)
[40] Penny and Atkinson (2011)
[41] Gelman and Hill (2007)
[42] Acock (2005)
[43] Rubin (1987)

values. MI is an adaptive technique that replaces each missing value by a vector of *M* imputed values. The imputed values reflect a distribution of possibilities.

Although the MI model may be created under MAR, the framework does not require or assume that the missing data is ignorable.[44]

There are two aspects of the analysis for which assumptions are required:

Data model: Use of true probability model

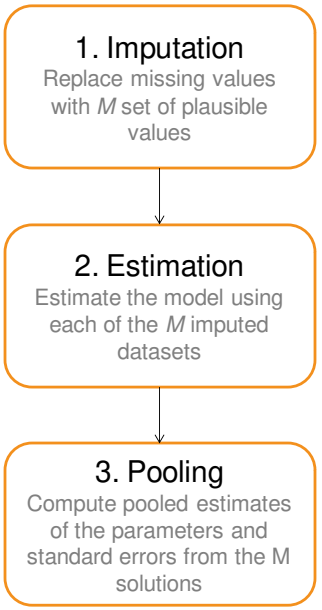
- The first step of the imputation process is to assume a probability model that relates the complete data to a set of parameters. The probability model and the prior distribution are used to calculate the predictive distribution for the missing data conditional on the available data. The model should incorporate all the information about the data generation process.[45] However, real data rarely conform to a convenient model. In most applications of MI, the probability model is simply an approximation of the true model. Fortunately, MI is robust to departures from the imputation model.

Prior distribution: Use of true imputation model

- To obtain the predictive probability of the missing values, a prior distribution of the model parameters must be quantified together with a correct data model. The prior distribution should reflect the nature of the model parameters and should occur prior to seeing the data.[46] For a moderately large sample size, a close approximation of the true prior distribution gives the same results.[47]

MI involves three steps, described in figure 20.

Figure 20: Process of multiple imputation

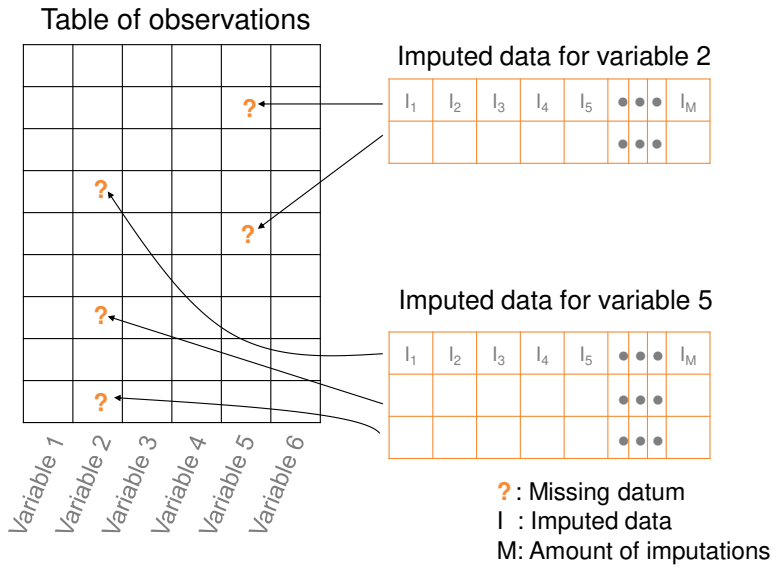


Source: Marchenko (2009)

[44] Schafer (1999)
[45] Sinharay, *et al.* (2001)
[46] Schafer and Olsen (1998)
[47] Sinharay, *et al.* (2001)

During the imputation process, *M* sets of imputed data are created by replacing each missing datum by the first component in the vector/matrix to form the first completed data set, and so on. Figure 21 shows the schematic representation of MI, where M is the amount of imputations.

Figure 21: Imputation process



In the second stage, a regression model is selected and standard estimation process is used to analyse each dataset independently.

The final stage involves combining the *M* sets of results to form one inference that reflects uncertainty due to missing value pattern. The combined inference displays the sensitivity of inference using rules described in Rubin (1987).

Justification for using multiple imputation (MI)

MI has many advantages over the single imputation method and other traditional approaches. The MI paradigm accounts for missing data uncertainty, which removes any underestimation of the estimates' variance and produces unbiased standard errors.[48] MI has been shown to perform favourably under a variety of missing data situations, and shown to produce unbiased estimates. It is more flexible than fully parametric methods by allowing users to identify the imputation process.[49] When the imputation is randomly drawn to reflect the distribution of data, it increases efficiency of the estimation process.[50] It is highly efficient even for small values of imputations.[51]

Further, MI is computationally simpler for most practical situations than Maximum Likelihood Estimation (MLE) and Bayesian estimation. The MLE method is problem specific, whereas, an MI imputed dataset can solve the missing data problem in many analyses.[52]

Finally, a growing body of evidence suggests that MI provides valid inferences for statistical analysis. Since model assumptions

[48] Acock (2005)
[49] Marchenko (2009)
[50] Rubin (1987)
[51] Schafer and Olsen (1998)
[52] Schafer and Graham (2002)

are applied on the missing component, not the entire dataset, the method is robust.[53]

Criteria

This section outlines criteria used across the three stages of MI, as seen in figure 20 . The first two criteria are used during the 'imputation stage'. The last criterion is used during the 'pooling stage'.

Imputations

Our analysis adopts 20 imputations. There is conflicting literature about the number of imputations required to produce robust and unbiased inferences.[54] To evaluate the amount of imputations, we use the efficiency model proposed by Rubin (1987).

The efficiency of an estimate based on M imputations is approximately:[55]

$$\left(1+\frac{\gamma}{M}\right)^{-1/2}$$

where γ is the fraction of missing information and M is the amount of imputation.

The percentage of missing data from the CEQ is on average less than 1% (seen in table 16), and on average 6% in the AUSSE (seen in table 14). As seen in table 13, 20 imputations are sufficient to produce 100% efficiency in our analysis

Table 13: Efficiency evaluation

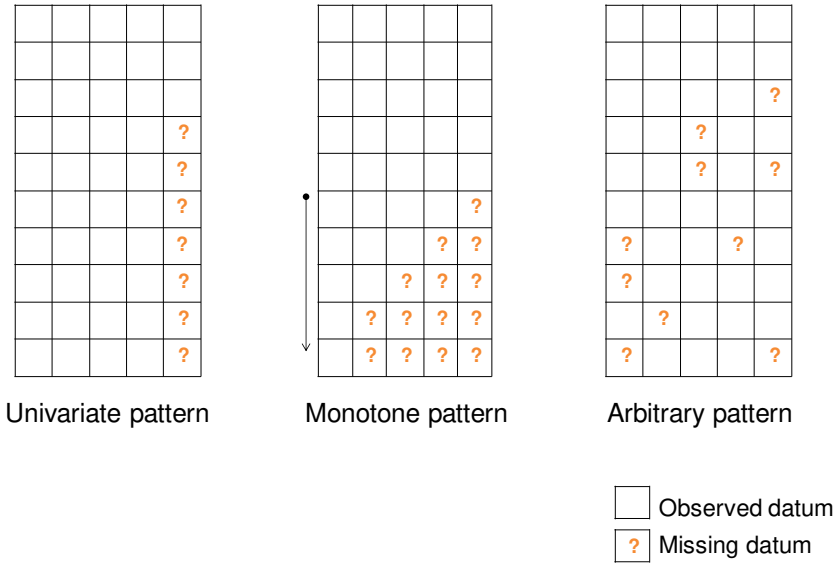
Imputations (M)	Fraction of missing information (γ)						
	0.1	0.15	0.2	0.25	0.3	0.35	0.4
3	98%	98%	97%	96%	95%	95%	94%
5	99%	99%	98%	98%	97%	97%	96%
8	99%	99%	99%	98%	98%	98%	98%
10	100%	99%	99%	99%	99%	98%	98%
12	100%	99%	99%	99%	99%	99%	98%
15	100%	100%	99%	99%	99%	99%	99%
20	100%	100%	100%	99%	99%	99%	99%

Missing value pattern

During the imputation process, a missing value pattern must be identified. There are three types of missing values, shown in figure 22 below.

[53] Schafer*, et al.* (2010)
[54] Rubin (1987) proposed that 2-3 imputations are sufficient to produces coefficient estimates. According to Schafer and Olsen (1998) and Sinharay*, et al.* (2001) 3-5 imputations are sufficient to obtain excellent results. Finchman and Cummings (2003) believe, for most applications, 10 imputations should be sufficient. However, Spratt*, et al.* (2010) argues that that MI should be based on 25 or more imputations.
[55] Rubin (1987)

Figure 22: Patterns of missing values



A 'univariate pattern' describes a pattern where missing values occur on a single variable only. Missing data corresponds to the Monotone pattern when it can be arranged to create a point where missing values start to occur. This pattern usually occurs in a panel data where respondents drop out prior to the end of the study.

An arbitrary pattern is the most common missing value pattern, where missing values scatter without any conclusive pattern. The pattern commonly occurs through self-reported surveys.

The pattern that most resembles our data is Arbitrary Pattern. A sequence of univariate imputations with fully conditional specification (FCS) is used, where missing values are filled iteratively using a Gibbs-like algorithm to obtain imputed values. The method is based on simulating from a Bayesian posterior predictive distribution.

Pooling of estimates

Once the missing data has been imputed and based on the imputed data, estimates and standard errors are found for each imputed set. The estimates and standard errors are combined using the rules described in Rubin (1987).

Note that the process is performed for each variable where there is at least one missing datum.

First we find the estimates and standard errors average using:

$$\bar{\beta} = \frac{1}{M}\sum_{i=1}^{M}\hat{\beta}_i$$

$$\bar{S} = \frac{1}{M}\sum_{i=1}^{M}\hat{S}_i$$

where $\hat{\beta}_i$ represents an estimate from imputation i and $\hat{S}_i$ represents the standard error from imputation i.

To calculate the between-imputation variance, denoted by B, we have used the following function.

$$B = \frac{1}{M-1}\sum_{i=1}^{M}(\hat{\beta}_i - \bar{\beta})^2$$

Using the between-imputation variance and the average standard error, the total variance, denoted by T, is calculated.

$$T = \bar{S} + \left[\left(1 + \frac{1}{M}\right) \times B\right]$$

In order to evaluate the significance of the predictor variables, we need a Multiple Imputation adjusted degree of freedom. The calculation of the Multiple Imputation adjusted degree of freedom, df, is as followed.

$$df = (M-1)\left(1 + \frac{M \times \bar{S}}{(M+1) \times B}\right)^2$$

A significance test is performed by comparing the ratio:

$$t = \frac{\bar{\beta}}{\sqrt{T}}$$

to the Student t-distribution using the degree of freedom calculated above.

Imputation Model

The imputation model is described in figure 23.

Figure 23: Imputation model

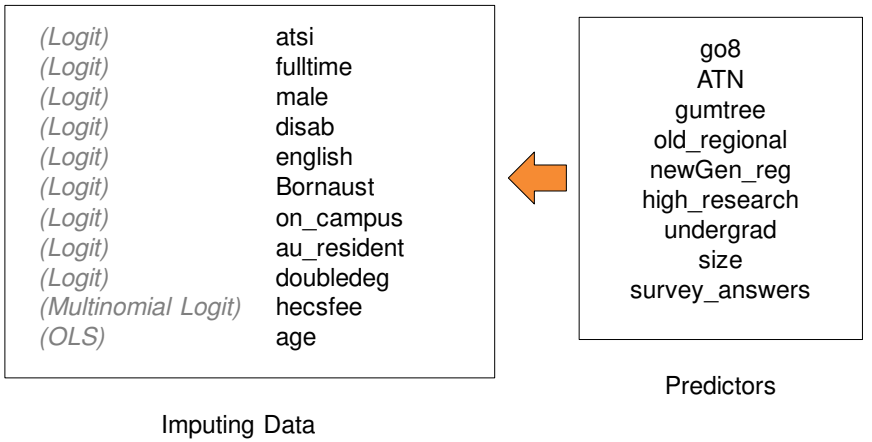


Table 14: Missing values and descriptive statistics of outcome variables from the AUSSE

Code	Observation	Missing	Missing (%)	Mean	Median	Standard Deviation	Maximum	Minimum
EF_AC1	9143	417	4%	2.44	2	0.84	4	1
EF_AC2	9153	407	4%	3.21	3	0.74	4	1
EF_AC3	9129	431	5%	3.01	3	0.81	4	1
EF_AC4	9139	421	4%	3	3	0.84	4	1
EF_AC5	9146	414	4%	3.19	3	0.81	4	1
EF_AC6	9077	483	5%	2.89	3	1.03	5	1
EF_AC7	9027	533	6%	2.08	2	0.86	5	1
EF_AC8	9109	451	5%	2.48	2	0.79	5	1
EF_AC9	8865	695	7%	1.28	1	0.65	5	1
EF_AC10	8998	562	6%	3.62	3	1.71	8	1
EF_AC11	9168	392	4%	3.14	3	0.76	4	1
EF_AL1	9434	126	1%	2.75	3	0.84	4	1
EF_AL2	9349	211	2%	2.34	2	0.9	4	1
EF_AL4	9328	232	2%	2.57	3	0.9	4	1
EF_AL5	9271	289	3%	1.4	1	0.73	4	1
EF_AL6	9237	323	3%	1.52	1	0.83	4	1
EF_SI3	9151	409	4%	1.72	2	0.76	4	1
EF_SI4	9175	385	4%	2.38	2	0.78	4	1
EF_SI5	9017	543	6%	1.4	1	0.71	4	1
EF_SI6	9099	461	5%	2.59	3	1.12	5	1
EF_EE3	9151	409	4%	2.74	3	0.88	4	1
EF_EE11	8582	978	10%	1.96	2	1.14	8	1
EF_WL1	9275	285	3%	2.27	2	1.02	4	1
EF_WL2	9142	418	4%	2.77	3	0.83	4	1

Table 14 (continued)

Code	Observation	Missing	Missing (%)	Mean	Median	Standard Deviation	Maximum	Minimum
EF_WL3	9152	408	4%	2.83	3	0.8	4	1
EF_WL4	9120	440	5%	2.6	3	0.92	4	1
EF_WL5	9080	480	5%	3.71	4	1.21	5	1
EF_WL6	9081	479	5%	3.08	3	0.87	4	1
LO_HT1	9153	407	4%	3.21	3	0.74	4	1
LO_HT2	9129	431	5%	3.01	3	0.81	4	1
LO_HT3	9139	421	4%	3	3	0.84	4	1
LO_HT4	9146	414	4%	3.19	3	0.81	4	1
LO_GL1	9101	459	5%	3	3	0.78	4	1
LO_GL2	9081	479	5%	3.08	3	0.87	4	1
LO_GL3	9118	442	5%	2.93	3	0.83	4	1
LO_GL4	9093	467	5%	2.78	3	0.88	4	1
LO_GL5	9091	469	5%	3.24	3	0.74	4	1
LO_GL6	9067	493	5%	2.86	3	0.86	4	1
LO_GL7	9114	446	5%	2.81	3	0.92	4	1
LO_GL8	9085	475	5%	2.94	3	0.86	4	1
LO_GL9	9093	467	5%	3.02	3	0.84	4	1
LO_GD4	9089	471	5%	2.76	3	0.89	4	1
LO_GD6	9037	523	5%	2.42	2	0.96	4	1
LO_CR1	8180	1380	14%	1.96	2	0.89	4	1
LO_CR2	8193	1367	14%	2.35	2	0.92	4	1
LO_CR3	8182	1378	14%	2.36	2	0.93	4	1
LO_CR4	8173	1387	15%	2.11	2	0.95	4	1
LO_CR5	8164	1396	15%	2.3	2	0.96	4	1
LO_OS1	9103	457	5%	2.93	3	0.78	4	1
LO_OS2	9097	463	5%	3.06	3	0.74	4	1
LO_OS3	9130	430	4%	3.25	3	0.78	4	1

Table 15: Missing values and descriptive statistics of explanatory variables from the AUSSE

Code	Observation	Missing	Missing (%)	Mean	Median	Standard Deviation	Maximum	Minimum
ATAR	9560	0	0%	83.18	81.5	10.14	100	59
GO8	9560	0	0%	0	0	0	1	0
ATN	9560	0	0%	0	0	0	1	0
gumtree	9560	0	0%	0	0	0	1	0
old_reg	9560	0	0%	0	0	0	1	0
new_gen_reg	9560	0	0%	0	0	0	1	0
size	9560	0	0%	1180	1120	705	3296	229
high_research	9560	0	0%	1	1	0	1	0
multilingual	9356	204	2%	0.16	0	0.37	1	0
male	9452	108	1%	0.23	0	0.42	1	0
disab	9309	251	3%	0.06	0	0.24	1	0
atsi	9337	223	2%	0.02	0	0.15	1	0
FT_study	9366	194	2%	0.88	1	0.33	1	0
on_campus	9429	131	1%	0.85	1	0.36	1	0
auspermres	9430	130	1%	0.87	1	0.33	1	0
PE1	9149	411	4%	2.63	3	0.84	4	1
PE2	9144	416	4%	5.52	6	1.41	7	1
ED1	9110	450	5%	1.31	1	0.46	2	1
SL1	9144	416	4%	5.52	6	1.41	7	1
SL2	9144	416	4%	5.14	5	1.37	7	1
SI1	9342	218	2%	1.97	2	0.85	4	1
SI2	9310	250	3%	1.68	1	0.81	4	1
LE1	9078	482	5%	4.65	5	1.52	7	1
LE2	9114	446	5%	1.85	2	0.88	4	1
age	9447	113	1%	24	21	8	70	16

Table 16: Missing values and descriptive statistics of outcome variables from the CEQ

Code	Observation	Missing	Missing (%)	Mean	Median	Standard Deviation	Maximum	Minimum
ceq101	75135	9,904	0.1318	3.021561	4	1.498693	5	0
ceq103	75135	9,880	0.1315	3.085925	4	1.515869	5	0
ceq127	75134	10,072	0.1341	2.919105	3	1.498105	5	0
ceq115	75135	9,993	0.133	3.092061	4	1.499906	5	0
ceq110	75135	9,946	0.1324	3.082145	4	1.526533	5	0
ceq108	75135	58,071	0.7729	0.7743262	4	1.509764	5	0
ceq139	75135	58,113	0.7734	0.6528116	3	1.313307	5	0
ceq146	75135	58,118	0.7735	0.7999068	4	1.548438	5	0
ceq106	75135	9,935	0.1322	3.107899	4	1.550356	5	0
ceq114	75135	9,914	0.1319	3.388754	4	1.586093	5	0
ceq123	75135	9,968	0.1327	3.308658	4	1.546327	5	0
ceq142	75135	10,001	0.1331	3.245997	4	1.534773	5	0
ceq132	75135	9,978	0.1328	3.342157	4	1.603311	5	0
ceq143	75135	10,011	0.1332	3.307393	4	1.556679	5	0
ceq111	75135	32,244	0.4291	2.251547	4	2.071157	5	0
ceq117	75135	32,267	0.4295	2.159779	4	2.001653	5	0
ceq136	75135	32,340	0.4304	2.213256	4	2.035867	5	0
ceq140	75135	32,325	0.4302	2.353803	4	2.162564	5	0
ceq148	75135	32,350	0.4306	2.200492	4	2.030551	5	0
ceq149	75135	10,051	0.1338	3.327025	4	1.583362	5	0
ceq118	75135	53,968	0.7183	1.022293	4	1.718867	5	0
ceq131	75135	53,985	0.7185	0.9400812	3	1.613458	5	0

Table 17: Missing values and descriptive statistics of explanatory variables from the CEQ

Code	Observation	Missing	Missing (%)	Mean	Median	Standard Deviation	Maximum	Minimum
fulltime	74966	169	0.22%	0.7677881	1	0.4222463	1	0
on_campus	74913	222	0.30%	0.8765101	1	0.3290009	1	0
male	75017	118	0.16%	0.3611581	0	0.4803395	1	0
disab	74863	272	0.36%	0.0211987	0	0.1440473	1	0
atsi	74662	473	0.63%	0.0056387	0	0.0748801	1	0
english	74442	693	0.92%	0.7181833	1	0.4498875	1	0
bornaust	73521	1,614	2.15%	0.5837516	1	0.4929391	1	0
au_resident	74863	272	0.36%	0.7916861	1	0.4061052	1	0
double_deg	73923	1,212	1.61%	0.1013487	0	0.3017919	1	0
age	74976	159	0.21%	28.96986	25	9.147326	88	19
hecsfee	74808	327	0.44%	2.476847	2	0.9917239	5	1
go8	75135	0	0.00%	0.4527184	0	0.4977627	1	0
ATN	75135	0	0.00%	0.1405869	0	0.3475973	1	0
gumtree	75135	0	0.00%	0.1789712	0	0.3833307	1	0
old_regional	75135	0	0.00%	0.0789645	0	0.2696852	1	0
newGen_reg	75135	0	0.00%	0.057044	0	0.2319282	1	0
high_research	75135	0	0.00%	0.8509217	1	0.356168	1	0
undergrad	75135	0	0.00%	0.5944633	1	0.4909989	1	0
size	75135	0	0.00%	1290.286	1208	734.4497	3296	228

Appendix J: Joint analysis of AUSSE and CEQ surveys

Our regression analysis uses findings from both the CEQ and AUSSE surveys in order to generate wider, more reliable, results. As there is a lot of overlap in subject matter, the two surveys are good candidates to analyse jointly. Individual questions are grouped into similar topic areas to make broader conclusions. There are some challenges with this approach. We mention these issues here for completeness and to support further research.

Statistical variation is a key concern when analysing the outcomes of the two surveys. We expect a level of randomness in any statistical analysis, partly caused by unobservable characteristics. Our challenge is to understand if any variation/contradiction is caused by underlying differences in the actual surveys.

While AUSSE and the CEQ cover similar aspects of teaching and learning, they have differently worded questions and are given to students at different stages of their university experiences. The AUSSE tends to ask more questions on any topic that are more action oriented. The language used in a question may affect how respondents answer it, particularly if the questions are filled out quickly.

Further, the two surveys have different cohorts of respondents. First year students as well as later year students complete the AUSSE survey, whereas only graduated students complete the CEQ. This means that the CEQ results are more highly affected by students' final academic year. It is possible that first and later year students will give different answers to the same question. For example, first year students are less likely to be exposed to practicums, yearlong projects, or any workforce engagement opportunities.

In addition, the two surveys include a different composition of universities, and there is slightly different time periods in the data. The CEQ survey is of students who finished their degrees in 2008-2009. The AUSSE surveyed students who are due to finish in 2011-2014. Students and teachers are unlikely to differ significantly over short period of time. However, if either of these things did occur it could affect our results.

The amount of survey respondents is also different. The AUSSE survey includes, on average, 9,038 observations. The CEQ survey includes, on average, 45,418 observations. The difference means the AUSSE results are inherently noisier and therefore less likely to be significant, if the true results are different from zero.

Appendix K: Charts of results

Figure 24: Summary of results

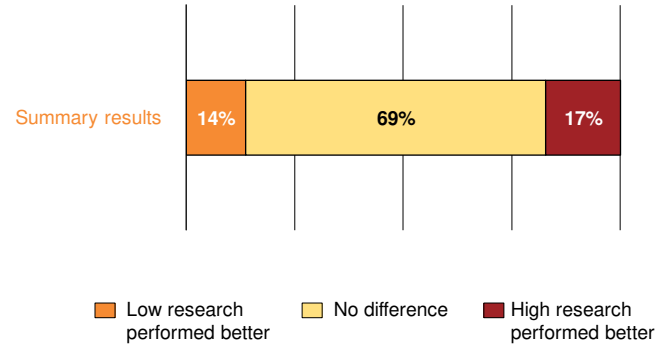


Figure 25: Summary of results across four topics

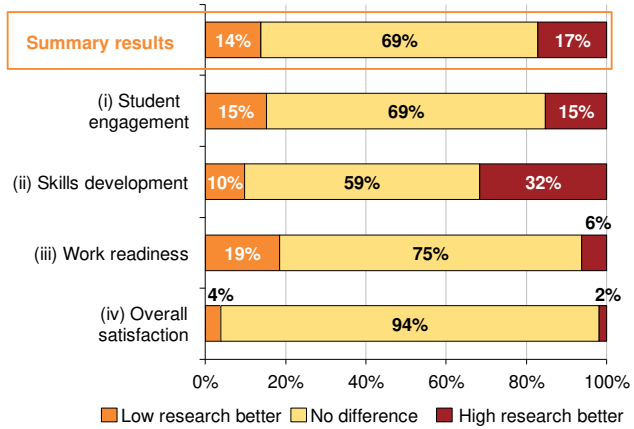


Figure 26: Summary results on student engagement

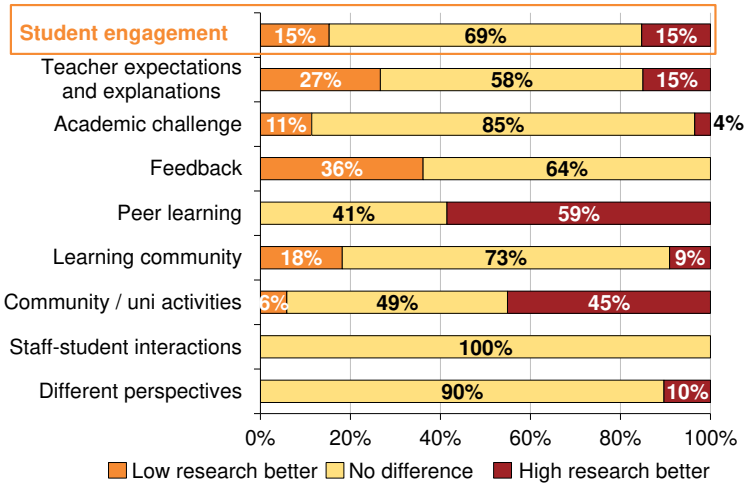


Figure 27: Teacher expectations and explanations

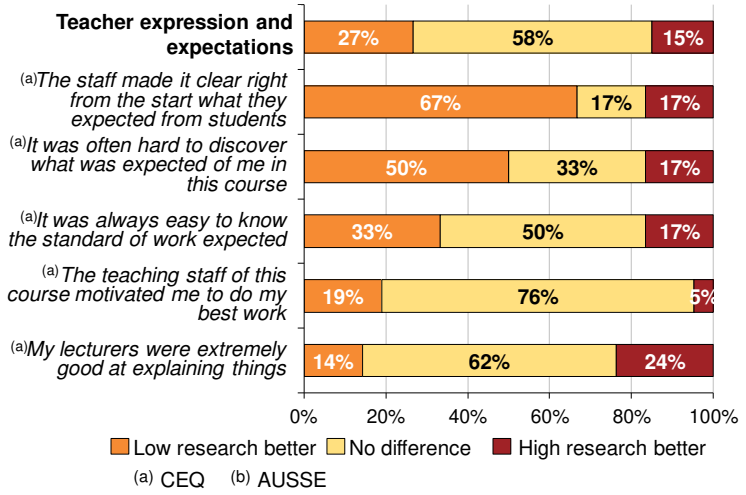


Figure 28: Academic challenge

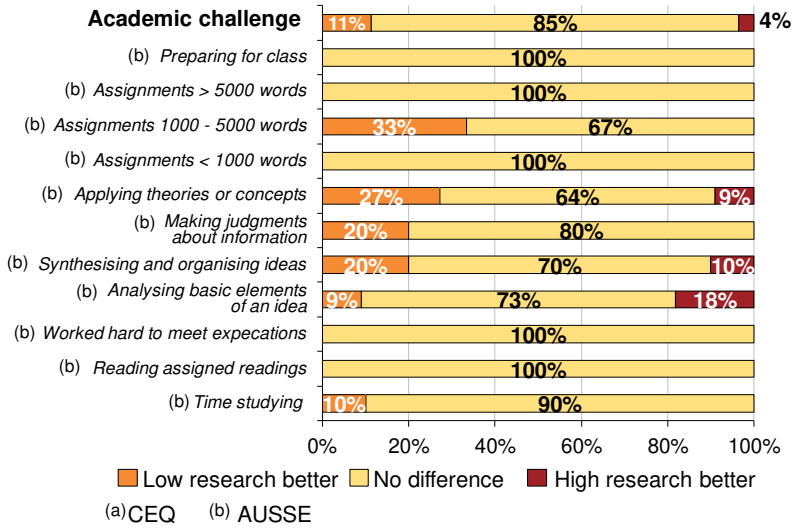


Figure 29: Feedback

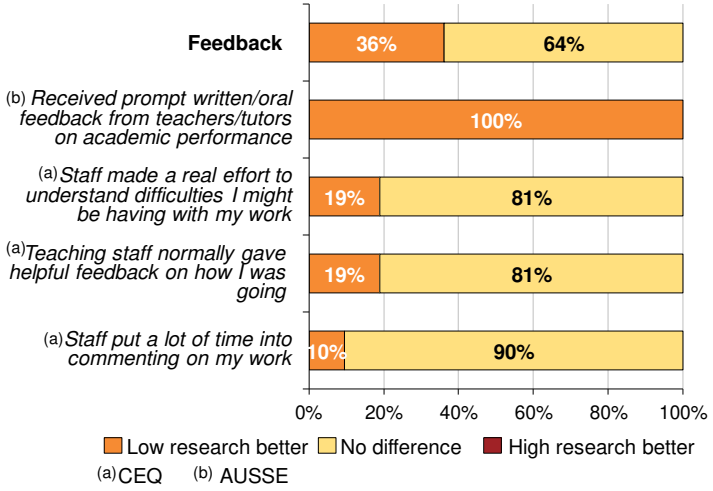


Figure 30: Peer learning

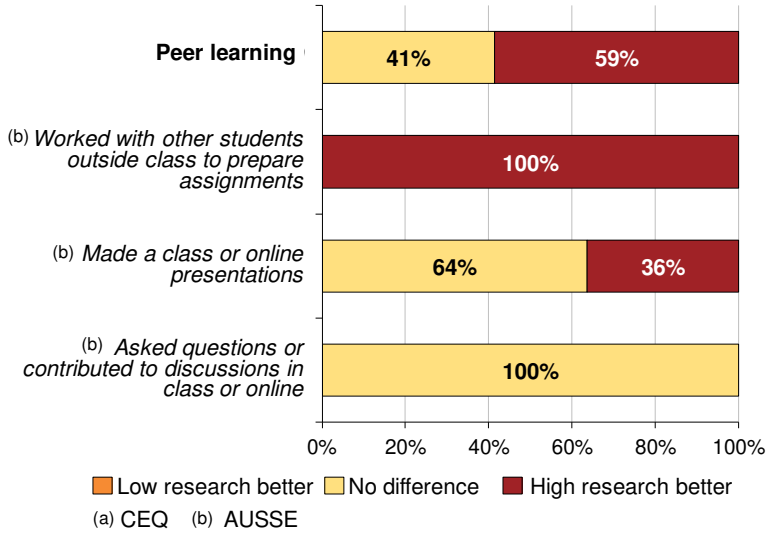


Figure 31: Learning community

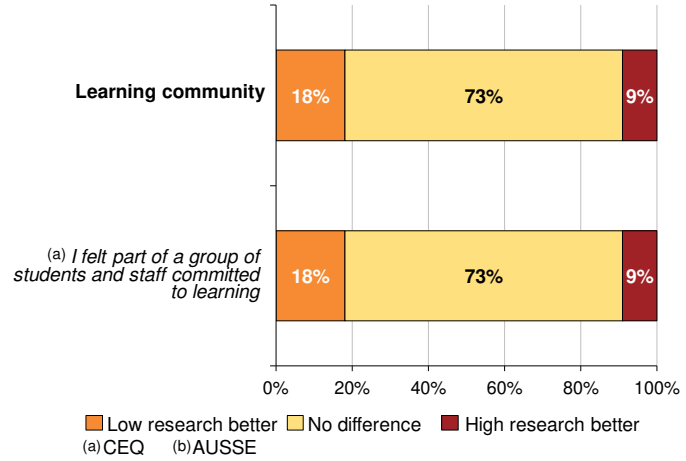


Figure 32: Community / university activities

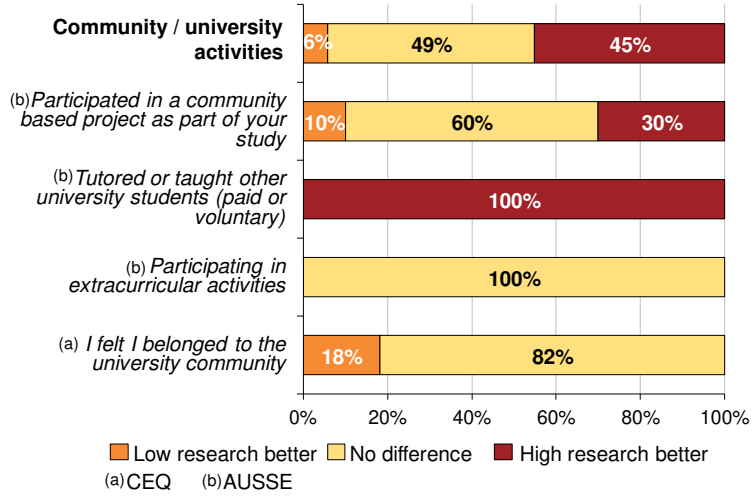


Figure 33: Student-staff interactions

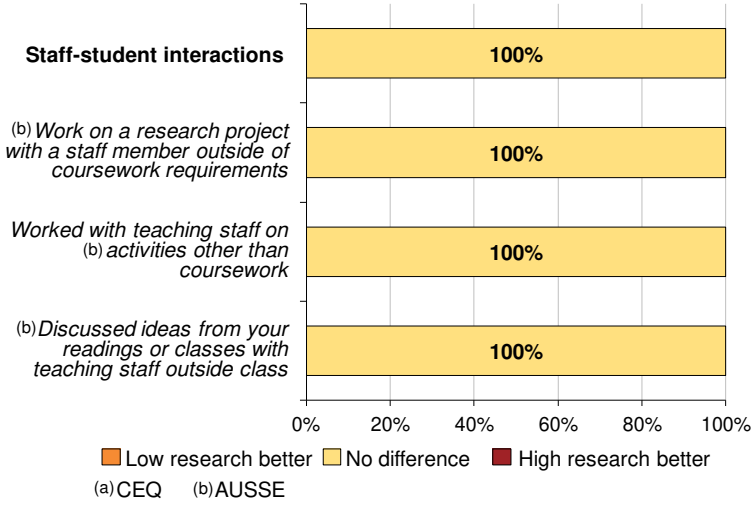


Figure 34: Different perspectives

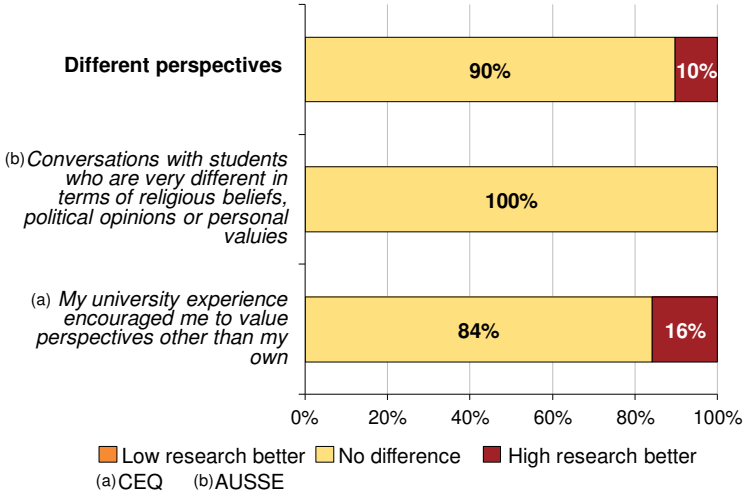


Figure 35: Summary of skills development results

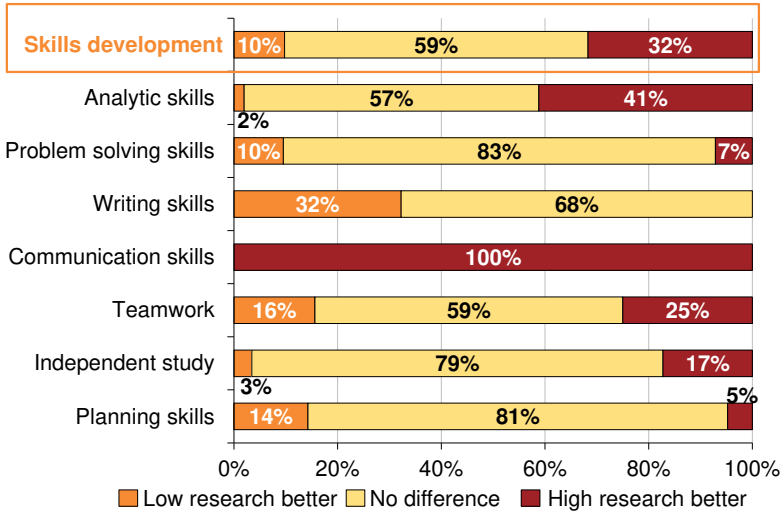


Figure 36: Analytic skills

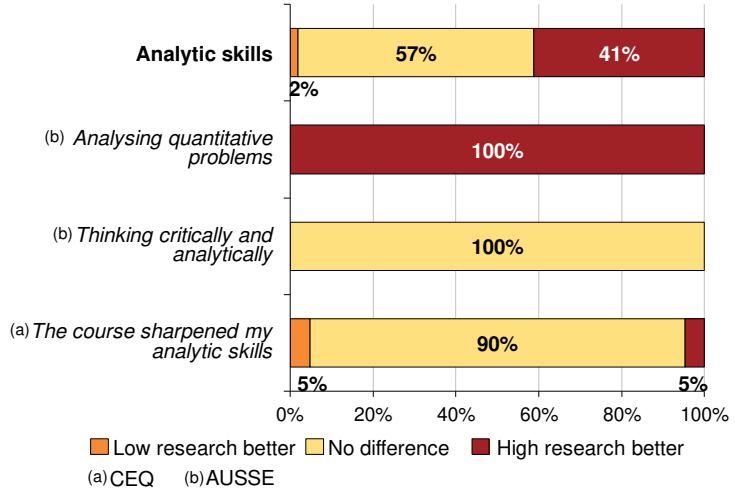


Figure 37: Problem-solving skills

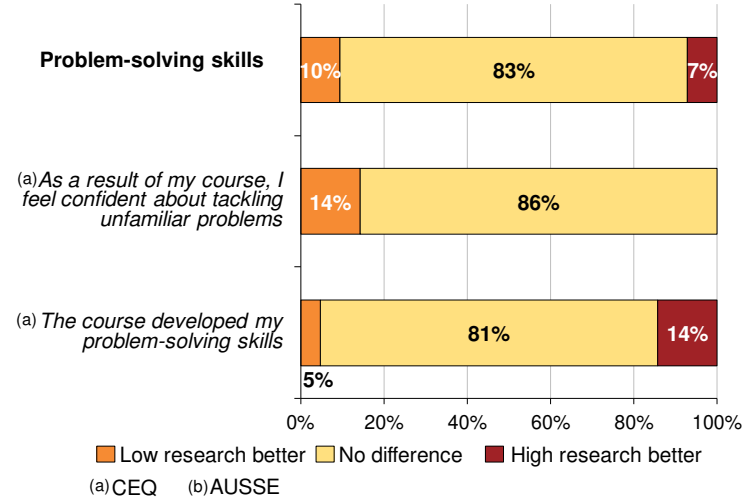


Figure 38: Communication skills

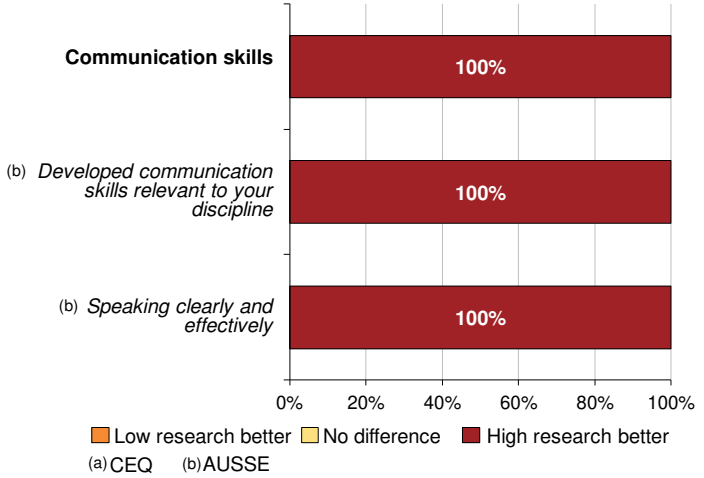


Figure 39: Writing skills

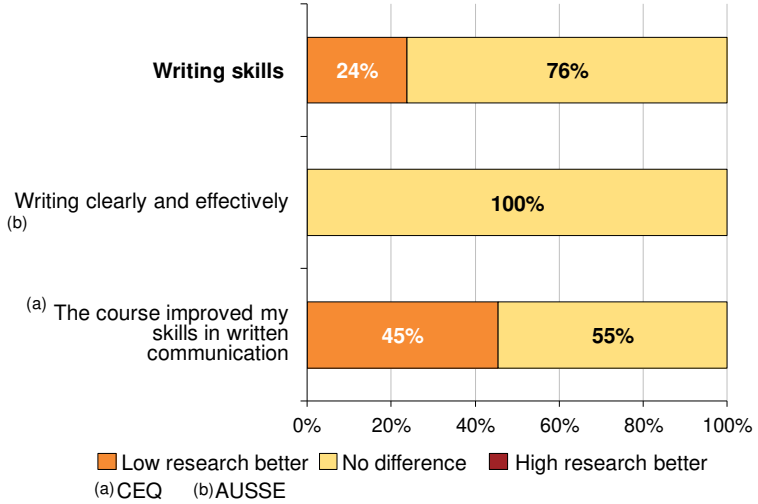


Figure 40: Teamwork

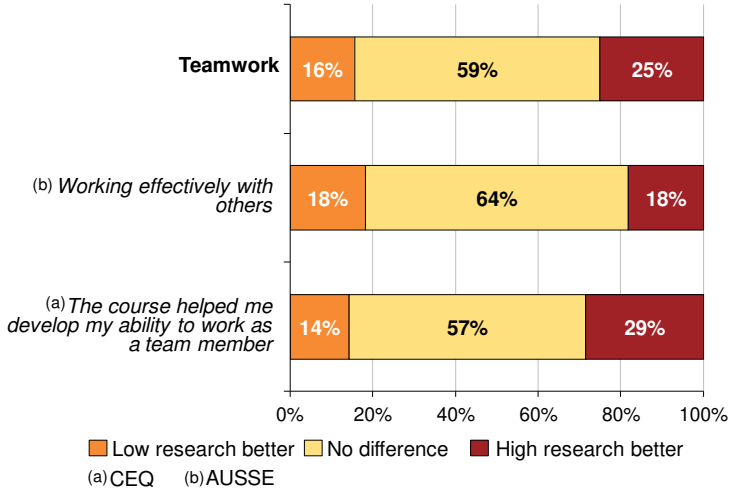


Figure 41: Independent study

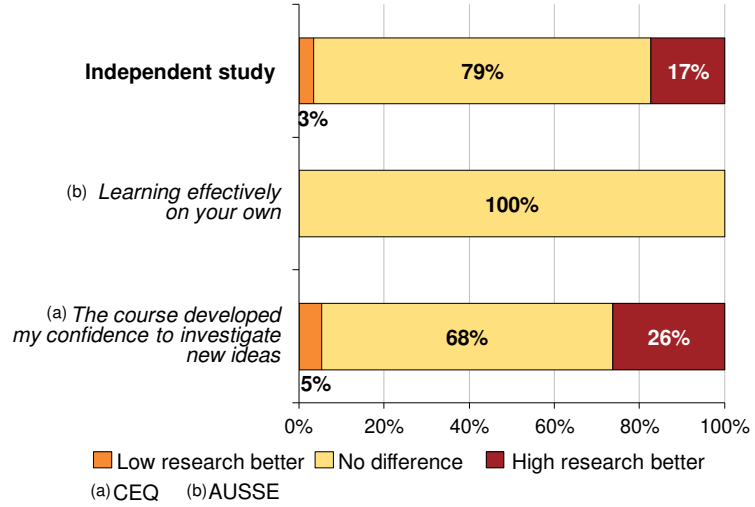


Figure 42: Planning skills

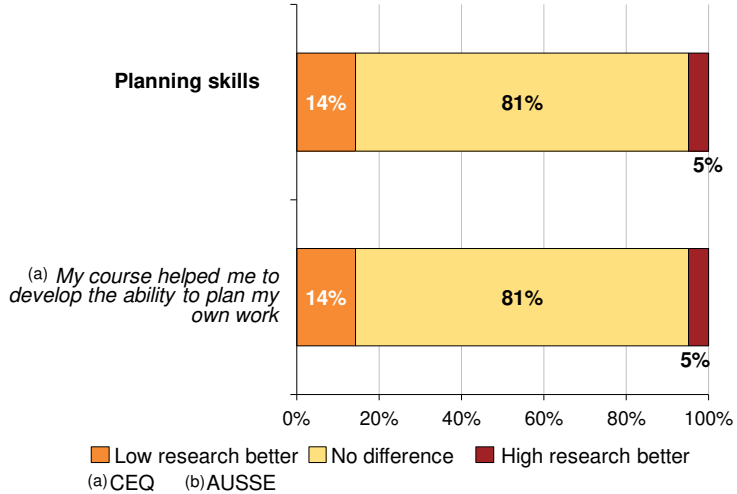


Figure 43: Summary of work readiness results

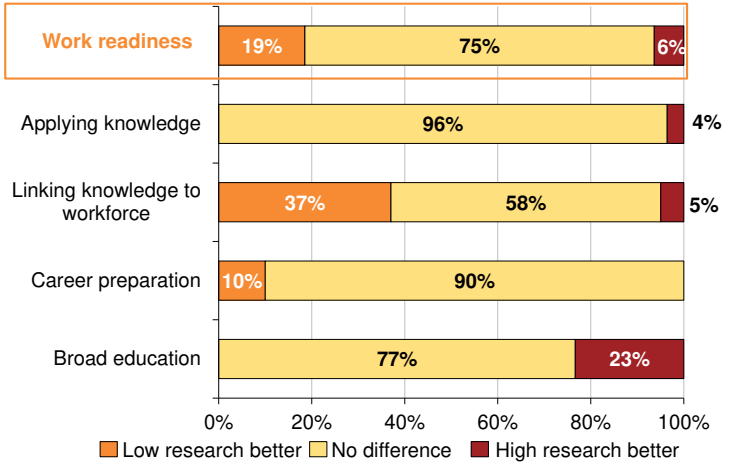


Figure 44: Applying knowledge

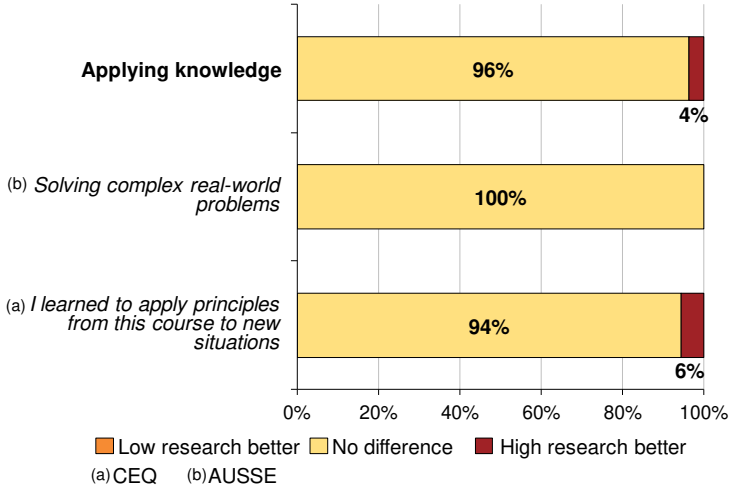


Figure 45: Linking knowledge to workforce

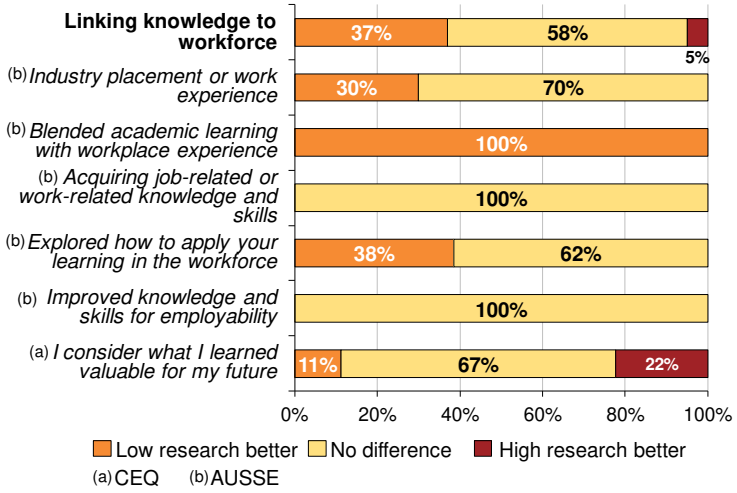


Figure 46: Career preparation

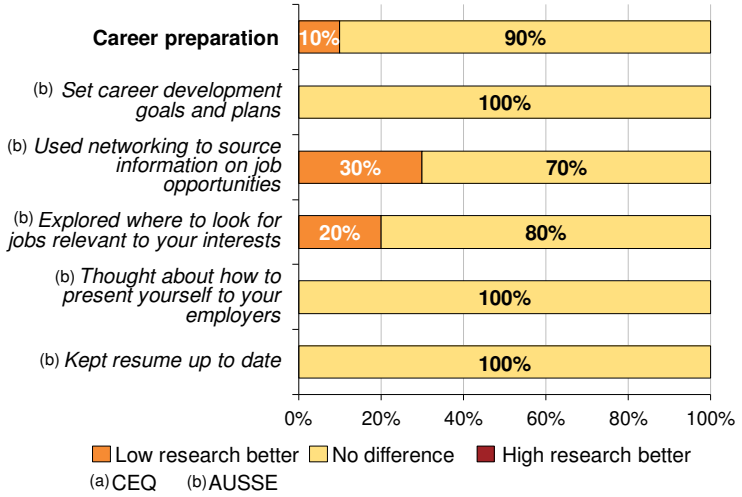


Figure 47: Broad education

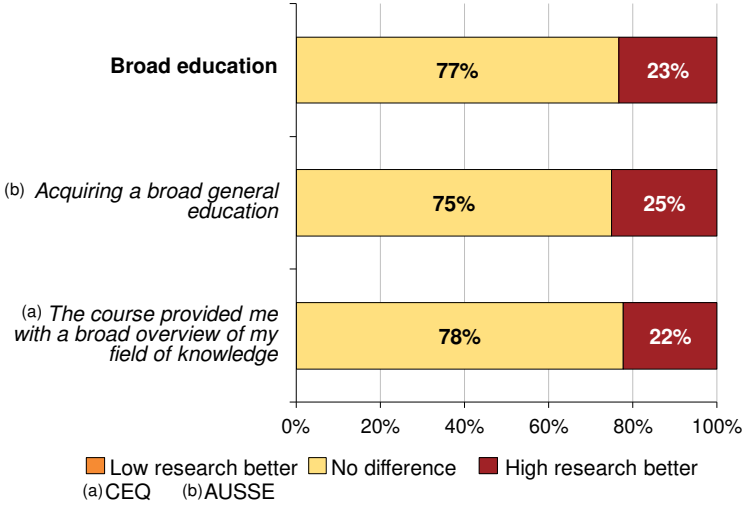


Figure 48: Overall satisfaction

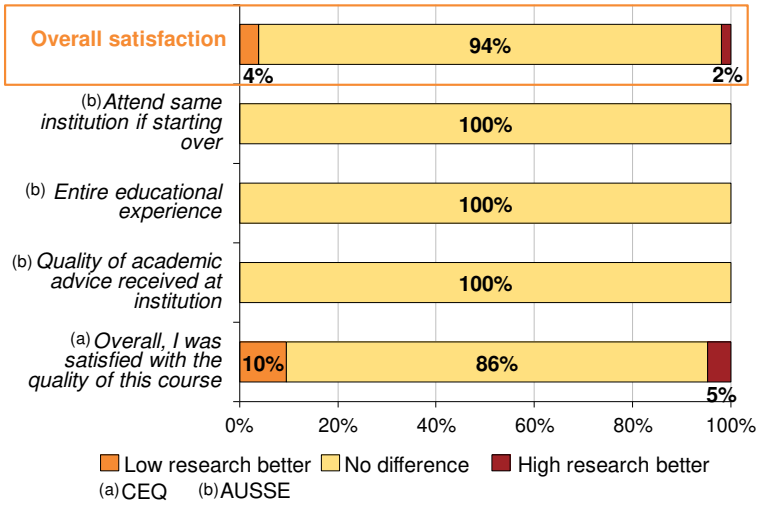
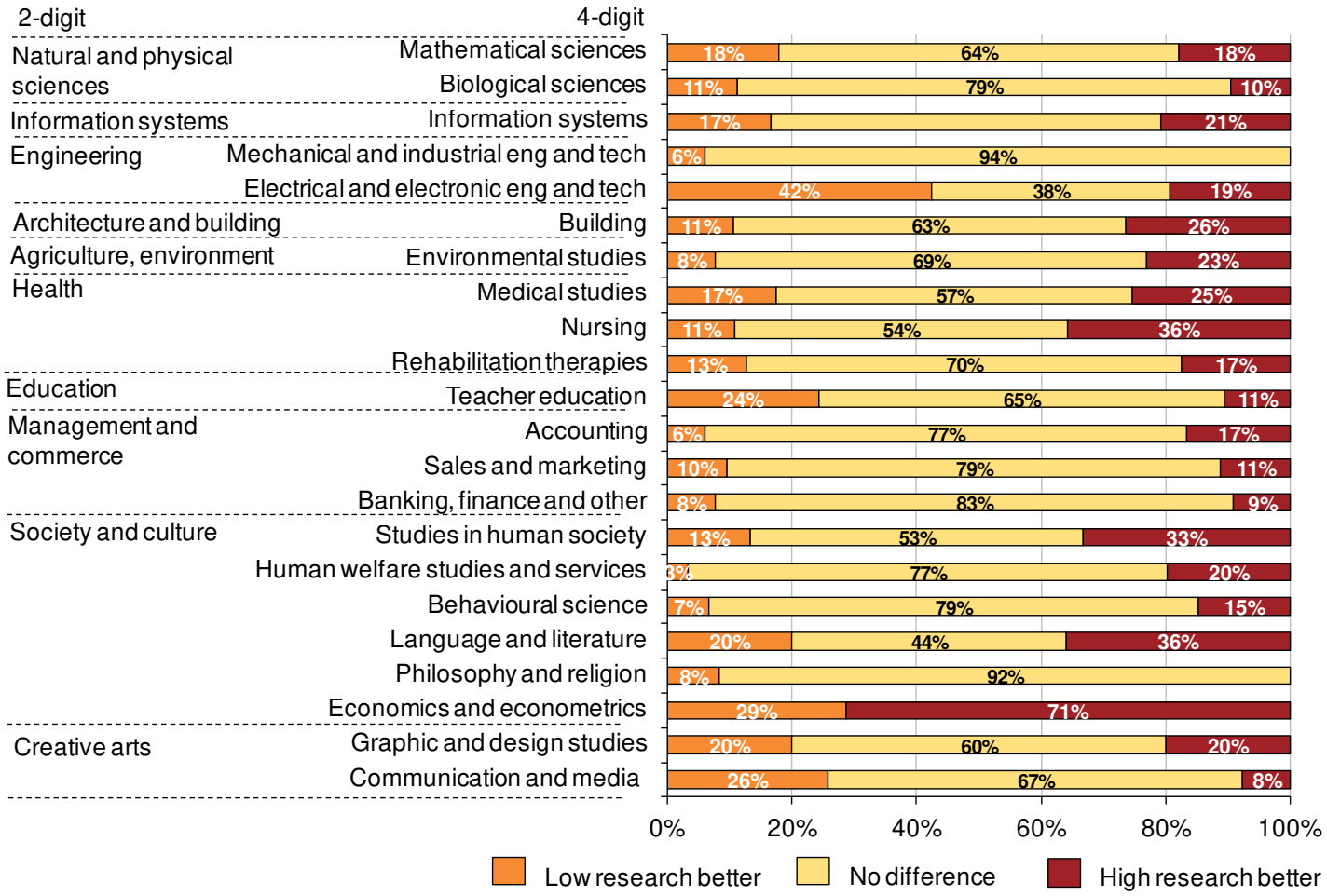
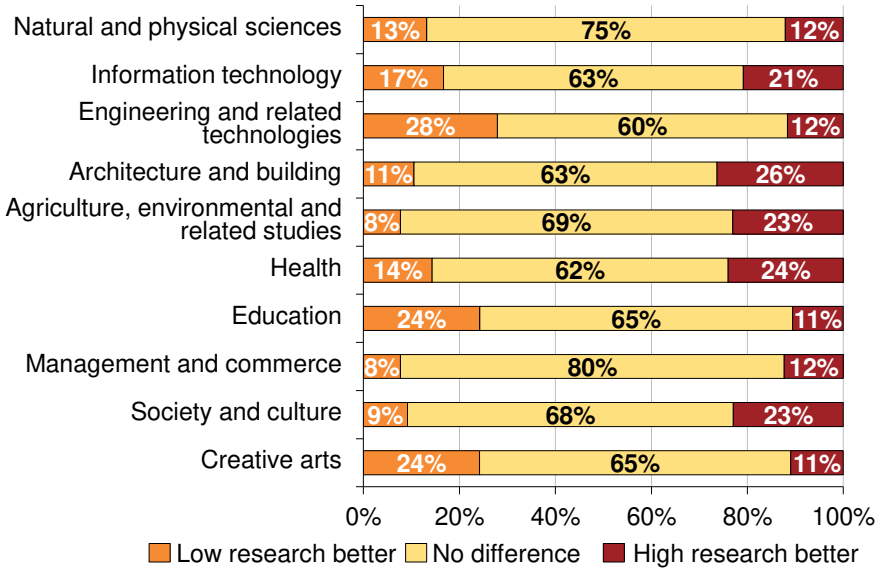


Figure 49: Field of education level results, 4 digit-level



Note: 'Economics and Econometric' results should be treated with caution given only a small number of questions had adequate sample size for regression analysis.

Figure 50: Field of education level results, 2-digit level



Appendix L: Regression results, by discipline

Table 18: Regression results, by discipline

	Student engagement																
4 digit	Feedback				Teacher expectations and explanations					Peer learning			Learning community	Community / uni activities			
	ceq101	ceq103	ceq127	EF_SI4	ceq115	ceq110	ceq108	ceq139	ceq146	EF_AL1	EF_AL2	EF_AL4	ceq118	ceq131	EF_EE11	EF_AL5	EF_AL6
Mathematical Sciences				-0.2								0.4				0.5	
Biological Sciences				-0.2								0.4				0.5	
Information Systems				-0.2								0.4				0.5	
Mechanical and Industrial Eng and Tech																	
Electrical and Electronic Eng and Tech		-0.2		-0.2	-0.2	-0.3						0.4				0.5	
Building				-0.2								0.4				0.5	
Environmental Studies				-0.2								0.4				0.5	
Medical Studies				-0.2		0.9						0.4	1.2			0.5	
Nursing				-0.2					-0.3		1.1	0.4				0.5	
Rehabilitation Therapies			-0.2	-0.2	0.3						0.8	0.4		-0.5		0.5	-0.4
Teacher Education	-0.2	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	-1.6	-0.3			0.4	-0.3	-0.4		0.5	1.1
Accounting				-0.2			0.5	0.4	1.2		0.7	0.4	-0.3			0.5	0.8
Sales and Marketing		-0.3	-0.3	-0.2	-0.2	-0.3						0.4				0.5	
Banking, Finance and Related Fields				-0.2				-1.0	-0.3			0.4				0.5	
Studies in Human Society				-0.2	0.5							0.4				0.5	
Human Welfare Studies and Services				-0.2	0.4						1.2	0.4				0.5	1.3
Behavioural Science				-0.2	0.3							0.4				0.5	
Language and Literature				-0.2	0.3							0.4				0.5	
Philosophy and Religious Studies																	
Economics and Econometrics				-0.2								0.4				0.5	
Graphic and Design Studies			-0.2	-0.2								0.4				0.5	
Communication and Media Studies	-0.1	-0.3		-0.2		-0.4	-0.4	-0.9	-0.3			0.4				0.5	

Note: EF_AL1, EF_AL4, EF_AL5, EF_SI4, and EF_EE11 are based on fixed model.

Table 18 (continued)

4 digit	Student engagement															
	Academic challenge											Different perspectives		Staff-student interaction		
	EF_AC11	EF_AC6	EF_AC1	EF_AC2	EF_AC3	EF_AC4	EF_AC5	EF_AC7	EF_AC8	EF_AC9	EF_AC10	ceq148	EF_EE3	EF_SI3	EF_SI5	EF_SI6
Mathematical Sciences									-0.4							
Biological Sciences							-0.4									
Information Systems																
Mechanical and Industrial Eng and Tech																
Electrical and Electronic Eng and Tech																
Building																
Environmental Studies																
Medical Studies	-0.4			-0.3	-0.6	-0.4	-0.4		-0.3			0.9				
Nursing																
Rehabilitation Therapies									-0.5							
Teacher Education					1.1											
Accounting						-0.3										
Sales and Marketing																
Banking, Finance and Related Fields																
Studies in Human Society				1.0								0.7				
Human Welfare Studies and Services				0.6			0.9									
Behavioural Science																
Language and Literature							-0.6					0.9				
Philosophy and Religious Studies																
Economics and Econometrics																
Graphic and Design Studies									-0.4							
Communication and Media Studies					-0.5											

Note: EF_AC6, EF_AC7, EF_AC9, EF_AC10, EF_SI3, EF_SI5, EF_SI6, and EF_EE3 are based on fixed model.

Table 18 (continued)

	Skills development													
4 digit	Teamwork		Analytic Skills			Problem solving Skills		Writing Skills		Planning Skills	Independent study		Communication skills	
	ceq106	LO_GL8	ceq114	LO_GL5	LO_GL6	ceq123	ceq142	ceq132	LO_GL3	ceq143	ceq117	LO_GL9	LO_GL4	EF_WL3
Mathematical Sciences					0.3			-0.3					0.3	0.4
Biological Sciences	0.5				0.3								0.3	0.4
Information Systems					0.3	-0.2		-0.4					0.3	0.4
Mechanical and Industrial Eng and Tech								-0.3						
Electrical and Electronic Eng and Tech					0.3		-0.2	-0.2		-0.3	-0.4		0.3	0.4
Building					0.3								0.3	0.4
Environmental Studies					0.3	0.7							0.3	0.4
Medical Studies	1.1		0.4		0.3	1.4				0.5	1.3		0.3	0.4
Nursing					0.3	0.4					0.4		0.3	0.4
Rehabilitation Therapies		0.6			0.3			-0.3					0.3	0.4
Teacher Education			-0.2		0.3		-0.2	-0.2					0.3	0.4
Accounting	0.2				0.3								0.3	0.4
Sales and Marketing	0.5	1.0			0.3								0.3	0.4
Banking, Finance and Related Fields	0.4				0.3			-0.3					0.3	0.4
Studies in Human Society	-0.4				0.3						0.9		0.3	0.4
Human Welfare Studies and Services	0.5				0.3								0.3	0.4
Behavioural Science					0.3			-0.2		-0.3	0.6		0.3	0.4
Language and Literature		-0.5			0.3						0.7		0.3	0.4
Philosophy and Religious Studies	-0.7													
Economics and Econometrics					0.3								0.3	0.4
Graphic and Design Studies					0.3			-0.3					0.3	0.4
Communication and Media Studies	-0.5	-0.6			0.3		-0.3	-0.3		-0.3			0.3	0.4

Note: LO_GL3, LO_GL4, LO_GL5, LO_GL6, LO_GL9, and EF_WL3 are based on fixed model.

Table 18 (continued)

	Work readiness															Overall Satisfaction			
4 digit	Broad Education		Applying know ledge		Linking know ledge to w orkforce						Career Readiness					Satisfaction			
	ceq111	LO_GL1	ceq136	LO_GD4	ceq140	EF_WL2	EF_WL4	EF_WL6	EF_WL1	EF_WL5	LO_CR1	LO_CR2	LO_CR3	LO_CR4	LO_CR5	ceq149	LO_OS1	LO_OS2	LO_OS3
Mathematical Sciences							-0.6		-0.2										
Biological Sciences							-0.6		-0.2	-0.5			-0.3	-0.6					
Information Systems									-0.2										
Mechanical and Industrial Eng and Tech																			
Electrical and Electronic Eng and Tech					-0.3				-0.2							-0.4			
Building									-0.2										
Environmental Studies									-0.2										
Medical Studies	0.3				0.9		-0.5		-0.2	-0.7			-0.4			0.6			
Nursing	0.3				0.8				-0.2										
Rehabilitation Therapies	0.5		0.3		0.5				-0.2					-0.4					
Teacher Education									-0.2							-0.4			
Accounting									-0.2										
Sales and Marketing									-0.2										
Banking, Finance and Related Fields									-0.2										
Studies in Human Society		0.9					-0.5		-0.2										
Human Welfare Studies and Services		0.4							-0.2										
Behavioural Science	0.7				0.6				-0.2										
Language and Literature		0.8					-0.6		-0.2										
Philosophy and Religious Studies																			
Economics and Econometrics									-0.2										
Graphic and Design Studies									-0.2										
Communication and Media Studies					-0.3				-0.2	-0.6				-0.5					

Note: EF_WL1, EF_WL2, EF_WL6, LO_GD4, LO_CR1, LO_CR2, LO_CR5, LO_OS1, LO_OS2, and LO_OS3 are based on fixed model.

References

ABS (2010) *Education and training experience 2009, Cat. 6278.0*, Australian Bureau of Statistics

ACER (2010) *Staff student engagement survey (SSES)*, Australian Council for Educational Research

Acock, A. C. (2005) 'Working With Missing Values', *Journal of Marriage and Family*, 67(4), p 1012-1028

Allen, M. (1996) 'Research productivity and positive teaching evaluations: Examining the relationship using meta-analysis', *Journal of the Association for Communication Administration* 2, p 77-96

ARWU (2013) 'Academic Ranking of World Universities', accessed 1 October 2013, from http://www.shanghairanking.com/index.html

Barrett, G. and Milbourne, R. (2012) 'Do excellent research environments produce better learning and teaching outcomes?', *The Economic Record*, 88, p 70-77

Bexley, E., James, R. and Arkoudis, S. (2011) *The Australian academic profession in transition*, Centre for the Study of Higher Education, The University of Melbourne

Brew, A. (2010) 'Imperatives and challenges in integrating teaching and research', *Higher Education Research and Development*, 29(2), p 139-150

Carini, R., Kuh, G. D. and Klein, S. (2006) 'Student engagement and student learning: Testing the linkages', *Research in Higher Education*, 47(1), p 1-30

Coates, H. (2006) *Student engagement in campus-based and online education: University connections*, Taylor & Francis

Coates, H. (2009) 'Development of the Australasian survey of student engagement (AuSSE)', *Higher Education*, 60, p 1-17

DIICCSRTE (2012a) *Higher education standards framework (threshold standards) 2011*, Department of Industry, Innovation, Science, Research and Tertiary Education

DIICCSRTE (2012b) *Students: Selected higher education statistics 2011,* Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education

DIICCSRTE (various years) *Higher education research data collection*, Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education

Dodd, T. (2013) 'UWA scores first with US web course', *The Australian Financial Review,* 24 June 2013, p 24

Faia, M. A. (1976) 'Teaching and research: Rapport or mesalliance ', *Research in Higher Education*, 4, p 235-246

Feldman, K. (1987) 'Research productivity and scholarly accomplishment of college teachers as related to their instructional effectiveness: A review and exploration', *Research in Higher Education Next*, 26, p 227 - 246

Figlio, D., Schapiro, M. and Soter, K. (2013) 'Are tenure track professors better teachers?', from

Finchman, M. and Cummings, J. N. (2003) 'Multiple Impuation for Missing Data: Making the Most of What You Know', *Organizational Research Methods*, 6(3), p 282-308

Fox, J. and Weisberg, S. (2002) *An R and S-Plus Companion to Applied Regression*, Sage Publications

Galbraith, C. and Merrill, G. (2012) 'Faculty research productivity and standardised learning outcomes in a university teaching environment: a Bayseian analysis of relationships', *Studies in Higher Education*, 37(4), p 469-480

GCA (1995-2013) *Graduate course experience questionnaire*, Graduate Careers Australia

GCA (2012) *Graduate course experience 2011*, Graduate Careers Australia

Gelman, A. and Hill, J. (2007) *Data Analysis Using Regression and Multilevel/Hierarchical Models*, Cambridge University Press

Hattie, J. and Marsh, H. W. (1996) 'The relationship between research and teaching: a meta- analysis', *Review of Educational Research*, 66(4), p 507 - 542

Hensher, D. A. and Greene, W. H. (2003) 'The Mixed Logit model: The state of practice', *Transportation*, 30, p 133-176

Jenkins (2004) *A Guide to the Research Evidence on Teaching-Research Relations*, Higher Education Academy

Jenkins, A. and Healey, M. (2005) 'Institutional strategies to link teaching and research', from www.heacademy.ac.uk/resources.asp?process=full_record&section=generic&id=585

Kuh, G. D., Cruce, M., Shoup, R. and Kinzie, J. (2008) 'Unmasking the effects of student engagement on first-year college grades and persistence', *The Journal of Higher Education*, 79(5), p 540-563

Laird, N. M. and Ware, J. H. (1982) 'Random-Effects Models for Longitudinal Data', *Biometrics*, 38, p 963-974

Larkins, F. and Croucher, G. (2013) 'Research', in *The Dawkins revolution 25 years on*, G. Croucher, S. Marginson, A. Norton and J. Wells, Eds., Melbourne University Press, p 248-264

Marchenko, Y. (2009) 'Multiple-imputation analysis using Stata's mi command', 2009 UK Stata Users Group Meeting, United Kindom, from

Marsh, H. and Hattie, J. (2002) 'The relation between research productivity and teaching effectiveness', *The Journal of Higher Education*, 73(5), p 603 - 641

Norton, A. (2013a) *Keep the caps off! Student access and choice in higher education*, Grattan Institute

Norton, A. (2013b) *Mapping Australian higher education, 2013 version*, Grattan Institute

Norton, A., Sonnemann, J. and Cherastidtham, I. (2013) *Taking university teaching seriously*, Grattan Institute

Norton, A., Sonnemann, J. and McGannon, C. (2013) *The online evolution: When technology meets tradition in higher education*, Grattan Institute

NSSE (2012) *National Survey of Student Engagement, 2012 overview*, Indiana University Center for Postsecondary Research, accessed 1 June 2013, from http://nsse.iub.edu/institutional_report/NSSE_Overview_2012.pdf

Pascarella, E., Seifert, T. and Blaich, C. (2010) 'How effective are the NSSE benchmarks in predicting important educational outcomes?', *Change: The Magazine of Higher Learning*, 42(1), p 16-22

Pascarella, E. and Terenzini, P. (2005) *How college affects students: A third decade of research*, John Wiley & Sons

Penny, K. I. and Atkinson, I. (2011) 'Approaches for dealing with missing data in health care studies', *Journal of Clinical Nursing*, 21, p 2722-2729

Radloff, A. (2010) *Student engagement at New Zealand Institutes of Technology and Polytechnics*, ACER

Ramsden, P. and Moses, I. (1992) 'Associations between research and teaching in Australian higher education', *Higher Education*, 23, p 273-295

Rubin, D. B. (1987) *Multiple Imputation for Nonresponse in Surveys*, John Wiley & Sons, Inc.

Schafer, J. L. (1999) 'Multiple imputation: a primer', *Statistical Methods in Medical Research* 8, p 3-15

Schafer, J. L., Ezzati-Rice, T. M., Johnson, W., SKhare, M., Little, R. J. A. and Rubin, D. B. (2010) *The Nhanes III Multiple Imputation Project*, Centers for Disease Control and Prevention, US from http://ftp.cdc.gov/pub/Health_Statistics/NCHS/nhanes/nhanes3/7a/doc/jsm96.pdf

Schafer, J. L. and Graham, J. W. (2002) 'Missing Data: Our View of the State of the Art', *Phychological Methods*, 7(2), p 147-177

Schafer, J. L. and Olsen, M. K. (1998) 'Multiple Imputation for Multivariate Missing-Data Problems: A Data Analyst's Perspective', *Multivariate Behavioral Research*, 33(4), p 545-571

Sinharay, S., Stern, H. S. and Russell, D. (2001) 'The Use of Multiple Imputation for the Analysis of Missing Data', *Psychological Methods*, 6(4), p 317-329

Spratt, M., Carpenter, J., Sterne, J. A. C., Carlin, J. B., Heron, J., Henderson, J. and Tilling, K. (2010) 'Strategies for Multiple Imputation in Longitudinal Studies', *American Journal of Epidemiology*, 172(4), p 478-187

Stappenbelt, B. (2013) 'The effectiveness of the teaching-research nexus in facilitating student learning', *Engineering Education*, 8(1), p 111-121

TEQSA (2012) *Application guide: application for accreditation of a higher education course of study (AQF qualification)*, Tertiary Education Quality and Standards Agency

Trigwell, K. (2005) 'Teaching-research relations, cross-disciplinary collegiality and student learning', *Higher Education* 49, p 235 - 254

Witte, K., Rogge, N. C., L. and Puyenbroeck, T. V. (2012) 'Economies of scope in research and teaching: a non-parametric investigation', *Omega*, 41(2), p 305 - 314

Zaman, M. Q. (2004) *Review of the Academic Evidence on the Relationship Between Teaching and Research in Higher Education*, Department for Education and Skills