Engaging learners effectively in the sciences:

The pathway from secondary to university education

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Philosophy
in
Science

at Massey University, Manawatu,
New Zealand.

Helen Hughes

2011

Abstract

Considerable evidence exists of a world-wide trend of declining student numbers in school and university sciences. Much of the research evidence relating to student engagement in the Sciences has focused on school students, with very little focusing on university students, and even less on the transition and engagement of students from school to university science. This research seeks to understand how university students become or remain engaged in science during their transition from school to university.

Data were collected using a mixed-methods design that included a questionnaire and focus groups. Participants consisted of first-year university students from the College of Science, alongside their lecturers and paper coordinators; plus secondary school students studying one or more sciences, alongside their teachers.

Analysis of questionnaire data revealed five ‘teacher efficacy’ scales (Lecturer Qualities, Relevant Contexts, Scientific Method, Self-Directed Learning, and Maximising Technology) that correlated with three ‘student engagement’ scales (Commitment to Performance, Learning with Excitement, and Discovering Meaning). Thematic analysis of qualitative data supported these relationships between teacher efficacy and student engagement. Student engagement was most strongly influenced by lecturers’ qualities, along with the ability to place scientific knowledge into contexts that were relevant to the student. However, lecturers’ and teachers’ perceptions of their teaching qualities were significantly greater than those of their students and, conversely, students’ perceptions of their own engagement were significantly greater than those of their teachers/lecturers.

The findings provide clear evidence that more widespread use of best practice pedagogies and provision of relevant contexts would promote student engagement in the Sciences at both secondary and tertiary education levels. In arriving at this conclusion, the present study explores some key questions:

- Student engagement is not lost in transition; but are students engaged at all?
- Teachers influence student engagement; but are teachers reaching their potential?
- Teaching needs to be more engaging; but what does that involve?
- Undergraduates want to become scientists, but must they wait until postgraduate studies?

Acknowledgements

I am grateful to Massey University's Pro-Vice Chancellor College of Sciences, Professor Robert Anderson for entrusting me with this research project. I am also grateful to Ako Aotearoa, New Zealand's National Centre for Tertiary Teaching Excellence for the funding that made this research possible.

Special thanks goes to all those who guided me, especially my supervisors Professor Tim Parkinson and Dr Dianne Gardner for their direction and rigorous standards. In addition, Bill MacIntyre, Marg Gilling and Bob Rosemergy for their support with qualitative data collection; Mrs Gay Trowe for transcribing focus group recordings; and Mrs Glennis Warbutton for data entry. The assistance of the administrative staff in the College of Sciences, the Centre for Academic Development and e-Learning is also gratefully acknowledged. I am also grateful to the participants of this study for their time and effort. I particularly acknowledge the willingness of the Principals of the five schools that gave me access to their Science staff and students. Similarly, the Programme Directors and Paper Coordinators who gave me access to their staff and students from the College of Sciences at Massey University, New Zealand.

Approval to conduct the study was granted by the Massey University Human Ethics Committee: Southern B 09/12.

Publications

There have been several publications arising from this thesis. The primary publication was the Final Report, which was published by Ako Aotearoa in June 2011:

Parkinson, T., Hughes, H., Gardner, D., Suddaby, G., Gilling, M., & MacIntyre, B. (2011). *Engaging learners effectively in science, technology and engineering: The pathway from secondary to university education*. Wellington, New Zealand: Ako Aotearoa.

In addition, several conference papers have been presented:

MacIntyre, B., Gardner, D., Gilling, M., Hughes, H., Parkinson, T., Rosemergy, B., & Suddaby, G. (2010). *Engaging secondary school learners effectively in science: Voices of students and teachers*. In S. Dolinšek, T. Lyons (Eds.), XIV IOSTE 2010 Socio-cultural and Human Values in Science and Technology Education Conference Proceedings (pp. 715-724). Ljubljana, Slovenia: Institute for Innovation and Development of University of Ljubljana.

MacIntyre, B., Parkinson, T., Gardner, D., Suddaby, G., & Hughes, H. (2010). *Transition and engagement in the sciences: From school to university.* Paper presented at STEM in Education, Brisbane, Australia.

Parkinson, T., MacIntyre, B., Hughes, H., Gardner, D., Gilling, M., & Suddaby, G. (2010). *Engagement in the sciences: The pathway from secondary to tertiary learning*. Paper presented at Careers and Transition Education Conference, Auckland, New Zealand.

Contents

List of Tables

List of Figures

1. Literature Review

1.1. Science, Engineering & Technology

In New Zealand, a declining number of young people are choosing a tertiary education in the Sciences with a view to taking up science careers (Hipkins & Bolstad, 2005). This problem is by no means isolated to New Zealand and is especially evident in physics, chemistry and mathematics. The same trend is apparent in Australian universities where, between 1989 and 2005, enrolments decreased by 33.7% in the mathematical sciences, in the physical sciences by 19.4%, and in chemical sciences by 5.3% (Dobson, 2007). European countries have likewise seen declining numbers of students choosing to study physical sciences, engineering and mathematics at university. For example, in the United Kingdom, between 1996-1997 and 2001-2002, the number of students registered in physical sciences decreased by 10.2%. Meanwhile, a different story is apparent in the biological and computer sciences. The same study in the UK reported that registrations grew 15.7% for life sciences and 61% for computer science (European Commission, 2004); and in Australia, Biological Sciences increased by 74.9% (Dobson, 2007).

In New Zealand, Australia, Europe, and the United States, significant government funding has been directed towards research into the reasons why there is a high level of departure intention among first-year university students. Their investment has been justified by a study by the Higher Education Funding Council for England (HEFCE) in 1997, which estimated the direct costs to taxpayers of higher education non-completion to be about 90 million pounds a year (Evans, 2000). In Australia, McInnis et al. (2000b) found that 18% of their first-year sample withdrew from at least one unit of study and about one-third considered deferring their studies. The results of a longitudinal study among first-year students in Australia revealed that departure intention was around 23% in 2009, although this figure had fallen significantly since2004 and 2009 (James et al., 2009). Results from the Australasian University Study of Student Engagement indicated that 34.5% of first-year students expressed ‘departure intention’ (AUSSE, 2009). In a New Zealand study of tertiary institutions, Zepke et al. (2006) found that full withdrawal ranged from 13% to 58% and that, on average, 33% of remaining students had considered at least partial withdrawal. At Massey University, during the Academic Year 2009, a total of 1399 students enrolled for the first time as an internal student in between one and ten 100-level (first year) papers (units of study) from the College of Sciences. Of these: 46.9% passed every paper in which they enrolled; 29.9% remained enrolled in every paper, but failed or did not finish one or more of their papers; 17.1% withdrew from one or more paper (of which, only 28% went on to pass every paper in which they remained enrolled); and 6.3% withdrew from all or did not complete any of the papers in which they enrolled (College of Sciences, unpublished).

In addition, there appears to be a parallel trend of fewer students progressing from undergraduate to postgraduate study of science, which, in turn, eventually translates to fewer scientists entering the workforce. For example, between 1993 and 2003, the percentage of graduates studying for a PhD, which is the most common route to becoming a professional scientist, had dropped in all European countries (European Commission, 2004). In Australia, the number of graduates with a PhD in chemistry per million people dropped from eighteen in 1969 to eight in 2001 (Australian Council of Deans of Science, 2001).

The combination of fewer students choosing a tertiary education in physics, chemistry and mathematics; a general increase in the proportion of students who decide to quit their tertiary studies (Zepke et al., 2006; AUSSE, 2009); a declining number of PhD students in the Sciences; and an overall decline in scientists entering the workforce poses problems for national economies and has become a matter of high priority for governments.

For example, in Australia, the government expressed the view that the decline in student uptake of post-compulsory Science, Technology, Engineering and Mathematics (STEM) study, the shortage of a skilled science-qualified workforce and a decreasing number of qualified science teachers restricts the development and expansion of science and technology based industry and compromises Australia's capacity to maintain a sufficient market share in these key areas (Tytler et al., 2008). Consequently, Australia declared that the country had six years to find 75,000 additional scientists to meet the demands of the 'knowledge economy', and that most would need doctorates in physics, chemistry and mathematics (Andrews, 2004). Similar issues have been identified in the United States (National Science Foundation, 2009).

In New Zealand, the Ministry of Research, Science and Technology (MoRST) stated that New Zealand's economic success depends, to a large extent, on the growth of smart companies based on the ideas coming from universities and Crown Research Institutes, or the support these research organizations can provide to business. Consequently, one of their strategic priorities is 'Engaging New Zealanders with science and technology' (MoRST, 2010). However, there is evidence that New Zealand is performing poorly in comparison to other OECD countries when it comes to generating quality employment prospects for science graduates. On one hand, when it comes to researchers as a percentage of total employment, New Zealand, at 1.0%, scores above every country except Finland, Iceland and Japan, and is considerably higher than the OECD average of 0.75%. On the other hand, gross expenditure on Research and Development (R&D) as a percentage of Gross Domestic Product (GDP) in New Zealand in 2007 was 1.17%, compared to the OECD average of 2.25% (OECD, 2009). In other words, New Zealand invests less GDP per researcher than any other OECD country (MoRST, 2009).

1.2. Defining student engagement

Newman et al. (1992) define student engagement as 'active involvement, commitment and concentrated attention, in contrast to superficial participation, apathy or lack of interest' (p. 11). Engaged students are those who absorb the content delivered by their teacher in sufficient detail that they are not only able to explain it themselves but also apply their knowledge to everyday contexts and even develop their own related theories (Biggs, 1999). By contrast, a disengaged student typically only takes notes and memorises facts and key points in order to obtain a 'pass' for the course (Marton and Säljö 1976; Biggs 1999; Exeter et al., 2010). In a paper commissioned for New Zealand's Royal Society and the Prime Minister's Chief Science Advisor, Bull et al. (2010) cites three 'dimensions' used in educational research. The first is 'behavioural engagement', which is demonstrated by students who are involved and participating, meaning that they are likely to be on task and following instructions. The second is 'emotional engagement' that manifests as signs of interest / enjoyment and means that students find the learning sufficiently worthwhile / challenging to give it their attention and effort. Lastly, 'cognitive engagement' manifests at a surface level through a student's ability to describe what they have learned or complete a task accurately. However, at a deeper level, a student who is cognitively engaged is likely to initiate self-directed investigation or setting and solving related challenges. Any of these three 'dimensions' of engagement can be present on its own or in conjunction with others.

1.3. Studies of student engagement in the classroom

Krause (2007) identified three environments in which students are likely to become engaged with their learning: in the classroom or in study-related activities; in participation in out-of-class activities located either on campus (e.g. student clubs, sports, mentoring programmes) or off campus (e.g. paid part-time employment); or in the workplace (i.e. skill-based employment training). Engaging students in the classroom involves two parties: the teacher, who must provide a course which engages students' attention, and the students, who must engage with the course content (McGroarty et al., 2004). The following six studies examine student engagement in the classroom. The first four studies relate to science at secondary school; while the final two studies relate to general studies at tertiary level, although it should be noted that these studies all took place in a secondary school context:

Osborne and Collins (2001) examined students' values, beliefs and experiences with secondary school science in the United Kingdom. They used focus groups to collect qualitative data that was interpreted using thematic analysis. The author's conclusion emphasises that, whilst science is considered to be an important subject, this is a message that is not adequately transmitted to students during their experience of science at school. Consistent throughout the qualitative data collected was the theme that relevance, the 'vital ingredient', was missing for far too many pupils from far too many of the science topics that they were taught. It was observed that school science engages when it makes connections to the pupils' everyday lives. In part, this explains the success of human biology because its application is immediate, transparent and unquestionable. In contrast, physics and chemistry have fewer points of contact with pupils' experiences.

The work of Lindhal (2003) in Sweden also used qualitative methods (participant observation and interviews) to study students' experiences and attitudes in lower secondary school science. Lindhal's dissertation presents four key findings: (1) pupils are interested in science but not as much as in other subjects, in part because they feel the wider purpose of science is not made clear; (2) as early as Grade 5, pupils are developing an idea of their future career which remains the focus of their attention throughout secondary school meaning that, once they have lost interest in something, it is very difficult to reignite their interest and allegiance; (3) even able students with high marks, the 'right' background and a natural interest in science are not being engaged by science at school; (4) rewarding student's understanding of scientific concepts is paramount because this is often not recognised in their marks.

Lyons's (2003, cited in Lyons, 2006) study in Australia explored the influences of socio-cultural factors on student's decision making in their enrolment in science classes. He surveyed teachers and students and then interviewed students individually. Lyons found that over one-half of those choosing two or even three science courses had been quite critical of their earlier classroom experiences, which he observed to be consistent with Atwater and Wiggins's (1995) quantitative research, which found only 25% of students intending to pursue study or careers in science or technology held positive attitudes to science.

The research carried out by Hipkins et al. (2006) in New Zealand started with focus group interviews in secondary schools, which informed their follow-up survey. Of particular interest, the authors reported that a cluster labelled "serious science" students had the most committed intentions to study science at university. They represented one-third of the surveyed Year 13 students and tended to be taking more than one traditional science subject and at least one mathematics subject in their final year of school. In contrast, just under a quarter of the Year 13 students, who were predominantly males, formed a cluster labelled the "science/business" student. These had chosen science and mathematics subjects, in particular physics and calculus, which they typically combined with computer science as well as business-oriented subjects. Finally, the authors identified that 44% of students belonged to a cluster labelled "keeping options open" students, who demonstrated a greater level of indecision about future study plans; were less likely to be confident about their academic ability in sciences; were less likely to be enjoying science study but were influenced by pressure from their families to persevere with science studies; and were most likely to be taking a mixed-bag of subjects that often included non-traditional science disciplines, such as agriculture, horticulture and earth science.

In the United States, there is the National Survey of Student Engagement (NSSE), which is derived from its predecessor, the College Student Experiences Questionnaire (CESQ). The survey compromises eighty-five questions which focus on the responses of first and final year baccalaureate students to a range of institutional activities (Kuh, 2004). The instrument underwent rigorous psychometric testing and through a process of Principal Component Analysis, the NSSE study identified seven student engagement scales: transition engagement scale (TES), academic engagement scale (AES), peer engagement scale (PES), student-staff engagement scale (SES), intellectual engagement scale (IES), online engagement scale (OES), and beyond-class engagement scale (BES). Recommendations arising from the NSSE have consistently highlighted the need for institutional-level systems designed to identify and respond to students who are disengaged, especially enrolment procedures and assistance to help match students to appropriate courses and institutions; consideration of a national framework for academic standards in the first-year of tertiary study; and strategies to inform students of the nature of the engagement that effective higher education requires of them in order to enable them to take responsibility for their own academic progress (Kuh et al., 2005).

A second tertiary survey, the Australasian Survey of Student Engagement (AUSSE), was presented in 2007 to twenty-five institutions in Australia and New Zealand. At the time of writing this thesis, there are three survey instruments used to collect the data reported in the AUSSE: firstly, the Student Engagement Questionnaire (SEQ), which is closely aligned to the NSSE (ACER, 2009) and surveys first and last year baccalaureate students; secondly, the Postgraduate Student Engagement Questionnaire (PSEQ); and, finally, the Staff Student Engagement Questionnaire (SSEQ), which incorporates much of the Faculty Survey of Student Engagement (FSSE) from Indiana University's Centre for Postsecondary Research. In an analysis of AUSSE data relating specifically to New Zealand students in 2010, although nearly one third had seriously considered leaving their university, most students (72.7%) planned to stay and continue with their studies. In general, students were also very satisfied with their experience at university with 78.8% of first-year and 74.8% of later-year students rating the quality of academic advice received as ‘good’ or ‘excellent’. The vast majority of New Zealand university students also indicated that given the chance to start over, they would attend the same university again (89.1%) (Harris & Coll, unpublished).

1.4. Addressing student engagement in the classroom

The European Commission (2004) recommends that universities become more committed to evaluating and rewarding teaching excellence. This is because conventional pedagogies have been linked to problems with students’ engagement in science at both secondary and tertiary level (Ramsden, 1991; Osborne & Collins, 2001; European Commission, 2004; Hipkins et al., 2006; Lyons, 2006). A conventional, teacher-centred course typically involves the transmission of concepts required for the syllabus, or the transmission of knowledge from the lecturer, with few opportunities for student interaction and little regard for students’ existing knowledge of a topic (Exeter et al., 2010).

Positive levels of student engagement, retention, higher quality learning outcomes and improved perceptions of teaching quality have all been attributed to student-centred, active learning (Ramsden, 1991; Zepke et al., 1991; Trigwell, Prosser & Waterhouse, 1999). Zepke et al. (2006) described ‘learner-centeredness’ as a situation in which students ‘feel they belong in an institutional culture, where they experience good quality teaching and support for their learning and where their diverse learning preferences are catered for’ (pp.587-600). As an example of good quality teaching, Chickering & Gamson (1987) identify that an effective teacher of undergraduate students: (1) encourages contact between students and faculty; (2) develops reciprocity and cooperation among students; (3) encourages active learning; (4) gives prompt feedback; (5) emphasizes time on task; (6) communicates high expectations; and (7 respects diverse talents and ways of learning.

In terms of good quality teaching in a science context, Tytler (2003) presents a model relating to the secondary sector, which arose from research funded by the Victorian government in Australia. The research project identified eight components that effectively support student learning and engagement in science (Tytler, 2003, Tytler, 2007b). These are: (1) Students are encouraged to actively engage with ideas and evidence; (2) Students are challenged to develop meaningful understandings; (3) Science is linked with students’ lives and interests; (4) Students’ individual learning needs and preferences are catered for; (5) Assessment is embedded within the science learning strategy; (6) The nature of science is represented in its different aspect; (7) The classroom is linked to the broader community; (8) Learning technologies are exploited for their learning potentialities. While these components were observed in secondary classrooms, they might also be pertinent to effective teaching and engagement in the tertiary science environment.

Adopting these models of ‘best-practice’ may require a difficult transition by academic staff from teaching to facilitating learning (Clarke, 2000). In reality, a combination of factors makes it challenging to create engaging learning environments, especially where large class sizes result in students being anonymous to their teachers (Kuh et al., 2005), which is in stark contrast to the typical secondary school environment. Perhaps as a consequence, one study found that only 26% of first-year tertiary students believed that staff were actually interested in their progress (James et al., 2009).

A key study by Exeter et al. (2010) investigated the challenges of teaching large first-year classes at university. In contrast to other studies have defined ‘large’ class sizes as being between 100 and 500 students, Exeter et al. (2010) defined ‘large’ as classes over 550 students. This is because, at the University of Auckland in 2007, over 30 first-year courses had enrolments exceeding 500 students, of which 10 classes had enrolments well in excess of 1000. Results revealed that, although it would be easy to assume didactic lectures would be the default approach to teaching large classes, techniques commonly used in small classes could be successfully employed in very large classes to engage students. These techniques included problem-based learning, small-group discussions and strategies that enable students to frequently ask questions.

In contrast to the techniques reported by Exeter et al. (2010), other authors have argued that many academics do not question their assumptions about traditional transmission theories of teaching (Ramsden, 1991; Biggs, 1999). Specifically in the context of the Sciences and engineering (as opposed to Health Sciences), Ramsden (1991) reported that senior teachers relied on surface approaches (i.e. transmissive pedagogies) in teaching large first-year classes more frequently than senior teachers in the arts and social sciences. Similarly, the critique of tertiary education in science and technology undertaken by the European Commission also identified a reliance on simplistic and epistemologically-unsound pedagogic structures which may result in students failing to perceive their learning as relevant to their own situations (European Commission, 2004).

These finding may be a cause for concern, especially in light of data collected from first-year students that point towards a serious disconnection between the perceptions of students and their lecturers. Results from the AUSSE reveal that, in terms of academics’ understandings of how students feel, the perceptions of staff concerning their interactions with students were much more positive than the perceptions of students (AUSSE, 2009). For example, 34.5% of first-year students identified that they had had departure intentions, whereas the academic staff who taught these students perceived that only 10.9% had departure intentions. Similarly, the ‘Student and Staff Interaction’ score given by first year students was 19.8, compared to a score of 41.3 given by their teachers (where the results for the AUSSE scales are reported on a metric ranging from 0 to 100).

1.5. Rationale for the current study

The objective of the present study was to explore the perceptions of students and their teachers about the transition from secondary school to university. This is a unique investigation in the context of Science, Technology and Engineering. The two-part research design compares: (1) lecturers with students and; (2) secondary with tertiary education across the frontier of transition. The present study will use qualitative and quantitative data, which is an approach that has not been typical of the studies of student engagement to-date.

2. Methods

Approval to conduct the study was granted by the Massey University Human Ethics Committee: Southern B 09/12. These data were gathered using a mixed methodology. Firstly, a two-part questionnaire was developed, which was based primarily around previous studies in the Australian Science in Schools project (Tytler, 2003). It measured ‘teacher efficacy’ and ‘student engagement’. Secondly, focus groups/interviews asked participants to explore in greater depth the factors that promoted or inhibited engagement in science study.

Engagement in science was studied with four cohorts of participants:

(i) First-year university students;

(ii) University teachers of these students;

(iii) Year 12 secondary school students studying at least one science subject; and

(iv) Secondary school science teachers of these students.

Year 12 school students were included because they have made post-compulsory choices to study science, but have not yet necessarily decided to study science at the tertiary level; and because they have already have experience with the NCEA assessment regime. Year 13 students were not included as they have already made their decisions to study science(s) and are more likely to be preparing themselves for making their transition into the tertiary environment. Likewise, Year 11 students were considered to be not sufficiently far progressed with their academic choices to provide useful data for of this study.

2.1. Quantitative Investigation

Quantitative data from the four cohorts were collected using a cross-sectional anonymous questionnaire. Massey University and five high schools in the Manawatu and Greater Wellington regions of New Zealand agreed to participate in the study.

- First-year university students in the College of Sciences were addressed by a member of the research team during class times that had been pre-arranged with the coordinators and/or lecturers of individual units of study. Participants received a paper copy of the survey as they left the lecture theatre, which they were asked to complete and return at the end of a subsequent lecture. Students could also access and complete the survey anonymously via www.surveymonkey.com. As compensation for their time, all participants received a token for free coffee when they returned their survey to a box.

- University lecturers were recruited via email. Participants received a paper copy of the survey via internal mail. They were asked to complete and return the survey via internal mail. Participants also received one reminder via email.

- School students were recruited by their science teachers. Participants received a paper copy of the survey, which they were asked to complete during an allocated period of class time and return to their science teacher in an anonymous envelope.

- School teachers were recruited by their Principal/Head of Science. Participants received a paper copy of the survey, which they were asked to complete and return to their Principal/Head of Science before the scheduled date of their Focus Group.

The questionnaire used for University students is given in Appendix 1, the demographic questions in Appendix 2 and participant demographics in Appendix 4.

Of the first-year university students who responded to the questionnaire, the highest number were female (62%); Pakeha/Europeans (71%); those who had left school in 2007/8 (66%); and those who had undertaken the NCEA curriculum (73%). There was a good representation from across all degree programmes in the College of Sciences. For Year 12 school students, there were slightly more males (56%) than females (44%); the majority were also Pakeha/European (65%); and English was the most common first language (83%). There were approximately equal numbers of students studying biology, chemistry and physics.

The majority of university lecturer respondents were male (70%). The highest number of responses came from senior lecturers (42%), although there was good representation from across the hierarchy. Most respondents taught/tutored students for <10 hours per week (71%). At school, the gender ratio of school teacher respondents was virtually equal. Most had undertaken teacher training in New Zealand (82%) and half had been teaching science at Year 12 for between 4 and 11 years (52%).

The survey comprised 100 Likert-scale items; 50 items assessing teacher efficacy' (Tytler, 2003) and 50 items assessing 'student engagement'. All items were on a scale of 1 to 5, where 1 = never; 2 = rarely; 3 = sometimes; 4 = often; 5 = always.

All four cohorts were given the same questionnaire items, but items were reworded according to whether they were a student or a teacher. For example, students were asked, 'I am given the opportunity to influence the way that I am taught'; while lecturers/teachers were asked, 'I give students the opportunity to influence the way that they are taught'.

2.2. Qualitative Investigation

Qualitative data were collected through focus groups and individual interviews. Eight focus groups were held with first-year university students, one with final-year university students, twelve with Year 12 school students, seven with university lecturers and five with the teachers of science to Year 12 school students. Totals of 59 first-year university students, 43 Year 12 schools students, 41 university lecturers, and 30 school science teachers participated. Participants were recruited into focus groups/interviews as follows:

- First-year and final-year university students were recruited by a team member and focus group(s) were conducted at a mutually agreed time. Focus groups comprised eight participants or less.

- Lecturers of first-year students in the College of Sciences were invited by e-mail to participate in one of a series of focus groups. Respondents were selected on a ‘first-come-first-served’ basis, up to a maximum of eight participants per group.
- The study was introduced to school students by their science teachers, who had been briefed by the research team. Focus groups were held either during the time scheduled for a science class (with teacher permission) or during ‘free’ periods. Participants were selected randomly into groups of eight participants or less.
- School teachers were informed of the study and invited to take part by their Principal or Head of Science. Focus groups were held either after school or during the hour normally allocated to a departmental meeting. There were one or two focus groups per school.

Written consent was provided by all participants. Focus groups were facilitated by two members of the research team, one of whom led the discussion, while the other asked supplementary questions and kept notes. Focus group discussions and individual interviews were digitally recorded and transcribed by an independent person who had signed a Confidentiality Agreement. The questions asked during focus groups were specific to each participant group (Appendix 3).

2.3. Analysis of Data

2.3.1. Quantitative Data

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). The initial stages of analysis were based exclusively on the data derived from university and school students. Preliminary analysis of the questionnaire data, which was based upon the original eight factors of the SIS project (Tytler, 2003) suggested that these factors did not fit the data well. Principal component analysis with Promax rotation was conducted to assess the underlying structure for items 1-50 of the Questionnaire and, separately, for items 51-100. Factors with eigenvalues whose absolute value was ≥ 1.0 were initially identified; a total of ten factors for Items 1-50 and 7 factors for items 51-100. To assess whether the items that loaded against each of the ten factors formed reliable scales, Cronbach’s alpha was computed. Scales whose alpha value were >0.70, which indicated that they had reasonable internal consistency, were used for further analysis; the remaining factors were discarded. Further details are provided in the Results.

The five scales derived from items 1-50 were provisionally named Lecturer Qualities, Relevant Contexts, Scientific Method, Self-Directed Learning and Maximising Technology to reflect the items that compromised each scale (see Table 1). Scales derived from items 51-100 were named Commitment to Performance, Learning with Excitement and Discovering Meaning (see Table 2). Each respondent’s score on each scale was computed as the arithmetic mean of the scores on the items comprising that scale.

Each scale was examined for violations of normality by applying the guideline that, if skewness was $>+1.0$ or <-1.0, the distribution was significantly skewed. Distributions of all eight scales were normal, except Lecturer Qualities among university lecturers (skew = -1.120) and Self-Directed Learning among school teachers (skew = 1.512).

To examine the associations between teacher performance and student engagement, correlation and regression analyses were carried out. Analysis of group differences against the teacher performance and student engagement scales was carried out using univariate analysis of variance (ANOVA) with post-hoc tests to identify which of the main effects were significant. Games-Howell was selected for post-hoc comparison as it takes unequal group sizes into account (Field, 2009). Where appropriate, comparisons were also made between data using t-test and χ^2 analysis. To examine the associations between teacher performance and student engagement, correlation and regression analysis were undertaken. Simple correlations and regressions were initially undertaken between each of the scales, after which partial regression analysis between all five of the scale of teacher performance and each of the scales of student engagement was undertaken.

2.3.2. Qualitative Data

The analytic method for the qualitative data was thematic analysis. Thematic analysis is a method for identifying, analysing and reporting themes within data. A theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set (Braun & Clarke, 2003). In this study, thematic analysis followed a 'realist' method in which the experiences, meanings and the reality of participants were reported. An inductive approach ('bottom-up') was applied. This means that the themes arose from the data, rather than from the specific questions that were asked of the participants or from *a priori* interests in the area.

Thematic analysis followed a six-step process (Braun & Clarke, 2003).

1. Familiarization. This involves a detailed reading and re-reading of transcribed data in order to develop preliminary ideas about themes and codes.
2. Generating initial codes. Relevant features of the data were identified and coded in a systematic fashion across the entire data set, and data relevant to each code were collated into a spreadsheet.
3. Searching for themes. Codes were collated into overarching themes, and all data relevant to each potential theme was identified. As this phase progressed it became evident that some codes clustered to reflect sub-themes and themes from the quantitative data.
4. Reviewing themes. Themes were reviewed to ensure that they were meaningful, and their interrelationships were explored.
5. Defining and naming themes. During the on-going process of identifying and analysing themes, each theme was refined and given a clear definition and name.
6. Reporting contents of themes. The findings were compiled and suitable examples were extracted to illustrate each theme. Each stage of the analysis was conducted with the research questions and aims in mind, and with consultation between research team members regarding data analysis and theme development.

3. Results

3.1. Quantitative Results

3.1.1. Principal Component Analysis

Initial analysis was undertaken to establish the factor structure of the scales using exploratory factor analysis. Principal component analysis of Items 1-50 of the questionnaire identified ten factors that had Eigenvalues ≥1.0. Cronbach's alpha for five out of these ten scales was ≥0.70, which indicated that they had reasonable internal consistency reliability. Scales with alpha values of <0.70 were not analysed further. Individual items which loaded on more than one factor were not included in scale development or further analysis

The five scales with alpha reliability ≥0.70 accounted for 40.7% of the variance in student responses. These 'teacher efficacy' scales were labelled as: Lecturer Qualities (LQ), Relevant Contexts (RC), Scientific Method (SM), Self-Directed Learning (SD) and Maximising Technology (MT).

The same methodology was applied to items 51-100 of the questionnaire. Factor analysis resulted in three scales with alpha values ≥0.70, which accounted for 39.1% of the variance in students' responses. These 'student engagement' scales were labelled as: Commitment to Performance (CP), Learning with Excitement (LE) and Discovering Meaning (DM). Individual items comprising each of these scales, their relative loadings and Cronbach's alpha values for each scale are given in Table 1 (teacher efficacy scales) and Table 2 (student engagement scales).

Each respondent's score on each scale was computed as the arithmetic mean of the scores (on a scale of 1 to 5, where 1 = never; 2 = rarely; 3 = sometimes; 4 = often; 5 = always) on the items comprising that scale.

Table 1: Factor loadings for Items 1-50: teacher efficacy scales

Principal Components Extraction; Promax (Oblique) Rotation	LQ	RC	SM	SD	MT	α
My lecturers inspire me with their enthusiasm	0.87					0.84
My lecturers stimulate me with the way they teach content	0.78					
My lecturers use a variety of techniques to help me learn a topic	0.74					
My lecturers care by creating a class environment that protects my individuality	0.53					
My lecturers value my contribution in class	0.47					
My lecturers relate science to things that interest me	0.47					
The criteria on which I will be assessed have been made clear to me	0.47					
My lecturers encourage me with their positive comments	0.43					
My lecturers support me with constructive feedback to go forward	0.42					
I am asked to learn how science impacts people, society & technology		0.71				0.75
I am asked to consider ethical issues surrounding science		0.61				
I am asked to learn about how science relates to contemporary issues		0.60				
I am asked to learn about major 'break-throughs' in science		0.60				
I am asked to learn how scientific ideas have developed over time		0.52				
I am assessed on my ability to interpret scientific data			0.73			0.74
I am expected to evaluate then interpret scientific data/evidence for myself			0.68			
I am expected to use data/evidence to solve scientific problems			0.63			
I am expected to plan the investigations that I undertake			0.48			
I am expected to use data/evidence to develop a logical scientific argument			0.47			
I am assessed on my ability to discuss scientific concepts			0.47			
I am given the opportunity to influence the way that I am taught				0.69		0.75
I am given the opportunity to influence what topics I am taught				0.67		
I am given the opportunity to interact with the wider science community				0.56		
I am given the opportunity to listen to external people talk about science				0.50		
I am given the opportunity to use up-to-date technology during investigations					0.74	0.77
I am given the opportunity to use up-to-date technology to develop knowledge					0.73	
My lecturers use up-to-date technology for teaching					0.72	
I am given the opportunity to use up-to-date technology to complete assignments					0.67	
						total
% Variance Explained	23.7	5.7	4.7	3.7	2.9	40.7

LQ: Lecturer Qualities

RC: Relevant Contexts

SM: Scientific Method

SD: Self-Directed Learning

MT: Maximising Technology

Table 2: Factor loadings for Items 51-100: student engagement scales

Principal Components Extraction; Promax (Oblique) Rotation	CP	LE	DM	α
I strive to do my best in science	0.83			0.88
I try to attend science classes	0.82			
I strive to get good grades in science	0.77			
I complete science assignments by their deadlines	0.77			
I strive to keep up to date with my science studies	0.70			
I intend to stay in science	0.65			
I work hard to understand things I find confusing about science	0.48			
I use the set texts and study guides to study science	0.48			
I set high performance standards for myself in science	0.47			
If I can, I study in an environment that is free from distraction	0.45			
I tell other people how much I enjoy studying science		0.87		0.84
I discuss science issues with other people		0.81		
I challenge myself to explore the 'deepest secrets' of science		0.71		
I get excited when I discover things about science		0.64		
I apply my knowledge of science to things in my life		0.63		
I do more science study than is required just to complete assignments		0.48		
After science class, I reflect on what I've learned		0.48		
I learn how science impacts people, society and technology			0.81	0.79
I learn about major 'break-throughs' in science			0.79	
I consider ethical issues surrounding science			0.74	
I learn how scientific ideas have developed over time			0.70	
I learn about how science relates to contemporary issues			0.66	
				total
% Variance Explained	28.2	6.7	4.2	39.1

CP: Commitment to Performance

LE: Learning with Excitement

DM: Discovering Meaning

3.1.2. Demographic Differences

Analyses of differences between demographic groups are given in Appendix 2. Overall, there were relatively few significant differences related to demographic factors.

Gender (Appendix 2.1):

The mean score for Commitment to Performance was significantly higher ($P<0.001$) for female students than for male students both at university and at school. No other differences between gender were present for any of the response groups.

Ethnicity (Appendix 2.2):

For Year 1 university students, the mean score for Self-Directed Learning was significantly higher for Maori ($P<0.01$), Pasifika ($P<0.001$) and Other ($P<0.001$) than for European/Pakeha students. The mean score for Scientific Method was significantly lower ($P<0.05$) for Pakeha/European.

For Year 12 school students, the scores for Lecturer Qualities, Relevant Contexts, Self-Directed Learning and Discovering Meaning were significantly higher ($P<0.05$) for Pasifika students than for other groups.

Programme of Study (Appendix 2.3):

The mean score for Commitment to Performance was significantly higher ($P<0.01$) for university students studying for the BVSc than for other science programmes. There were no significant differences related to the programme of study that university students had followed whilst they had been at school. However, mean scores for Commitment to Performance and Learning with Excitement were higher (both $P<0.01$) for school students who planned to study science at university than for those who did not.

Teachers (Appendix 2.4 and 2.5):

University lecturers who spent ≥16 h teaching in either Semester 1 ($P<0.01$) or Semester 2 ($P=0.07$) gave higher scores for their student’s Self-Directed Learning than did those who taught for a smaller number of hours. No scores varied according to position title, and there were no consistent patterns of difference related to being full-time versus part-time; or whether their preference was for discovering or disseminating information. Paper coordinators gave higher ($P<0.01$) scores to the scale Scientific Method than did those lecturers who were not paper coordinators. There were no significant differences among school teachers for any of the eight scales.

3.1.3. Group Differences

Data for each of the five teacher efficacy and three student engagement scales are presented in Appendix 5, Tables 5a to 5h.

Lecturer Qualities

Differences in mean scores for Lecturer Qualities (Appendix Table 5a) between groups were significant ($F_{3,\ 1057}$ = 52.7; P<0001; Figure 1).

Mean scores given by university students were significantly lower than those from university lecturers (P<0.001) and significantly higher than those from school students (P<0.001). The mean scores from school students were significantly lower than given by school teachers (P<0.001).

Mean scores from school students studying a single science subject were significantly lower than first-year university students, but not from school students studying more than one subject ($F_{3,890}$=3.79, P=0.01).

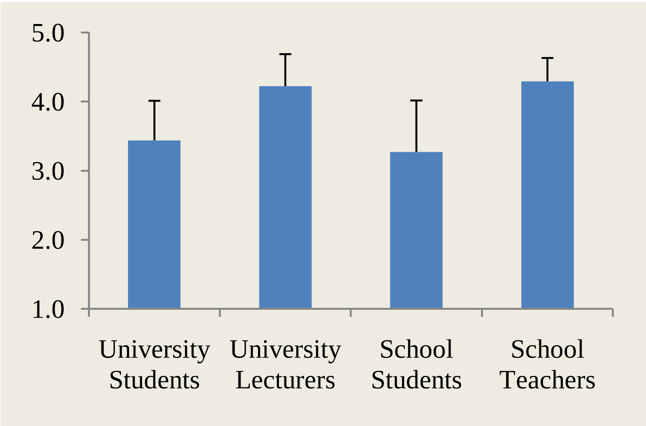

Figure 1: Mean scores & SD for Lecturer Qualities

Relevant Contexts

Differences of mean scores for Relevant Contexts (Appendix Table 5b) between groups were significant ($F_{3, 1102}$ = 67.6; P<0.001; Figure 2).

Mean scores were significantly (P<0.001) higher from university students than for school students; a difference which was unrelated to whether school students were studying 1, 2 or 3 sciences ($F_{3, 917}$=57.43, P<0.001).

Mean scores given by school students were significantly (P<0.01) lower than those given by school teachers.

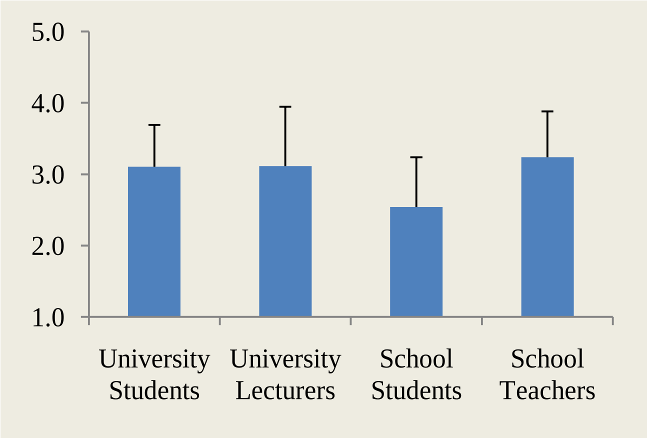

Figure 2: Mean scores& SD for Relevant Contexts

Scientific Method

Differences of mean scores for Scientific Method (Appendix Table 5c) between groups were not significant (Appendix Table 5c: $F_{3, 1087}$ = 1.3; NS; Figure 3).

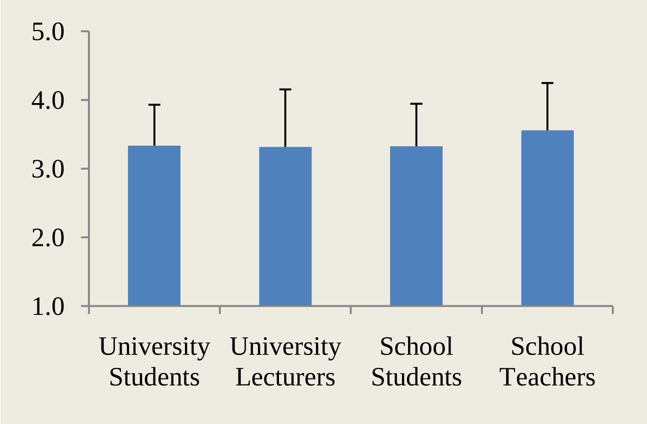

Figure 3: Mean scores & SD for Scientific Method

Self-Directed Learning

Mean scores for Self-Directed Learning (Appendix Table 5d) differed significantly between groups ($F_{3, 1111}$ = 17.5: P<0.001; Figure 4).

Mean scores were significantly higher from university students than from university lecturers (P<0.01). Mean scores from school students studying a single science subject were significantly lower than those of first-year university students ($F_{3, 926}$=13.63, P<0.001).

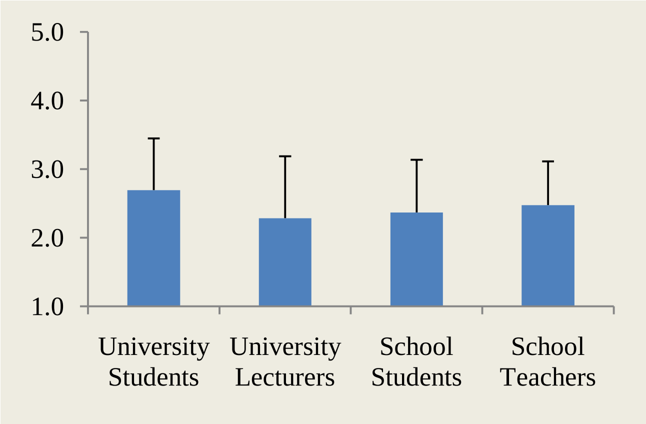

Figure 4: Mean scores & SD for Self-Directed Learning

Maximising Technology

Mean scores for Maximising Technology (Appendix Table 5e) differed significantly between groups ($F_{3, 1107}$ = 40.3: P<0.001; Figure 5).

Mean scores given by university students were significantly (P<0.001) higher university students than those given by school students; a difference which was unrelated to whether school students were studying 1, 2 or 3 sciences ($F_{3,924}$=29.86, P<0.001).

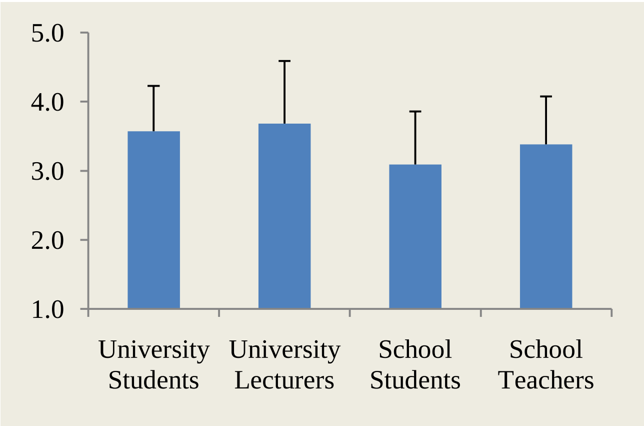

Figure 5: Mean scores & SD for Maximising Technology

Student Engagement scales

Mean scores for the three scales of Commitment to Performance (Appendix Table 5f), Learning with Excitement (Appendix Table 5g) and Discovering Meaning (Appendix Table 5h) all differed significantly between groups ($F_{3,1053}$ = 34.2; P<0.001, $F_{3, 1078}$ = 43.9; P<0.001, $F_{3, 1097}$ = 39.2; P<0.001, respectively; Figure 6).

Mean scores for Commitment to Performance and Learning with Excitement given by university students were significantly higher than those given by either university lecturers (P<0.001) or school students (P<0.01).

Mean scores for Commitment to Performance by school students taking only one science subject were lower than school students taking more science subjects and university students, but there was no significant difference between school students taking 3 core science subjects and university students ($F_{3,895=36.55,}$ =36.55, P<0.001).

Mean scores given for Learning with Excitement by school students taking 3 core science subjects and university students were higher than those given by school students taking one or two science subjects ($F_{3, 918}$ = 43.45, P<0.001).

Mean scores for Discovering Meaning from university students were higher than those from school students taking 1, 2 or 3 subjects ($F_{3, 924}$=35.22, P<0.001).

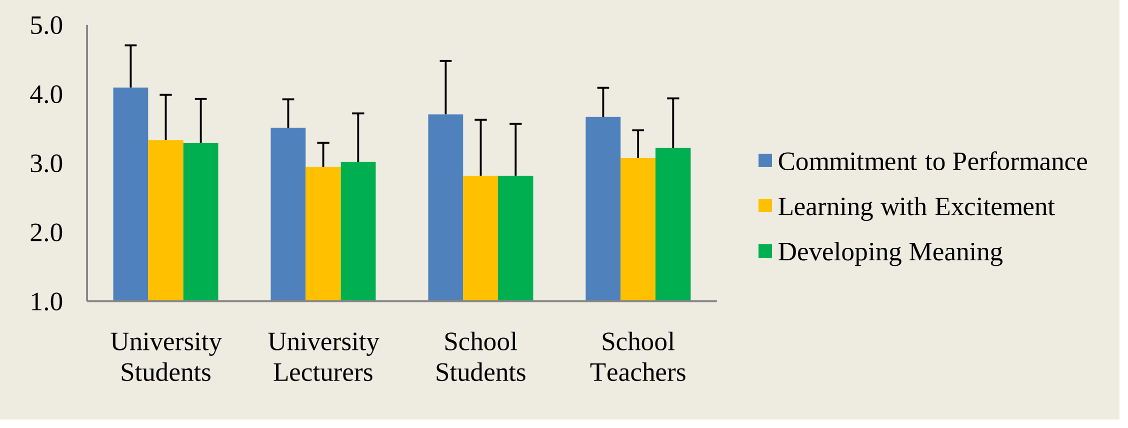

Figure 6: Mean scores & SD for Student Engagement Scales

3.1.4. Correlation and Regression Analysis

In order to examine relationships between 'teacher efficacy' and 'student engagement', bivariate correlations were carried out (Table 3 for first-year university students and Table 4 for Year 12 school students). At the simple bivariate level, all teacher efficacy scales were positively related to the three student engagements scales, except that Commitment to Performance was not significantly related to Self-Directed Learning for university students.

Table 3: Correlations (Pearson's-r) between scales of teacher efficacy and student engagement for first-year university students

	LQ	RC	SM	SD	MT	CP	LE	DM
Lecturer Qualities	1.000							
Relevant Contexts	0.500***	1.000						
Scientific Method	0.459***	0.547***	1.000					
Self-Directed Learning	0.407***	0.451***	0.481***	1.000				
Maximizing Technology	0.480***	0.396***	0.466***	0.324***	1.000			
Commitment to Performance	0.382***	0.267***	0.288***	-0.083	0.327***	1.000		
Learning with Excitement	0.409***	0.448***	0.396***	0.254***	0.207***	0.463***	1.000	
Discovering Meaning	0.453***	0.624***	0.513***	0.358***	0.323***	0.292***	0.540***	1.000

*** Correlation is significant at the P=0.001 level (2-tailed)

Table 4: Correlations (Pearson's-r) between scales of teacher efficacy and student engagement for Year 12 school students

	LQ	RC	SM	SD	MT	CP	LE	DM
Lecturer Qualities	1.000							
Relevant Contexts	0.457***	1.000						
Scientific Method	0.335***	0.364***	1.000					
Self-Directed Learning	0.490***	0.554***	0.264***	1.000				
Maximizing Technology	0.508***	0.455***	0.247***	0.466***	1.000			
Commitment to Performance	0.461***	0.144***	0.348***	0.163***	0.154***	1.000		
Learning with Excitement	0.358***	0.287***	0.274***	0.347***	0.161***	0.615***	1.000	
Discovering Meaning	0.371***	0.636***	0.237***	0.390***	0.300***	0.312***	0.522***	1.000

*** Correlation is significant at the P=0.001 level (2-tailed)

The next step in the analysis of the quantitative data was to explore which of the teacher efficacy scales made significant unique contributions to each of the three student engagement variables for university students (Table 5) and school students (Table 6).

For university students, the predictors of Commitment to Performance were higher Lecturer Qualities, Scientific Method and 'Maximising Technology' and lower 'Self-Directed Learning'. 'Learning with excitement' and Discovering Meaning were predicted by Lecturer Qualities, Relevant Contexts and Scientific Method, but not by Self-Directed Learning or Maximizing Technology.

Table 6 presents the teacher efficacy measures predicting student engagement for school students. Only Lecturer Qualities and Scientific Method predicted stronger Commitment to Performance in this group, while Lecturer Qualities, Scientific Method and Self-Directed Learning predicted Learning with Excitement. For 'Discovering Meaning the sole unique predictor was Relevant Contexts.

The overall relationship between teacher qualities and Commitment to Performance was stronger for university students (46% of variance accounted for by the regression model) than for school students (25% of variance). Similarly, scores for Learning with Excitement, the overall model was more strongly predictive for university (42% of variance) than school (17% of variance) students. Scores for Discovering Meaning were strongly predicted by the model for both groups of respondents: 85% of total variance explained for university students and 49% for school students.

Table 5: Linear regression analysis of teacher efficacy scales and student engagement scales for first-year university students

(a) Commitment to Performance

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.325	0.307 ***	6.700		
Relevant Contexts	0.120	0.116	2.497		
Scientific Method	0.212	0.210 ***	4.403	0.294	45.54***
Self-Directed Learning	-0.336	-0.412 ***	-9.515		
Maximizing Technology	0.163	0.175 ***	3.981		

*** P<0.001

(b) Learning with Excitement

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.277	0.243 ***	5.247		
Relevant Contexts	0.322	0.289 ***	6.106		
Scientific Method	0.219	0.201 ***	4.156	0.275	41.89 ***
Self-Directed Learning	-0.040	-0.045	-1.037		
Maximizing Technology	-0.099	-0.099	-2.243		

*** P<0.001

(c) Discovering Meaning

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.148	0.134 **	3.268		
Relevant Contexts	0.481	0.451 ***	10.742		
Scientific Method	0.240	0.227 ***	5.338	0.437	85.30 ***
Self-Directed Learning	-0.010	-0.012	-0.306		
Maximizing Technology	-0.036	-0.038	-0.962		

*** P<0.001.

Table 6: Linear regression analysis of teacher efficacy scales and student engagement scales for Year 12 school students

(a) Commitment to Performance

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.497	0.474 ***	8.128		
Relevant Contexts	-0.081	-0.074	-1.203		
Scientific Method	0.318	0.257 ***	5.079	0.265	25.46 ***
Self-Directed Learning	-0.061	-0.061	-1.009		
Maximizing Technology	-0.074	-0.073	-1.284		

*** P<0.001

(b) Learning with Excitement

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.239	0.211 ***	3.420		
Relevant Contexts	0.086	0.073	1.125		
Scientific Method	0.216	0.163 **	3.064	0.184	16.74 ***
Self-Directed Learning	0.222	0.206 **	3.263		
Maximizing Technology	-0.118	-0.110	-1.840		

*** P<0.001

(c) Discovering Meaning

Dependent variable	B	β	*t*	Adjusted R^2	F
Lecturer Qualities	0.106	0.103	1.973		
Relevant Contexts	0.625	0.586 ***	10.521		
Scientific Method	-0.002	-0.002	-0.035	0.404	48.69 ***
Self-Directed Learning	0.022	0.022	0.407		
Maximizing Technology	-0.024	-0.025	-0.481		

*** P<0.001.

3.2. Qualitative data

The qualitative component expanded upon the research questions in the quantitative survey, particularly regarding how school teachers and university lecturers influence learners to engage in the Sciences. It also explored the extent to which lecturers and students recognise the differences that exist between the learning environments of the secondary and tertiary sectors, and the strategies adopted to assist learners to progress between these environments (see Appendix 3 for specific questions)

The thematic analysis identified themes that corresponded with those identified in the quantitative analysis. These themes were developed, explored and clarified and are presented below with particular reference to the ways in which participants experienced and engaged with their education in science.

In this section quotes that are prefaced with [I] refer to the interviewer, those prefaced with [R] to respondents. Numbers following the [R] refer to different responses to the same question.

3.2.1. Lecturer Qualities

3.2.1.1. My lecturers are enthusiastic

The enthusiasm of the lecturer was recognized as an important factor in the engagement of students by most first-year university students and some of their lecturers. In every student focus group, comment was made upon the relationship between an enthusiastic teacher and students' levels of engagement. Students commonly said that when a teacher was enthusiastic, it made them more interested in learning. For example:

R: *The lecturer is very enthusiastic – it keeps you interested and keeps you awake*.

On the other hand, students considered that enthusiasm was by no means universal in their lecturers. Students were asked to indicate what proportion of lecturers were enthusiastic, made them very interested and kept them awake. Responses varied between '*1 or 2 out of 8'* to between 1 and 5 within a teaching year.

The link between lecturer enthusiasm and student engagement was also made through student complaints about lecturers who did not appear enthusiastic. For some, tone of voice was equated with a lack of enthusiasm, in that unenthusiastic lecturers spoke in monotone.

R: *The lecturer drones on – the voice is the same or varies a little. It is so boring. It seems like they are not enjoying it*.

Other students reflected on the reasons why lecturers might not appear enthusiastic. Some concluded that it might be difficult for lecturers to remain enthusiastic about presentations that they have delivered '*over and over*'. These students interpreted the ability to overcome this difficulty as a sign of enthusiasm among lecturers:

R: *He [the lecturer] changes his PowerPoints every time he lectures a subject. He changes them because he finds out more information so he's still enthusiastic about it.*

Similarly, a number of lecturers expressed their awareness of the relationship between their own enthusiasm and the engagement of students. For example, one lecturer response to the question 'what do you think it is that an excellent teacher does' was:

R: *Part of good teaching is to be passionate – even if you are not passionate about it. You've got to go in and you've got to enthuse about what you are doing, what you are teaching.*

For school students, there was a similar link between the enthusiasm of the teacher and the students' engagement. Many school students found themselves more inclined to learn when their teachers were enthusiastic:

R: *I really don't like it when the teachers aren't passionate about what they are teaching. They have to be really interested in it to get us interested in it.*

School students also related teachers' enthusiasm to their tone of voice; specifically equating the use of monotone with a lack of enthusiasm:

R: *It would be better if he tried to make his work be more interesting, like show some enthusiasm instead of being like monotone the whole time.*

Similarly, links were made between teachers' enthusiasm and their presence in the classroom. Several focus groups of school students mentioned teachers who were always late, or who left the classroom to perform other tasks; concluding that such teachers had a limited commitment to teaching. A further reason proposed for a lack of enthusiasm amongst school teachers was that some science teachers were obliged to teach subjects in which they did not specialize. The most common example was chemistry teachers having to teach physics.

A desire for a variety of teaching techniques was a common theme among first-year university students. Two key reasons for the desirability of variety emerged. Firstly, students found that a change of technique refocused their attention. For example, there was a consensus in one focus group that, without variety, '*after about twenty minutes you start falling asleep*'. Secondly, students highlighted that different teaching styles enhanced their ability to learn:

R: *I like lecturers who recognize the different learning styles* [within a lecture theatre]*… They can recognize that the students are getting disengaged and they do something a little bit different next time or within the lecture*.

Recurring themes were reported by students who wanted lecturers to use a greater variety of teaching techniques:

- Several students spoke of humour as an effective means of communication. The ability to present information in a light-hearted manner was connected to a more enjoyable and stimulating learning experience. For example: '*There's one lecturer who sort of makes it very kind of casual and humorous at the same time giving us the facts. So we can enjoy listening somehow*'.
- Students frequently mentioned diagrams. These students typically believed their memory was more effectively triggered by something visual than by text alone. For example: '*I like it when lecturers*

use visual situations because when I'm in an exam or something I'm like, oh, what does this key word mean and I will relate it back to some visual diagram or something.'

- Several students spoke about the value of media such as movie clips, which were reported to help them connect theory to reality in situations when live demonstrations were inappropriate. For example, '*Like in animals last year he went on YouTube and it was really good. You could actually see the baby happening so it just wasn't him saying this is what happens in animals*'.
- Other students strongly advocated the value of demonstrations. One student commented: '*I like it when they – during the demo – they show us everything... We saw everything like they explain it and do it. You read it and, oh, you can't – this thing will not convince you – you will not believe – but once you saw everything…*'
- Students frequently desired more practical experiments. The opportunity for a 'hands-on' education was cited as a key reason for pursuing science. For example, '*I think it's more effective if you get in there and do it yourself*'.
- Several students stated a preference for lecturers who adopted a discursive style rather than reading exclusively from their notes. A discursive style involved lecturers who turned to face the class, allowing opportunities for elaboration and explanation. For example: '*I don't like it when there's a lot of facts and figures and tables and numbers and they just put the table up and they don't explain each part and how it relates back to what we are learning*'.
- A common topic among students was the benefits of lecturers employing questioning as an effective means of developing student engagement with the lecture. For example: '*I like it when they will actually ask you questions… and they don't sort of let you sleep basically*'. While some students acknowledged that questions were frequently met with silence, even if they had previously found themselves feeling uncomfortable trying to answer a question under the spotlight, they agreed that questioning helped them learn. One student advocated a peppering of questions throughout the presentation slides, while another suggested ten questions at the end of every lecture. Some students from disciplines in fundamental sciences advocated the benefits of 'clickers' (i.e. in–class immediate-response devices) to assist questioning; while a student with previous experience in a polytechnic described how questions could be integrated into the study guide by leaving spaces for students to complete.
- Students frequently mentioned the benefits of summarizing as an aid to developing clarity of understanding, rather than questioning. For example: '*I like it when they do a summary. They tell us information over a set of lectures and then they summarise it into quite a simple way but it's the whole picture and things slot in for us*'.

However, notwithstanding students' desire for a variety of teaching techniques, students stated that there was a substantial proportion of lecturers who appeared to rely solely on reading an entire lecture directly from notes that were written on PowerPoint slides. The following were typical responses when the interviewer asked students what they disliked about science classes:

R1: *They [lecturers] just talk and talk…. they just sort of rambling on;*

R2: *When the lecturer just reads what it says on the slide*;

R3: *You'll know there's going to be just a PowerPoint and guys sitting up front, and you know you are just going to have to sit there for an hour and just take notes*.

In this context, a number of students debated the value of attending lectures and concluded that accessing lecture slides online via WebCT / Stream then reading them independently at home was a viable option, thus rendering lectures almost redundant:

I: If you think of your study as a whole, how important are lectures in terms of your whole learning experience?

R1: *Not very important.*

R2: *Not really. As long as they put the slides up on WebCT you can pretty much get what they are on about.*

Generally similar responses were given by school students. School students, especially boys, reported that humour stimulated their learning. One focus group believed that a teacher telling bad jokes was better than no jokes. The same group claimed that the ability to connect with a student's sense of humour was not age related, although some teachers were said to be '*past their sell-by date*'.

As with university students, school students found a variety of teaching methods desirable. However, similar problems were reported such as the expectation for students to spend extended periods copying notes from slides, whiteboards or text books. Like university students, school students found themselves wondering about the value of some lessons. Instead, they asked for more practical experiments and one focus group advocated field trips.

School students also enjoyed the variety of questioning, especially when it progressed on to a class discussion. Unlike university students, they did not report a particular fear of answering questions in class.

School teachers reported that they could not adequately meet student demands for practical demonstration due to excessive focus of the curricula on content (declarative) knowledge, student numbers, timetabling difficulties and a lack of equipment for practical teaching. One teacher sympathized with students disengaged by '*note driven*' teaching in science.

My lecturers relate science to things that interest me

First-year university students reported a strong relationship between content that did not interest them and immediate disengagement. Things that interested students were typically associated with content that they perceived could be useful in their future careers, or with content that was explicitly connected to their chosen specialisation. The following comment was typical:

R: *If it's things that we can easily relate to our future job that's easy to stay focused for*.

However, there were many issues about relating contents to individuals' interests in compulsory 100-level papers. A number of students gave examples of compulsory papers that superficially appeared to be linked to their degree programme, but in which they struggled to understand the relevance of some content, or in which content was taught in a way that did not make its relevance apparent. It was particularly notable that, where the lecturer did not relate content to things that interested the students, they were likely to become disengaged. One student expressed her feelings thus:

R: *At the moment … I'm not really seeing any relevance to it so it's kind of like making me disengage.*

Students who were studying aspects of biological science in humans commonly stated that studying papers with a bias towards animal sciences was inimical to good engagement. Specifically, having to undertake compulsory, generic 100-level papers that were taught with a bias towards the animal sciences, was widely cited as a cause of disengagement:

R: *My degree is Sport and Exercise Science and sometimes when I'm learning all about, say, enzymes in a cow's digestive tract I can't really see the relevance or it's not made apparent of how that's related to Sport and Exercise Science.*

Others of these disengaged students cited compulsory 100-level papers that were not specific to a programme; notably papers on communications. Students considered that such papers were not interesting because the content duplicated that from NCEA English. A few students defended the value of papers in communication: one who had been home-schooled found it '*a really useful experience in getting to work with groups more*'. However, on balance, there were more negative than positive reports on the relevance of these papers.

For university lecturers, there were likewise a number of instances when they acknowledged that many students were obliged to study content that was not explicitly linked to the 'reasons they came to university'. One of these lecturers reported that science programmes are organized in 'silos', which artificially force some students into inappropriate compulsory 100-level papers. The key example was students of food and nutrition who were taught physics in the context of engineering rather than that of life sciences because '*there's a great decree that food and nutrition is engineering'*. The same lecturer went on to propose a solution:

R: *Each piece of core science needs to be put in a position in the curriculum where it can be closely associated with the discipline that they want to go into*.

School students also reflected the sentiment that content which seems to be irrelevant is difficult to learn. One student said he wanted teachers to '*show you what you can actually do with what they are teaching you when we are older*'. To aid this process, students thought that teachers should talk more frequently about their own personal experiences and career history in science.

The criteria on which I will be assessed have been made clear to me

University students commonly expressed a desire for lecturers to be more explicit about assessment criteria. A common request was for more examples of previous exam questions and answers, and the suggestion was made that these examples could be reviewed during lectures. At one extreme, one students thought that lecturers should '*completely outline and go over*' everything that was required to pass their paper. However, the following comment was a more typical response:

R: *I like it when lecturers explain exactly what they are looking for in tests and exams and science and stuff instead of just leaving you in the dark*.

There were a few instances when lecturers talked about clarifying assessment criteria with students. One focus group briefly discussed their reservations about being too prescriptive about assessment, because the current system did not prepare students for employment. The following proposal was discussed at some length in a focus group of lecturers and, although the idea was eventually discarded as too ambitious for 100-level students, it was indicative of the direction in which such lecturers wanted to move:

R: *What about getting rid of assessment driven by the lecturer… but leaving it up to the student at the end of the semester to come to us and demonstrate or show or prove what they can do?*

My lecturers support me with constructive feedback to go forward

First-year university students valued individual feedback from their lecturers, with several expressing a desire for *more* feedback on assessments. Typically, these students wanted to clearly recognize the areas of knowledge in which they were deficient/needed improvement:

R: *They could give you feedback on, say for your assignments and things, like what you might have missed to go over and see where you are and what you actually do need to focus more on.*

Students were asked about their thoughts on feedback that they had previously received from their lecturers. A few students gave positive examples:

R: *With one lecturer, after our exam or our test, he went through where we went wrong individually when we pick up our test from him. He'll just go through where you went wrong and what he was looking for. You didn't even ask he just said, 'this is where you went wrong; what you learnt; this is good'. That sort of feedback is always good*.

Conversely, other students gave negative examples.

I: *Did you get good feedback on the assignment when you did get it back?*

R: *No… One comment, one tick and a mark.*

Students who desired feedback reported a limited number of opportunities to obtain it from lecturers in a one-on-one situation. Several students attributed class size and the lecture theatre environment as the greatest limitation. These students typically recognized small group environments as a better alternative. One student suggested that more tutorials might lead to more feedback:

R: *It would be really good if there were more tutorials to discuss what's happened in the lecture/labs, so there's more one-on-one. More feedback given.*

Another limitation to receiving feedback was reported to be lecturer ‘approachability’: some students specifically reported that lecturers could be ‘unapproachable’. One of these students made a direct connection between un-approachability and feeling too ‘scared’ to request feedback. However, more commonly students did not seek feedback from lecturers because:

R: *I don’t like it when they are really short with you like they don’t want to help you*.

Several lecturers confirmed the connection between their level of approachability and student bravery for seeking feedback. In respect to interpersonal interaction, lecturers frequently acknowledged the problems of class size and the lecture theatre environment. Lecturers described a preference for interpersonal interaction to occur in small group environments. One lecturer reported that, in the absence of an environment that facilitates interpersonal interaction, students perceive lecturers to be nothing more than inaccessible ‘*speaking heads at the front [of the lecture theatre*]’.

One focus group of school students reported how much they appreciated teachers who went through assessments, telling everyone what they did right and wrong, and how they could do better. In another case, students reported that some teachers just gave the mark back and said, ‘*sign here – you don’t pass’*. In one of these cases, a school student reported that they had considered seeking feedback after class but concluded that the teacher was probably too busy. At worst, one focus group of student described a teacher who seemed to have no time or positive comments for teenagers in general.

3.2.2. Relevant Contexts

This section considers the extent to which students perceive science to be meaningful in the context of their own experiences. A few students explicitly stated that the fundamental nature of science was meaningful. To some students, it was the fundamental nature of science that engendered meaning:

R: ‘*I like science because pretty much without science there’d be no life really’*.

To other students, and more commonly, the applicability of science to their everyday lives was the aspect of science that students enjoyed.

R: *The relevance it has to understanding how things in the world fit together.*

Students made a connection between being taught science in the meaningful context of everyday life and their own level of engagement: ‘*I really like it when the teacher challenges me to apply the knowledge to real-life situations’*. Other students were able to recall occasions when teachers had explicitly connected science content in a meaningful way to everyday life scenarios:

R: *I like it when you have a moment of realization when you are going to be using that information they just told you about. Like you can imagine yourself talking to a client about their animal and it’s like, okay, I know that at least one of those points is going to be used*.

The link between science and meaningful understandings was also made outside the domain of future career prospects:

R: *I reckon taking something like chemistry you start to think about – you used to think, for example, of a fire. It was just a fire but now it’s all these chemical reactions.*

Several students reported a desire to be taught science in a contemporary context. There was a link between higher levels of student engagement and being exposed through teaching to an area where '*new stuff is always coming out'*. Building on this theme of emerging science in a contemporary context, there was plenty of discussion about enjoyment of learning when it was combined with a sense of discovery:

R: *Say, ten years ago you could have learnt something completely different to what it actually is now or they'll make a new discovery about it… It's real interesting*.

Lecturers frequently reported an awareness that students want to learn science in a meaningful context. When lecturers were asked to reflect on what they considered that students most loved about science, there was a strong consensus a around 'real world application':

R: *We should bring the real world into the classroom and connect chemistry or whatever it is to things that are going on and I try and do that*.

However, lecturers also reported three reasons why a focus on meaningful understandings was often overshadowed by a focus on content. Firstly, lecturers frequently made reference to unavoidable content:

R: *Well, certainly content is quite important because you have a certain amount of language that you have to be familiar with in order to develop the more difficult concepts so there is a definite or certain amount of content*.

Secondly, there is a tension between assessment and learning. Overloaded periods of assessment distracted lecturers from challenging their students to develop meaningful understandings, particularly because assessments are far more often focused upon recalling content than upon using information in more creative contexts:

R: *You can actually teach them to pass an assessment but at the end not have a lot of knowledge.*

Lastly, teaching can be primarily driven by content *per se*, rather than the material the students need to be able to understand to utilize knowledge in an area. One lecturer who felt that his peers were somewhat 'obsessed' with disseminating content from their specialist area expressed his concerns thus:

R: *We all become a bit obsessed that they must know this and they must know that and it's the end of the world if they don't know that.*

School students were equally engaged by content that could be meaningfully associated with the world around them. One student reported how meaningful his understanding of new grasses had become when he saw them in action at home on the farm. Other students spoke about science being meaningful to contemporary society and technology. One student highlighted that science featured regularly in the news saying, '*they find new things anywhere in the world and you can relate it back to science'*. Finally, like university students, school students found that connecting theoretical science to meaningful contemporary issues made their whole learning experience worthwhile.

3.2.3. Scientific Method

There was an absence of discussion among first-year students about the scientific method. In other words, the process of designing investigations, collecting data then interpreting results to answer a scientific question did not arise in conversation. However, upon discussion with one focus group of final-year BSc students, it emerged that, even half way through their third year, they did not consider themselves scientists. This, they said, was a title reserved for post-graduates.

Upon discussing what was learned in laboratories, the students were not accustomed to designing their own investigations, although they hoped this would change in the second semester of their third year. One participant even went as far as saying that he would not feel confident to enter a laboratory to undertake work in his own discipline:

R: *If I was to go in to a job I don't feel I'd have all the necessary practical skills if I was to do something in Sport and Exercise... there's opportunity to learn a lot more laboratory skills and techniques.*

3.2.4. Self-Directed Learning

Students are given the opportunity to influence the way they are taught

Although students reported themselves to be stimulated by the use of a variety of teaching techniques, they generally felt that they had limited opportunities to affect how they were taught. As previously noted, some lecturers would change style when they noted that students were becoming disengaged. However, a much more common response was for students to express frustration that lecturers did not teach content in a way that suited their personal learning style:

I: *Do you feel that your lecturers are teaching to you to suit you as individuals?*

R: *In general, no. No, I don't think so. If we ask them. Sometimes. Sort of. Me personally, not really. No. No.*

Despite this, or, perhaps, consequentially, the majority of students did not seem to *expect* lecturers to take their personal learning styles into account. Several students reported that their apathy was connected to the realization that they represented just one of many learning styles in a lecture environment:

R: *It is hard when you are only one person out of a hundred and everyone learns differently*.

In this context, some students specifically questioned the value of lectures. One student was explicit in his belief that lectures were 'not very important'. Several other students claimed that, rather than attend a lecture that did not cater for their individual learning styles, they preferred to access lecture material on-line and teach themselves from home. Interestingly, there was relatively little consideration given by either students or lecturers to significant alternatives to a standard teaching repertoire of lectures and practicals. Tutorials were used by some lecturers, and, depending upon the mode of delivery of the tutorial, were valued by some students. However, innovative technologies, on-line techniques, problem-based learning and other contemporary learning techniques were rarely mentioned by either lecturers or students.

Students are given the opportunity to influence what they are taught

The relevance of compulsory 100-level papers was a major topic of discussion. Some students found that a broad education in science was relevant, and had no objections to the compulsory nature of some papers:

R: I think the science degree in general. Science, first-year, seems pretty broad.

I: *Is that something that you are okay with?*

R: *I think so. I think it's a good idea because… lot of people change their subjects so it's good to get a broad understanding to start with.*

Other students complained about being forced to study compulsory material which they did not think was relevant to their personal interests. Following on from the conversation above, one student offered a contrasting point of view:

R: *But if you're specific on what you have to do… then but having broad papers is not helping in any way.*

Other students used a financial argument to emphasize their objection to compulsory papers. The following comment was specifically in connection with a paper in communication:

R: *Really, [you're] only wasting $500 on a paper which you would rather spend advancing your course for your degree.*

Lecturers found themselves in a difficult situation in relation to some of some compulsory papers with unpopular content. On one hand, they recognized that it could be difficult to maintain students' engagement in such papers. However, on the other hand, and in defence of compulsory papers and unpopular content, they experienced great difficulty with developing the content of these papers, given that students educated in the NCEA system enter university with a highly variable level of content knowledge.

R: *It's hard to know what they actually do know by looking at their NCEA marks. I've had students that have NCEA Level 3 Physics and I'd swear that I was teaching them the material for the first time. I'm looking at the NCEA Level 3 exam going – look this is what I'm teaching, I'm only teaching NCEA Level 3 to you students – why can't you do it if you have the credits?*

As a consequence of this variation, much of the unpopular content at 100-level was necessary to create a 'level playing field' before second year. Lecturers appreciated that, consequently, some students found that neither their preferences for topics nor for teaching pace could be accommodated:

R: *You have to explain concepts again which they [able students] consider are trivial – a lot of them are trivial. They [able students] think, 'why are we wasting time going over this?'*

This situation proved to be just as frustrating to lecturers as to students. Lecturers recognized the need to 'stretch' able students, at the same time as needing to teach the basics to students who were either less able or who had not encountered material during their school studies. Some suggested 'high' and 'low' level first-year papers, but recognized the difficulties implicit in such a system for the maintenance of the overall standard required for the degree. Others suggested that minimum standards for entry from school should not be defined solely in terms of numbers of credits, but perhaps also either in terms of numbers of credits at levels higher than ‘achieved’, or perhaps in terms of specific units of [NCEA] study that were prerequisites for entry to particular papers or degrees.

Regardless, of the problems inherent in a heterogeneous intake to 100-level papers, lecturers offered few examples of situations in which students could choose what material to study within individual first-year papers. Hence, the main opportunity that students had to influence what they were taught lay with their selection of non-compulsory papers. In first-year, for some programs, there were either no, or one, non-compulsory paper choices available and, even where such choice could be exercised, the students again had no control over the content of the papers that they had selected.

Focus group conversations with school students and their teachers reported very similar issues to those experienced at university. Commonly, school students felt that their teachers never provided them with the opportunity to influence the contents that was taught, or the context in which it was taught. This, however, varied between teachers. For example, in one focus group, a student noted that, ‘*the entire class having to adapt to the way of the teacher, especially if they have got an obscure teaching style*’. On the other hand, a different focus group described a teacher who found ways to teach all his students in different ways until the class had developed a common understanding. One student expressed particular appreciation towards a teacher who allowed students to control their own learning by, for example, choosing whether or not to undertake a practical.

When it came to influencing topics, there was similar discontent among biology students who wanted more opportunity to choose between human, animal and plant biology. There was also objection to repetition of the same concepts year-on-year, taught from a slightly more challenging angle. Students generally appeared to prefer a wider range of topics representing the breadth of science.

3.2.5. Maximizing Technology

First-year university students appreciated the web-based learning support provided by electronic learning platforms (i.e. Moodle and WebCT), but indicated that their value was as a convenience rather than being pivotal to their learning. One student described using Stream to access presentation slides before lectures so that he could write notes on the slides during lectures. Another student described using Stream to access presentation slides after lectures in order to review them for content missed. However, several students indicated that they used Stream or WebCT to access presentation slides instead of attending lectures:

R: *As long as they put the slides up on WebCT you can pretty much get what they are on about and if not you can just go into the discussion on WebCT and find out what other people are saying*.

Some annoyance at the types of technology used in teaching was also expressed by students. Some students described their personal frustration with complexities of scientific computer programmes.

However, the majority of adverse comments surrounded lecturers who seemed uncomfortable with technology, leading to time-wasting technical problems:

R: *Probably would help if some of the professors got a little more tech-savvy before they started. I think it's been at least one lecture where a good ten minutes at the start waiting for them to get organized and set up the screen.*

Lecturers expressed a mixture of enthusiasm and hesitation towards technology. The more enthusiastic comments reflected a common perception among lecturers that students adapted well to technology; referring to students as 'whizz bangs'. Connected to this perception, some lecturers believed that the advancement of technology in teaching would lead to improvements. For example:

R: *One thing that we've started doing which I'm really keen on developing further is using the 'mastering biology' website. There's one for 'mastering physics' as well. Comes with a textbook where the students can get one-on-one interactive tutoring and weekly assignments and things and doing more of that kind of stuff, I think, is really useful.*

Other lecturers expressed concerns about the limitations of computer-based learning technology. One lecturer agreed with the principle of providing students with additional 'tools', but with the caveat that they should be '*the right tools*'. A subsequent discussion revealed why the value added to students' learning by current web-based teaching support can be limited:

R: *I think the way we use these tools can't be just to put everything and kitchen sink on to WebCT so they just consume it. It has to be in such a way that they make – it facilitates students to independent thinking and problem solving.*

School students, like university students, expressed reservations about their teachers' use of online learning technology. Firstly, they felt that teachers need to remember that online learning does not automatically make it relevant to students 'because it is online'. Secondly, there are limitations to online learning when computers are not always accessible or have broken down. Finally, many reported that the equipment in science laboratories was rarely clean, up-to-date or in adequate supply.

Generally, school students did not report having readily–available access to an online learning environment such as Moodle or WebCT, yet there were a clear consensus that they favoured more exposure to computers and resources on the internet. A couple of school students described websites [e.g. http://sci.waikato.ac.nz/evolution/], that were similar to the 'mastering biology' site [http://www.masteringbio.com/], as having been beneficial to their learning.

3.2.6. Commitment to Performance

I strive to do my best in science

The motivation of first-year students was a recurring theme in focus group discussions with university lecturers. The following comment provided a good summary of the characteristics that they would like to see in motivated students with a good work ethic:

R: *It would be nice if your students had the idea that they were students and being a student means you work 50 hours a week on study. You don't just go to lectures, you don't just go to labs, you do background, you do reading, you think, you try and tie everything together*.

Lecturers spoke frequently about the current level of motivation among school leavers. Although one group of lecturers agreed that school leavers were 'sweet' and 'keen to learn', none of the lecturers interviewed indicated that school leavers were 'striving'. Instead, lecturers more often than not suggested that school leavers lacked motivation. The following comment is a good example:

R: *They want to get a degree. But they want to get a degree with the least amount of work possible and with the least amount of inconvenience actually*.

However, lecturers had different perceptions of students who were not typical New Zealand school leavers. Frequently cited exceptions were mature students (R1), second year students (R2); overseas students (R3); students with career focus (R4); and veterinary students (R5):

R1: *I don't know what other people think but anybody who arrives as a first-year student who's 20, anybody who is mature, is essentially a very good student. Because they are motivated and organized and all of those things 18 year olds aren't.*

R2: *The first-years struggle but the ones that I get in the second year taking the first-year paper they are really, really good students and they interact and they get good grades.*

R3: *We are finding them [overseas students] an absolute joy – they are adding another dimension to the class, they are so enthusiastic.*

R4: *They [midwifery students] are all motivated because most of them are here with a set goal, i.e. the midwives students are hugely motivated.*

Veterinary students were described on numerous occasions as the epitome of students striving to do their best in science: (e.g.) '*well, there are certainly not very many non-motivated students in the vet programme that's for sure*'. Many lecturers attributed the dedication of veterinary students to the competitive nature of the BVSc and were saddened that other majors could not provide a similar incentive:

R5: *Well, they [veterinary students] work hard. That's a big difference. Because it's a competitive thing they know that only X number of students are going to be successful they have very good work ethic. If we could somehow have the same sort of carrot for other majors and say, look, we are only going to accept a certain number for chemistry.*

Students themselves did not often speak explicitly about their level of commitment. From the examples available, one student reaffirmed lecturers' perception of the typical New Zealand school leaver:

R*: It's just getting the motivation to do it [study]. Like, I suppose, the motivation's just not there. I don't know. I'm one of those people that need to be pushed. I know it's bad but...*

On the other hand, a veterinary student in Semester 2 (post-selection) reaffirmed lecturers' perception of such students, even despite the alleviation of pressure upon them after the selection process:

R: *Well, in the first semester we had to work hard, like it wasn't just personal pride that pushed us to work hard it was the need to work hard. I think like now though, at the moment, the second semester… it's so confusing because I know I don't have to get A pluses or whatever but I still want to do well.*

Similar trends were seen amongst school students and their teachers. One teacher described how, '*there is always a proportion of boys that are in there because they have to be there – they, typically, are unmotivated, they will do as little as possible in order to fulfil the requirements of the school and they can become problematic.'* Several students supported this statement complaining about peers who were disruptive in class.

I try to attend science classes

Non-attendance at lectures was widely reported in focus group discussion with university lecturers. Some lecturers estimated that average attendance levels were 75 to 90%, although others reported that attendance levels could be as low as 50% by mid semester. Non-attendance at lectures was undoubtedly a source of frustration to many lecturers: '*attending science class would be a step in the right direction for some students'*. One lecturer who had also taught in overseas universities attributed low attendance to a national trend, saying '*there seems to be a lot of skipping lectures in New Zealand anyway'*. Other accounts of low attendance tended to be associated with the negative perception that supplementary and online materials gave students the impression that they don't need to attend lectures. For example:

R: *But we don't encourage that [class attendance] because I put all my notes on the web and there's all sorts of reasons why they can just not go to lectures and not be that badly affected.*

Where tutorials were concerned, lecturers reported that attendance of one-third or one-quarter of the class would be good. Students who attended tutorials were typically higher-achieving students. Some lecturers described frustration because these students were not necessarily the ones who most needed extra tutoring. Other lecturers were positive about the opportunity to tutor an engaged audience.

School Teachers did not comment about the attendance of their students, presumably because of the greater degree of compulsion regarding attendance at school than at university. One school teacher did recognise the issues created by non-attendance at university, however:

R '[students], *actually told me that they don't even have to go to lectures next year at university because they will just get it off the internet.'*

I strive to get good grades in science

Several groups of lecturers discussed a common philosophy among first-year students was that '*C's get degrees'*. One lecturer reported a 10 to 20% difference between the grades achieved by first-year students taking 100-level papers and those achieved by second-year students in the same papers. It was suggested that one reason students do not strive for good grades is because, if they fail, they are entitled to re-enrol multiple times. The following conversation captured the essence of discussion:

R: It would be better for them [students] to get the idea that it's better to get A's than just sneak through with a C. C really isn't wonderful.

R: *Yes, it's that little 'C's get degrees'. Don't you hate it!*

R: *Yes, 'I got a C+; I studied too hard'.*

One teacher admitted, *'we do have a bit of a culture of running around after them, mothering them and I think that's going to have a huge impact.'* However, teachers reported that changing the culture might jeopardize grades, the subsequent reputation of the school *and* inflame parents who blame teachers when their children perform poorly.

Teachers also reported some resistance towards homework. According to one teacher, students frequently request revision periods because they do not understand that revision should be done at home. This teacher said, '*to them, learning is what you do at school'.* For some students, homework is a problem because they are engaged in part-time employment on school nights.

I set high performance standards for myself in science

Lecturers speculated that performance standards among students were heavily influenced by their experience of the NCEA system at high school. It was felt that the NCEA system had conditioned students to develop a mindset around obtaining credits rather than learning *per se*.

R: *That's a hangover from NCEA. Students are only motivated by assessment*.

A discussion about NCEA among one group of veterinary students confirmed the suspicions of lecturers that the typical New Zealand school leaver is predominantly motivated by assessment / credits:

R: *They [i.e. peers who did not have veterinary school in focus] were just going to get the credits to pass – it was much easier for them. They just kind of had to get the 'achieved' to get the credits. We knew what subjects we had to take – they just took whatever they knew they were going to get credits in*.

Consequently, lecturers widely perceived that school leavers only undertake tasks that are directly associated with obtaining marks. For instance, one lecturer described a belief that students have forgotten the importance of a long-term-performance-focus:

R: *If I say to them we have assessments; they might be worth 2%. First of all they'll say, this assessment should be worth 20%. When I say, no, it's worth 2% they will say, oh, well, I won't bother to do it and the argument is you should do it because it is actually to help you learn for your final exam… but they are just not interested in that. They are always focused on what's happening in the next ten minutes*.

Similarly, school teachers warned that NCEA is credit-driven, which allowed students to '*pick and choose whether they are going to even bother with a particular assessment*'. This attitude seems to be particularly prevalent when students had already gained enough credits to pass; or because students knew they would be given another chance to remedy a bad performance.

Furthermore, school teachers also said that students cannot fail NCEA; instead, the worst performance grade is ‘not achieved’, which indicates, ‘*will achieve, just haven’t done it yet*’. They considered that this situation was detrimental to students’ learning and their motivation. Moreover, teachers were concerned about the differentiation between ‘achieved’ grades and ‘merit’ or ‘excellent’ grades. The excessive reliance on key words in the grading system meant that very able students (whose overall performance would be commensurate with ‘merit’ or ‘excellent’ grades) often ended up with ‘achieved’ grades due to the omission of some key word (often, in the view of the teachers, related to a trivial point). This, the teachers felt, was a substantial de-motivator to above-average students: a series of ‘achieved’ grades when both student and teacher had expected much better results rapidly conditioned students towards doing as little as necessary to attain an ‘achieved’ grade, since extra effort was not rewarded with the appropriate higher grade.

I strive to keep up to date with my science studies / I work hard to understand things

Most university students recognized that ‘keeping up-to-date with science studies’ required them to study outside class. For example:

R: *You go to a lecture and you kind of pick up on a few concepts but you have to go back and read over it so you understand it. It’s more like teach yourself even though you are being taught in the lecture you really do teach yourself.*

However, a few students found it challenging to ‘keep up-to-date’. One student (R1) described being unaccustomed to homework, which had never been a requirement at school. Another student (R2) perceived that contact hours did not leave much time for private study. A third student (R3) described how students are distracted by the social scene:

R1: *Well, I wasn’t a big studier at school – my school didn’t even give me homework for 7th form, so after school was finished you didn’t do anything at night. Coming here you’ve actually got to do stuff and I did find that quite hard.*

R2: *I mean if the university expects everyone to do like twelve hours [private study] per paper – I mean if you’ve got three hours [contact time] per paper [in science] – I’m finding I don’t have as much [time as BA students]*.

R3: *A lot of people focus more on the social side and forget that they’ve got all this work to do as well so they get really behind.*

A common message from lecturers was that students should consolidate information between lectures to avoid falling behind.

R: *There are three lectures a week now – that’s going to present a lot of material – you don’t get a lot of chance to actually sort it out between times so a lot of people can get behind quite quickly and it’s very difficult to catch up.*

However, lecturers perceived a catalogue of reasons why many students struggled to keep up-to date. Categories of reasons included complacency (R1); poor time management (R2); paid employment (R3);

social distractions (R4); ineffective study techniques (R5); school backgrounds (R6); NCEA variation (R7):

R1: *They [students] clearly are reflecting on what they know and what they don't know but they just don't see any reason to go and fix it.*

R2: *I had a student came and saw me today and said I wonder if you can help me with some questions. I said, this is the assignment that was due in last Friday.*

R3: *I think a lot of it is students having part-time jobs and it's almost as though they take a full-time university course and then try and do it as a part-time student. At that age they have rudimentary time management skills and so things just fall by the way.*

R4: *They are learning all the things we learned as 18, 19 year-olds which are huge distractions. Some of them need to be taught how to plan a diary so that they meet their deadlines – they don't know how to do it.*

R5: *I find a lot of them work very hard at home but don't have much to show for their effort. Most of them that come in, they don't know how to do the right type of work.*

R6: *Different schools certainly have different attributes. There are certain schools out there that do as part of their goal create more independent learners. There are other schools who will simply spoon-feed the students to pass the exams.*

R7: *Yes, the general physics knowledge of the students coming in straight from school it really depends on the teacher and we have a number of students that have, in theory, done NCEA Level 3 and passed, yet if I asked them XXX 50% of my class will get it wrong.*

Again, there were very similar perceptions about the effort that students devoted to their studies amongst school teachers. One commented that '*today's generation – they don't want to do anything that's too hard*'. Another teacher reported that, when selecting subjects for Year 12 and 13, students and their parents are often concerned about whether science subjects are hard.

3.2.7. Learning with Excitement

Some evidence emerged from focus groups to support the notion that students learn about science with a degree of excitement. University students frequently commented on their excitement when discovering new things about science. When students were asked, 'what is your favourite thing about science', the following was typical of their responses:

R: *A sense of discovery. Like, there's so much that's not discovered yet. You never know what diseases you might come across there to find new cures and treatments and stuff and prevention and medication.*

In addition, students frequently described satisfaction when the knowledge of science could be applied to everyday life and used in conversation with other people. For example:

R: *I didn't realize half the stuff that we learnt was quite so interesting to go away to the gym and put that into practice.*

However, this enthusiasm for learning science is highly dependent upon prerequisites, such as being inspired by the enthusiasm of the lecturer.

There were mixed opinions about whether learning science was, or was not, exciting. Some school students mirrored the views of university students, that they found new information exciting. On the other hand, another student admitted, '*I would rather not discover some new scientific miracle – I would rather just pass my exam*.'

4. Discussion

This study examined the transition from high school to university in the Sciences from the perspectives of students and teachers in educational environments both sides of the transition. By using both quantitative and qualitative methods to investigate these four audience groups, this study is unique and therefore significant in advancing knowledge in its field. The following discussion presents four questions for consideration:

4.1. Student engagement is not lost in transition; but are they engaged at all?

Initial examination of the literature raised suspicions that student engagement might be lost in the transition from school to university, mainly due to a reduced level of interaction between students and their teachers in large university classes (Kuh et al., 2005). In the present study, quantitative results revealed that all 'student engagement' scales were significantly *lower* ($P < 0.001$) among school students than first-year university students. Indeed, the lowest scores were given by Year 12 students taking one core science; with scores increasing among those taking two core sciences. There was, in fact, no significant difference between the mean scores of first-year university students and school students taking all three core sciences. Similarly, Hipkins et al. (2006) reported heightened signs of engagement amongst high school students who were studying two or three core science subjects and/or mathematics in Year 13; or what they labelled 'serious scientists'.

Of the three scales of 'student engagement', the Commitment to Performance scale accounted for the greatest amount of variance amongst students' responses and had the highest overall numerical scores. Neither school nor university students gave scores for Learning with Excitement or Discovering Meaning that were as high as their scores for Commitment to Performance. It is intriguing to speculate about reasons for the different responses to these three scales. It seems possible that Commitment to Performance represents a student's <u>potential</u> commitment, whereas Learning with Excitement and Discovering Meaning represent a student's <u>actual</u> level of engagement with learning science. This leads to the question of whether 'feeling committed' is enough; or whether true engagement requires students to not only feel excitement for their learning, but also to have the belief that they are gaining something meaningful from their studies. One argument along these lines would be the 'stay, say, strive' theory of engagement (Aon Hewitt, 2011), which, although its foundations lie in *employee* engagement, is relevant to student engagement. The model places highest importance on 'striving', which mirrors the present study's scale of Commitment to Performance. However, the model characterizes an engaged employee as one who consistently speaks positively about their organisation and their role within that organisation. With this in mind, the lacklustre level of excitement for Learning with Excitement among students might point towards *dis*engagement.

4.2. Teachers influence student engagement; but are teachers reaching their potential?

The scales of 'teacher efficacy' were highly correlated with those of 'student engagement', whilst the qualitative data strongly supported these statistical associations. These results emphasise that the interaction between teacher and student was the pivotal factor that promoted or inhibited students' engagement. In terms of the extent to which this is true, regression analysis indicated that the 'teacher efficacy' scales could account for around 30% of variance in each scale of 'student engagement'. This is in close accord with the results of Hattie (2003), who reported that a teacher can influence 30% of variance in the achievement of secondary students.

However, results of the present study also indicated that teachers thought they were doing a better job at engaging students than did the students themselves. First-year university students had significantly lower ($P<0.001$) perceptions of Lecturer Qualities than did their lecturers, and lecturers had significantly lower ($P<0.001$) perceptions of 'student engagement' scales than first-year students. These differences in perception reflect a similar trend reported for university students (AUSSE, 2010) in which students considered themselves less engaged than did their lecturers and in which lecturers overestimated the proportion of students who were very satisfied with their learning environment. The apparent disjunction between the perceptions of students and their teachers in the current study raises questions about the value of results presented by Exeter et al. (2010), which are exclusively from teachers' perspectives, since, the results of the present study indicate that, in order to validate data reported by lecturers, simultaneously survey of their students also appears to be necessary.

In the present study, lecturers attributed lacklustre student engagement to several reasons: Firstly, lecturers deflected responsibility towards high school education. In part, they blamed New Zealand's NCEA curriculum, which was commonly perceived to nurture under-achievement rather than the pursuit of excellence among students. In addition, they blamed high school teachers, who they perceived were not adequately qualified in the subjects they taught, particularly physics. Consequently, many lecturers felt obliged to target their teaching towards the lowest common denominator, which they blamed in turn for the disengagement of higher achieving students.

Secondly, lecturers blamed students for an inherent lack of motivation. Again, this trend is confirmed by the AUSSE (2010), where data revealed a disjunction between the perception of students and lecturers in regards to how 'hard' students work. This has previously been reported by Biggs (1999) and labelled the 'blame-the-student' theory of teaching, which is practised by teachers who make the following assumption: '*If students don't learn, it's not that there is anything wrong with the teaching, but that they are incapable, unmotivated or otherwise not doing what they are supposed to be doing. The presumed deficit is not the teacher's responsibility to correct' (p22).*

Because lecturers appeared to be absolving themselves from responsibility for student's learning, students perceived that lecturers were effectively clearing their desks to create space and time for their research interests. Lecturers did nothing to dismiss students' perceptions when they talked about the pressure of the Performance-Based Research Fund (PBRF) in New Zealand. For example, one lecturer said:

R: "*Actually, I don't know if you've all got the same impression, but my impression from administration in the College of Science is to say, minimise the time you spend on teaching because we need you to go into PBRF and research. Therefore, teaching is not important because they are here anyway – just stand up – spend ten minutes or an hour preparing your* *lectures – go and deliver it – come back - write a paper. Spend ten minutes preparing for a lab – come back – write a paper. But don't spend too much time on this teaching*."

This is consistent with the statutory expectation of New Zealand's universities that degrees are taught by staff who are 'active in research' (Woodhouse, 1998). Academics teaching BSc papers in New Zealand have reported that undergraduates, "*don't get the education they should get*" because lecturers are preoccupied with research expectations (Hughes & Hughes, 2011) and that senior administrators have historically instructed academics to prioritize research because, "*if people are not going to do research, what differentiates us from a polytechnic?*" (Guilford & Hughes, unpublished). The pressure to 'publish or perish' in New Zealand has also been cited as a limitation in the adoption of online learning. One participant summarized the comments of many, saying that time dedicated to developing online teaching techniques, "*takes away from what the university really values – research*" (Walker et al., unpublished).

4.3. Teaching needs to be more engaging; but what does that involve?

When it comes to improving engagement from a teaching position, the present study revealed clear themes related to (a) student-directed learning opportunities; (b) student-centred teaching techniques; (c) using technology appropriately; and (d) teaching in relevant contexts:

(a) The Self-Directed Learning scale referred to the scope for students to direct their own learning. Both teachers' and students' scores showed that such scope was limited. Focus groups revealed that university students were resigned to the homogeneity of tertiary education, especially in the face of the large first-year class sizes. Most students said that they found this situation unfavorable. It was therefore surprising to see that Self-Directed Learning was negatively related to Commitment to Performance in the multivariate analysis. There are several possible explanations: (a) if a lecturer is proficient in student-centred learning techniques, that lecturer will engage students and inspire Commitment to Performance without consulting students around what and how they would like to learn; (b) seeking students' opinions for guidance might be perceived by first-year students as a sign of weakness or uncertainty in a lecturer; (c) university teaching diminishes students' confidence when they are prescribed volumes of compulsory content to learn, which may implicitly send the message that the lecturer knows what is best; (d) the result could be a statistical aberration.

(b) The literature is clear that, where the teaching environment is student-centred and linked to active learning, it is more likely that there will be deep learning, good retention of knowledge and an improved recognition of the value of information (e.g. Meyers and Jones, 1993). The present study concurred with this view, finding that student-centred teaching approaches delivered by enthusiastic lecturers were associated with higher levels of engagement among students. However, focus group discussions suggested that the majority of lecturers were neither enthusiastic nor stimulating in the way they taught content. Extensive discussion around teaching techniques suggested that lecturers relied primarily upon transmission methods of instruction, in an environment that was teacher-focused and did not stimulate active learning. Although the association between teaching techniques and student engagement is well known (Biggs, 1999; Entwistle, 1997), it appears that some lecturers have been slow to develop their teaching practice in accordance with this knowledge.

(c) While technology can provide opportunities, it must be used in the context of appropriate pedagogies and learning design principles (Stefani, 2010). Results from the present study support this view because, even though first-year university students indicated that up-to-date teaching technologies were being leveraged, there was a weak relationship between 'maximizing technology' and the 'student engagement' scales. This result is better understood in the context of Tytler's (2003) work, which suggested that online systems which merely manage teaching have little impact upon learning. The impact is likely to be much more positive when students can use technology to undertake active learning tasks, e.g. submit assignments, follow planned work schedules, contact experts via web quests, use data loggers attached to computers to record on-going data from an investigation, etc. It is possible that first-year university students consider technology to be a hygiene factor, which is a factor that can cause dissatisfaction if missing but do not necessarily motivate people if increased (Hertzberg, 1968). For instance, the following quote provides evidence of a student's dissatisfaction with a technology-related situation but indicates that improving the situation would only go as far as meeting the student's baseline expectations, as opposed to providing motivation above and beyond what is expected: *"Probably would help if some of the professors got a little more tech-savvy before they started. I think it's been at least one lecture where a good ten minutes at the start waiting for them to get organized and set up the screen".*

(d) Focus group discussions revealed that students are attracted to the Sciences because science is contemporary and meaningful to people, society and technology. It was a disappointment for some first-year university students who perceived that their lecturers did not present science content in contexts that were relevant to them. Once more, the scores given by students for Relevant Contexts were substantially lower than those given by their lecturers; leading to a disjunction that significantly contributed to students' lack of excitement in their learning. This result aligns with existing research (European Commission, 2004) that observed that the initial cause of disaffection amongst the majority of students entering university occurs when they were, '*typically plunged into novel seas of abstract thought and expected to swim for themselves*' (pp. 106). This problem is not, however, unique to university. Osborne and Dillon (2008) showed that school science is often presented as a set of stepping-stones across the scientific landscape and lacks sufficient exemplars to illustrate the application of science in context. In summary, the present study supplements existing literature around relevant contexts (e.g. Knowles et al., 1998; Biggs, 1999; Wlodskowski, 1999) and the benefits of providing students with a point of personal reference upon which they can base conceptual material.

4.4. Undergraduates want to become scientists; but must they wait until postgraduate study?

The multivariate regression analysis between teacher quality and student engagement scales showed that the Scientific Methods scale contributes significantly ($P<0.001$) to each of the three 'student engagement' scales. Taken together with the qualitative data, this highlighted that students appreciate the opportunity to directly participate in the planning, analysis and interpretation of scientific data. However, one of the most remarkable findings of this study was that the scores given by all participant groups for Scientific

Method indicated that mechanisms for challenging and investigating knowledge were not well embedded in students' science education. Focus groups generated an absence of discussion among first-year university students around the scientific method; and, when the subject of laboratory experience was raised within a focus group of third-year university students, they revealed that despite their high level of scientific content knowledge they had a low level of confidence in scientific methods. Furthermore, the consensus among third-year students was that they did not consider themselves 'scientists' and felt that this was a label reserved for post-graduate students. Following on from the present study, Hughes & Hughes (2011) undertook research in education in the BSc in Sport & Exercise Science and found further evidence that teaching and learning of the scientific method is often postponed until postgraduate years.

5. Conclusions

The present study adds to an existing body of literature on student engagement and provides a unique insight in to the Sciences at a tertiary level. It is the first study to have reported contrasts between the perspectives of teachers and students from both tertiary and secondary environments. The psychometric rigor behind the ‘teacher efficacy’ and ‘student engagement’ scales juxtaposed with deep and rich qualitative data gives the present study great potential to influence education policy in the Sciences.

The primary observation of this study was that while students may perceive themselves as being committed to their studies, this does not mean that they are engaged with the Sciences. When it comes to attributing responsibility, teachers blame students and students blame teachers; highlighting that teachers and students are significantly disconnected. Resolving this disjunction presents a challenge of academic culture change, which can be examined at a macro, meso and micro level (Miner, 2005):

5.1. Challenges facing culture change at the macro level

Today’s students are young adults from across the socio-economic spectrum, many of whom have invested heavily in their futures with thousands of dollars of student debt. Government policy has led to annual tuition fees rising from $3,500 in 1999 (Ministry of Education, 2000) to between $5,000 and $6,000 in the Sciences in 2010 (Ministry of Education, 2010). As students come to perceive themselves as the paying clients of education service providers, the quality of tertiary education has come under scrutiny. In 2003, the New Zealand government introduced the Performance-Based Research Fund (PBRF) to enhance the quality of research-led teaching. However, subsequent research has found no correlation between universities’ PBRF ratings and their cost of tuition fees (Smart, 2010). In addition, a rigorous quality assurance system does not exist in New Zealand to hold academics accountable for their teaching. This is in contrast to the Quality Assurance Agency for Higher Education (QAA) in the United Kingdom.

5.2. Challenges facing culture change at the meso level

In response to the climate created by PBRF in New Zealand, a previous study was commissioned by the Head of the Institute of Veterinary, Animal and Biomedical Sciences (IVABS) at Massey University (Guilford & Hughes, unpublished). The objective was to investigate possible strategies to readjust the balance between teaching and research eminence. Academic participants highlighted a perception that a Professor in teaching would only ever be the poor cousin of a Professor in research. Therefore, those academics that were stimulated by pedagogy were perceived to be living in the shadow of their research-oriented colleagues and felt pessimistic about their career progression prospects. Institutional strategies for rewarding and recognising quality teaching performance is therefore the first meso-level challenge.

A second meso-level challenge facing culture change is programme-level reform. The present study suggests that teaching programmes in the Sciences need to be improved. One strategy would be for all BSc undergraduates to study a core scientific stratum of chemistry, biology, physics and mathematics

(Hughes & Hughes, 2011). Designing these core papers would need extensive consultation between university faculty members and teachers of NCEA sciences, in an effort to avoid duplication and build effectively on the foundations of what has already been learned. From this platform, BSc programmes could allow deep preparation in one discipline (e.g. veterinary science, engineering, agriculture, exercise science, biology, fundamental science etc). Using the example of exercise science, baseline physics and biology would be built upon by the department's biomechanist; while baseline chemistry and biology would be built upon by a physiologist. With this deep preparation coming from within specialist departments, it means that exercise science students could learn about mammalian biology in the context of humans; while BVSc students could learn in an animal context.

An opportunity for greater levels of active learning (even problem-based learning) lies within the 'deep preparation' of students in one discipline (Biggs, 1999; Hughes & Hughes, 2011). In regards to the volumes of content information that was limiting the 'active' nature of many lecturers' teaching approaches; a good proportion of that content could be directed in to the large-class Faculty-level papers. This would leave discipline-level lecturers free to build subject-specialist knowledge in innovative ways, such as problem-based learning (or similar). Of particular importance to the Sciences, problem-based learning would lead to increased exposure to the scientific method in the laboratory / field environment. This would address research that suggests some BSc students are not necessarily proficient scientists upon graduation (Ammonnette et al, 2010; Hughes & Hughes, 2011).

5.3. Culture change at the micro level

A stagnation of teaching techniques was reported in the current study, which reflects previous tertiary educational literature (Biggs, 1999). In part, the stagnation could be explained by academic's preoccupation with research expectations (Woodhouse, 1998; Hughes & Hughes, 2011, Guilford & Hughes, unpublished; Walker et al, unpublished). In part, the stagnation could also be explained by high levels of autonomy among academics who are scarcely motivated by anyone outside their close circle of research collaborators; meaning that it is particularly difficult for administrators to engage academics in change (Guilford & Hughes, unpublished).

On the other hand, the stagnation of teaching may only be relative to the pace of change among students. In 2010, it was reported that 85% of the world's children owned a mobile phone, while only 73% owned books at home (Jennings, 2011). This raises a question around how academics will need to adapt their teaching to engage future generations of students. In addition, the top 10% of in-demand jobs in 2010 did not exist in 2004 (Jennings, 2011). This means there is an increasing need for academics to prepare students for jobs that do not currently exist; in order to solve problems that we do not know are problems yet. In other words, develop a baseline of generic / non-technical skills (Alan & Hughes, 2009; Hughes & Hughes, 2011) along with the aptitude to apply discipline-based content in contexts that we cannot yet anticipate. This is a compelling argument in favour of teaching techniques such as problem-based learning (PBL), which compel students to develop the capacity to think analytically and innovatively about content in real-life contexts.

5.4. Next Steps: A Personal Reflection

From my perspective, the current study has juxtaposed students as paying clients with a consumer-right to engaging, student-centric teaching services with academics who resist the modernization of teaching, partly because they don't have the time to modernize and partly because they feel there is nothing wrong with the way it has always been done. Meanwhile, neither the institution at a meso level nor the government at the macro level are providing the incentive to revolutionise micro-level teaching but, instead, feed the prominence of research through PBRF.

Therefore, I believe the present study leads towards a case for organisational culture change. Based on the perspective that I have gained from five studies that I have undertaken at Massey University (Guilford & Hughes, unpublished; Flemming et al, 2009; Alan & Hughes, 2009, Hughes & Hughes, 2011; present study), I believe that the most effective way to manage change in the tertiary education sector is via 'micro-leaders', i.e. grass-root academics who are natural innovators and thought leaders. Their successes can be leveraged as testament that change is possible (Rogers, 1962). However, from my past professional experience as a Management Consultant, I also know that organisational change requires courageous and constructive leadership united by a clear customer-focussed vision for the future (Grant et al., 2010; Jones et al., 2006). In my experience, organisational culture does not change quickly and, at the best of times, it can take decades to shift. However, if there is rationale for change, such as that presented in the current study, it is important to take small steps in the right direction.

References

Aikenhead, G. (2005). Science-based occupations and the science curriculum: Concepts of evidence. *Science Education*, 89, 242–275.

Ako Aotearoa (2010). *Tertiary Teaching Excellence Awards 2010*. Retrieved from http://akoaotearoa.ac.nz/ako-aotearoa/ako-aotearoa/resources/pages/ttea-2010-winners

Allan, F. & Hughes, H., (2009). *A gap analysis between international best practice and current methods of disseminating non-technical capabilities to veterinary undergraduates in New Zealand*. Wellington: Ako Aotearoa.

Ammonette, W. E., English, K. L., & Ottenbacher, K. J. (2010). Nullius in Verba: A Call for the Incorporation of Evidence-Based Practice into the Discipline of Exercise Science. *Sports Medicine*, 40, 449-457.

Andrews, P. (2004). *Building brain-based industries? First, find the brains*. Paper presented at the Australasian Research Managers Society Workshop “Beyond Brain Drain”, St Lucia.

Aon Hewitt (2011). *Trends in Global Employee Engagement.* Retrieved from: http://www.aon.com/attachments/thought-leadership/Trends_Global_Employee_Engagement_Final.pdf

Astin, A. W. (1993). *What matters in college: Four critical years revisited*. San Francisco: Jossey Bass.

Atwater, M. M., Wiggins, J., & Gardner, C. M. (1995). A study of urban middle school students with high and low attitudes toward science. *Journal of Research in Science Teaching*, 32, 665–677.

Australasian Survey of Student Engagement (AUSSE) (2009). *Engaging Students for Success: Australasian Student Engagement Report.* Melbourne: Australian Council for Educational Research.

Australasian Survey of Student Engagement (AUSSE) (2010). *Doing more for learning: Enhancing engagement and outcomes.* Melbourne: Australian Council for Educational Research.

Australian Council of Deans of Science (2001). *Science at the crossroads*. Canberra: Australian Council of Deans of Science.

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development,* 18(1).

Bishop, G., Riley, S., Shrestha, S., McPhail, A,, Campbell, B., & Riley, E. (2008). *Preparation for the transition from high school to university – Impact on retention in the first-year of engineering*. Paper presented at the International Conference on Engineering Education, Budapest, Hungary.

Braun, V., & Clarke, V. (2003). Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3, 77-101.

Britt, T., Adler, A., & Bartone, P. (2001). Deriving benefits from stressful events: The role of engagement in meaningful work and hardiness. *Journal of Occupational Health Psychology,* 6(1), 53-63.

Bull, A., Gilbert, J., Barwick, H., Hipkins, R., and Baker, R. (2010). *Inspired by science*. A paper commissioned by the Royal Society and the Prime Minister's Chief Science Advisor. Wellington: New Zealand Council for Educational Research.

Carini, R., Kuh, G., & Klein, S. (2004). Student engagement and student learning: Testing the linkages. *Research in Higher Education*, 47(1).

Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 39(7), 3-7.

Coates, H. (2008). *Beyond happiness: Managing engagement to enhance satisfaction and grades*. Melbourne: Australian Council for Educational Research.

College of Sciences, unpublished

Dobson, I. R. (2007). *The IT Education Bubble: An analysis of university student statistics 2002-2005*. Victoria: Australian Council of Deans of Science.

Entwistle, N. (1997). Contrasting perspectives on learning. In F. Marton, D. Hounsell, & N. Entwhistle (Eds.), *The Experience of Learning* (pp. 3–22). Edinburgh, Scotland: Scottish Academic Press.

European Commission. (2004). *Europe needs more scientists: Report by the high level group on increasing human resources for Science and Technology*. Brussels: European Commission.

Evans, M. (2000). *Planning for the Transition to Tertiary Study: A Literature Review*. Perth: Australasian Association for Institutional Research.

Exeter, D.J., Ameratunga, S., Ratima, M., Morton, S., Dickson, M., Hsu, D. & Jackson, R. (2010). Student engagement in very large classes: the teacher's perspective. *Studies in Higher Education*. 35 (7), 761-775.

Fleming, J., Martin, A., Hughes, H., & Zinn, C. (2009). Maximizing work-integrated learning experiences through identifying graduate competencies for employability: A case study of sport studies in higher education. *Asia-Pacific Journal of Cooperative Education*, 10(3), 189-201.

Fullarton, S., Walker, M., Ainley, J., & Hillman, K. (2003). *Longitudinal studies of Australian youth: Patterns of participation at Year 12*. Melbourne: Australian Council for Educational Research.

George, R. (2006). A Cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education*, 28(6), 571–589.

Grant, A M., Green, L. S., Rynsaardt, J. (2010). Developmental coaching for high school teachers: Executive coaching goes to school. *Consulting Psychology Journal: Practice and Research*, 62(3), 151-168.

Guilford, G. & Hughes, H., (unpublished). *What motivates academics?*

Gunstone, R., & Northfield, J. (1992). *Conceptual change in teacher education: The centrality of metacognition*. Paper prepared for the invited symposium "Conceptual Change Approaches in Teacher Education" at the meeting of American Educational Research Association, San Francisco.

Harris, T. & Coll, R. (unpublished). *New Zealand university students' departure intentions.*

Hattie, J. (2003). *Teachers make a difference: What is the research evidence?* Melbourne: Australian Council for Educational Research.

Herzberg, F. (1968). One more time: how do you motivate employees? *Harvard Business Review* (January-February), 53-62.

Hipkins, R., & Bolstad, R. (2005). *Staying in science: Students' participation in secondary education and on transition to tertiary studies.* Wellington: New Zealand Council for Educational Research.

Hipkins, R., Roberts, J., Bolstad, R., & Ferral, H. (2006). *Staying in science 2: Transition to tertiary study from the perspectives of New Zealand first-year3 science students.* Wellington: New Zealand Council for Educational Research.

Hu, S., & Kuh, G. (2003). Being (dis)engaged in educationally purposeful activities: The influences of student and institutional characteristics. *Research in Higher Education,* 43(5).

Hughes, J. D., & Hughes, H. (2011). *Sport & Exercise Science as a rigorous science education: A discussion for teachers of the discipline*. Wellington: Ako Aotearoa.

Indiana University Center for Evaluation and Education Policy (CEEP). (2009). *Engaging the Voices of Students: A Report on the 2007 & 2008 High School Survey of Student Engagement.* Retrieved 02 June 2010 http://ceep.indiana.edu/hssse/pdf/HSSSE_2009_Report.pdf.

James, R., Krause, K.-L., & Jennings, C. (2009). *The first-year experience in Australian universities: Findings from 1994 to 2009.* Melbourne University: Centre for the Study of Higher Education.

Jennings, C. (2011). *'Learning at the speed of business': Innovation lessons for Higher Education learned from the corporate sector*. Paper presented at the Follow the Sun Learning Futures Festival, hosted by the Beyond Distance Research Alliance, Online. http://www2.le.ac.uk/departments/beyond-distance-research-alliance/festival/session-recordings/uk-day-2 (accessed 13 April, 2011).

Jones, Q., Dunphy, D., Fishman, R., Larne, M., & Canter, C. (2006). *In great company: Unlocking the secrets of cultural transformation*. Sydney, Australia: Human Synergistics.

Kahn, W. A. (1992). To be fully there: Psychological presence at work. *Human Relations*, 45(4), 321-348.

Koslow, S. (2005). *If creative scientists sustain New Zealand's knowledge economy, how is science education doing: Insights from recent university science graduates.* Wellington: The Royal Society of New Zealand.

Krause, J. R., Krause, K., and Jennings C. (2009). *The First-year Experience in Australian Universities: Findings from 1994 to 2009.* Melbourne University: Centre for the Study of Higher Education

Krause, K. 2007. New perspectives on engaging first year students in learning. Brisbane: Griffith Institute for Higher Education. http://www.griffith.edu.au/__data/assets/pdf_file/0005/37490/FYEEngagemtGriffith2007.pdf (accessed May 16, 2011).

Krause, K.-L. (2005). Serious thoughts about dropping out in first-year: Trends, patterns and implications for higher education. *Studies in Learning, Evaluation, Innovation and Development*, 2(3), 55-68.

Krause, K.-L., & Coates, H. (2008). Students' engagement in first-year university. *Assessment and Evaluation in Higher Education*, 33(5), 493-505.

Krause, K.-L., Hartley, R., James, R., & McInnis, C. (2005). *The first-year experience in Australian universities: Findings from a decade of national studies.* Canberra: AGPS.

Krause, K-L. (2005). *Engaged, inert or otherwise occupied? Deconstructing the 21st century undergraduate student.* Keynote address presented at the Sharing Scholarship in Learning and Teaching: Engaging Students Symposium, James Cook University, Townsville, Queensland. 21-22 September.

Kuh, G. D. (2001). Assessing what really matters to student learning: Inside the National Survey of Student Engagement. *Change*, 33(3), 10-17.

Kuh, G. D. (2003). What we're learning about student engagement from NSSE. *Change*, 35(2), 35-44.

Kuh, G. D. (2004). *The National Survey of Student Engagement: Conceptual framework and overview of psychometric properties.* Bloomington: Indiana University Center for Postsecondary Research and Planning.

Kuh, G. D., Kinzie, J., Schuh, J. H., Whitt, E. J. & Associates. (2005). *Student success in college: Creating conditions that matter*. San Francisco, CA: Jossey-Bass.

Kuh, G., Kinzie, J., Cruce, T., Shoup, R., & Gonyea, R. (2007). *Connecting the dots: Multi-faceted analyses of the relationships between student engagement results from the NSSE, and the institutional practices and conditions that foster student success.* Indiana: Center for Postsecondary Research.

Lindhal, B. (2003). *Pupils' responses to school science and technology? A longitudinal study of pathways to upper secondary school.* (Unpublished thesis). Kristianstad University, Sweden.

Longden, B. (2004). Interpreting student early departure from higher education through the lens of cultural capital. *Tertiary Education and Management*, 10, 121-138.

Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education*, 28(6), 591-613.

McGroarty, E., Parker, J., Heidemann, M., Lim, H., Olson, M., Long, T., Merrill, J., et al. (2004). Supplementing introductory biology with on-line curriculum. *Biochemistry and Molecular Biology Education*, 32(1), 20–6.

McInnis, C. (2001). *Signs of disengagement? The changing undergraduate experience in Australian universities.* Inaugural professorial lecture. Melbourne University: Centre for the Study of Higher Education.

McInnis, C., James, R., & Hartley, R. (2000). *Trends in the first-year experience*. Canberra: DEETYA Higher Education Service.

McMahon, B. (2003). Putting the elephant into the refrigerator: Student engagement, critical pedagogy and antiracist education, *McGill Journal of Education*, 38(2), 257-273.

Miner, J. B. (2005). *Organizational Behavior 1: Essential theories of motivation and leadership* (pp. 13-14). Armonk, N.Y. : M.E. Sharpe.

Ministry of Education. (2000). *New Zealand's Tertiary Education Sector: Profile and Trends 1999*. Retrieved from: http://www.oecd.org/dataoecd/1/35/1917408.pdf

Ministry of Research, Science and Technology (MoRST). (2009). *Research, Science and Technology Scorecard 2009*. Retrieved from: http://www.morst.govt.nz/publications/statistics/scorecard/.

Ministry of Research, Science and Technology (MoRST). (2010). *Statement of intent: 2010/11*. Retrieved from: http://www.morst.govt.nz/publications/corporate-reports/soi/SoI-2010-2011/.

Myers, C., & Jones, T. B. (1993). *Promoting active learning.* San Francisco: Jossey-Bass Publishers.

National Science Foundation. (2009, April 27). *President pledges clean energy education opportunities to inspire the next generation of scientists & engineers.* Retrieved from: http://www.nsf.gov/news/news_summ.jsp?cntn_id=114700

National Survey of Student Engagement (NSSE). (2009). *Assessment for improvement: Tracking student engagement over time – Annual results 2009*. Indiana University: Center for Postsecondary Research.

Organisation for Economic Cooperation and Development (OECD). (2008). *Education at a glance 2008: OECD indicators*. Paris: OECD.

Organisation for Economic Cooperation and Development (OECD). (2009). *PISA 2006 Technical Report*. Paris: OECD.

Organisation for Economic Cooperation and Development (OECD). (2009). *OECD Science, Technology and Industry Scoreboard 2009*. Paris: OECD.

Osborne, J. F., Simon, S., & Collins, S. (2003). Attitudes towards Science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: A focus group study. *International Journal of Science Education*, 23(5), 441–467.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: Nuffield Foundation.

Pargetter, R. J., Mclnnis, C., James, R., Evans, M., Peel, M., & Dobson, I. R. (1999). *Transition from secondary to tertiary: Performance study*. Canberra: DEETYA Higher Education Service.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research* (Vol. 2). San Francisco, CA: Jossey-Bass.

Peel, M. (2000). 'Nobody cares': the challenge of isolation in school to university transition. *Journal of Institutional Research.*

Prosser, M., Ramsden, P., Trigwell, K., & Martin, E. (2003). Dissonance in experience of teaching and its relation to the quality of student learning. *Studies in Higher Education*, 28(1).

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

Ramsden, P. (1991). A performance indicator of teaching quality in higher education: The Course Experience Questionnaire. *Studies in Higher Education*, 16, 129-150.

Rogers, E. M. (1962). *Diffusion of Innovations*. New York: Free Press.

Saks, A. (2006). Antecedents and consequences of employee engagement. *Journal of Managerial Psychology,* 21(7).

Schagen, S., & Hodgen, E. (2009). *Why engineering, technology, or science? The views of first-year tertiary students*. Wellington: New Zealand Council for Educational Research.

Schaufeli, W., & Salanova, M. (2007). Efficacy or inefficacy, that's the question: Burnout and work engagement, and their relationships with efficacy beliefs. *Anxiety, Stress, and Coping,* 20(2), 177-196.

Schaufeli, W., Bakker, A., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and Psychological Measurement*, 66, 701.

Schreiner, C., & Sjøberg, S. (2004). Sowing the seeds of ROSE: *Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education).* University of Oslo: Department of Teacher Education and School Development.

Sjøberg, S., & Schreiner, C. (2005). *Young people and science – attitudes, values and priorities: Evidence from the ROSE project*. Keynote presentation at the European Union Science and Society Forum, Brussels.

Smart, W. (2010). *Comparing university tuition fees with PBRF performance*. Wellington, New Zealand: Ministry of Education, Tertiary Sector Performance Analysis and Reporting. Retrieved May 21, 2011, from http://www.educationcounts.govt.nz/__data/assets/pdf_file/0009/70488/tuition-fees-vs-PBRF-scores3b.pdf

Stefani, L. J. A., Clarke, J., & Littlejohn, A. H. (2000). Developing a student-centred approach to reflective learning. *Innovations in Education and Training International,* 37(2).

Telford, M., & Caygill, R. (2006). *PISA 2006: How ready are our 15 year-olds for tomorrow's world?* Wellington: Ministry of Education New Zealand.

The Higher Education Academy UK. (2008). *Comparative review of British, American and Australian national surveys of undergraduate students.* York: The Higher Education Academy.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition (Second Edition).* Chicago: University of Chicago Press.

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education,* 37, 57-70.

Tytler, R. (2003). A Window for a purpose: Developing a framework for describing effective science teaching and learning. *Research in Science Education,* 33, 273-298.

Tytler, R. (2006). *Re-imagining science education: Engaging students in science for Australia's future.* Melbourne: Australian Council for Educational Research.

Tytler, R. (2007). School innovation in science: A model for supporting school and teacher development. *Research in Science Education,* 37, 189-216

Tytler, R., Osbourne, J., Williams, G., Tytler, K., & Cripps-Clark, J. (2008). *Opening up pathways: Engagement in STEM across the primary-secondary school transition.* Melbourne: Australian Department of Education, Employment and Workplace Relations.

Umbach, P., & Wawrzynski, M. (2005). Faculty do matter: The role of college faculty in student learning and engagement. *Research in Higher Education,* 26(2).

Walker, R., Brown, M., Moore, C., & Hughes, H. (unpublished). *The Stream Experience: Adopting an online learning environment in the College of Business at Massey University.*

Watene, S. (2006). *A merging of a Eurocentric model – learning communities with an indigenous model – whakawhanaungatanga.* Paper presented at the 9th Pacific Rim First-year in Higher Education Conference, Engaging Students, Griffith University, Gold Coast Campus, Australia. 12-14 July.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. New York: Cambridge University Press

Woodhouse, D. (1998). Auditing research and the research/teaching nexus. New Zealand Journal of Educational Studies, 33(1), 39–53.Wlodskowski, R.J. (1999) *Enhancing Adult motivation to learn.* Jossey-Bass Publishers, San Francisco.

Zepke, N., Leach, L., & Prebble, T. (2006). Being learner centred: one way to improve student retention? *Studies in Higher Education*, 31(5), 587–600.

Appendices

Appendix 1: Questionnaire questions

The first 50 items refer to ‘teacher efficacy’ and the second 50 to ‘student engagement’

Questions were randomised through the questionnaire

1. I am asked to learn how scientific ideas have developed over time
2. I am asked to learn about major 'break-throughs' in science
3. I am asked to learn how science impacts people, society and technology
4. I am asked to learn about how science relates to contemporary issues
5. I am asked to consider ethical issues surrounding science
6. My lecturers explain science in the context of real-life examples
7. My lecturers relate science to things that interest me
8. My lecturers use a variety of techniques to help me learn a topic
9. My lecturers teach content directly out of a textbook / written notes
10. My lecturers explain the principles of a topic before teaching me detailed facts
11. My lecturers use my existing knowledge of science as a starting point
12. My lecturers use my questions as a springboard for the next step
13. I am expected to apply my previous science knowledge to new topics
14. I am expected to integrate knowledge across different sciences
15. I am expected to develop my knowledge through class discussion
16. I am expected to contribute my knowledge to team projects
17. I am given the opportunity to reflect on which tasks helped me learn most effectively
18. I am given the opportunity to seek clarification on things I am trying to learn
19. I am expected to undertake practical science investigations
20. I am expected to plan the investigations that I undertake
21. I am expected to evaluate then interpret scientific data/evidence for myself
22. I am expected to use data/evidence to solve scientific problems
23. I am expected to use data/evidence to develop a logical scientific argument
24. I am given the opportunity to influence what topics I am taught
25. I am given the opportunity to influence the way that I am taught
26. I am given the opportunity to learn at my own pace
27. I am given the opportunity to collaborate with other people
28. The criteria on which I will be assessed have been made clear to me
29. I am assessed using a variety of methods
30. Assessment is embedded throughout my course
31. Assessment tasks allow me to demonstrate what I have learned from a topic
32. My lecturers give me feedback on my performance in assessment tasks
33. I am assessed on my ability to memorise scientific facts
34. I am assessed on my ability to interpret scientific data
35. I am assessed on my ability to discuss scientific concepts
36. My lecturers use up-to-date technology for teaching
37. I am given the opportunity to use up-to-date technology during investigations
38. I am given the opportunity to use up-to-date technology to complete assignments
39. I am given the opportunity to use up-to-date technology to develop my knowledge

40. I am given the opportunity to interact with the wider science community
41. I am given the opportunity to study science outside the classroom / laboratory
42. I am given the opportunity to listen to external people talk about science
43. My lecturers inspire me with their enthusiasm
44. My lecturers encourage me with their positive comments
45. My lecturers support me with constructive feedback to go forward
46. My lecturers empower me with useful resources
47. My lecturers stimulate me with the way they teach content
48. My lecturers reward me with fair grades
49. My lecturers value my contribution in class
50. My lecturers care for me by creating a class environment that protects my individuality
51. I learn how scientific ideas have developed over time
52. I learn about major 'break-throughs' in science
53. I learn how science impacts people, society and technology
54. I learn about how science relates to contemporary issues
55. I consider ethical issues surrounding science
56. I apply my previous science knowledge to new topics
57. I integrate knowledge across different sciences
58. I develop my knowledge through class discussion
59. I contribute my knowledge to team projects
60. I reflect on which tasks helped me learn most effectively
61. I seek clarification on things I am trying to learn
62. I undertake practical science investigations
63. I plan the investigations that I undertake
64. I evaluate then interpret scientific data/evidence for myself
65. I use data/evidence to solve scientific problems
66. I use data/evidence to develop a logical scientific argument
67. I take the opportunities that are given to listen to external people talk about science
68. I take opportunities to influence what topics I am taught
69. I learn at my own pace
70. I chose to collaborate with other people when I am given the opportunity
71. I learn by memorising scientific facts
72. I learn by interpreting scientific data
73. I learn by discussing scientific concepts
74. I use technology to develop my knowledge
75. I interact with the wider science community
76. I ask questions in science class
77. I take the opportunities that are given to me to study science outside the classroom / lab
78. I strive to get good grades in science
79. I set high performance standards for myself in science
80. I tell other people how much I enjoy studying science
81. I get excited when I discover things about science
82. I apply my knowledge of science to things in my life
83. I discuss science issues with other people
84. I strive to do my best in science

85. I use resources in addition to the set text to study science
86. I use the set texts and study guides to study science
87. After science class, I reflect on what I've learned
88. I do more science study than is required just to complete assignments
89. I ask for help from my science lecturers
90. I challenge myself to explore the 'deepest secrets' of science
91. Before I start a science assignment, I plan how I am going to do it
92. I complete science assignments by their deadlines
93. I take opportunities to influence the way that I am taught
94. It takes me no longer to complete science assignments than the hours suggested
95. If I can, I study in an environment that is free from distraction
96. I balance social activities / employment so it doesn’t distract me from studying science
97. I try to attend science classes
98. I work hard to understand things I find confusing about science
99. I strive to keep up to date with my science studies
100. I intend to stay in science

Appendix 2: Demographic questions of different participant groups

Participant Group	Questions
All groups	• Gender • Ethnicity
University students	• Degree programme • Prior school science curriculum • Year of leaving school
School students	• School science curriculum • Science subjects currently being studied • Intention to study science at university
University lecturers	• Academic Title • Paper coordinator • Number of hours teaching each semester • Full time/part time • Task preference
School science teachers	• Number of years teaching science at high school • Location of primary teacher training

Appendix 3: Focus group and interview questions

Participant Group	Questions
University Students	• What is your favourite thing about Science? • Please complete these statements: In science class, I really like it when... In science class, I really *don't* like it when... In science class, I would really like it if... • What is the biggest difference between Science at school and university?
University Lecturers	• What three things engage your students in your Science papers? • What knowledge and skills do students have when they enter your class; and what do you want them to have by the end of the year? • What can students do to help themselves? • What can lecturers do to help students engage with their learning? • If you could 'blue sky' your area of science teaching, what would you do?
University Programme Directors	• What knowledge and skills do students have when they enter your programme; and what do you want them to have by the end of the year? • How well prepared are school-leavers for entrance to tertiary science study? • What are the major issues that your programme faces in teaching students who have just completed high school?
School Students	• What is your favourite thing about Science? • Please complete these statements: In science class, I really like it when... In science class, I really *don't* like it when... In science class, I would really like it if... • What are your plans for the future?
School Teachers	• What three things engage your students in your Science classes? • What knowledge and skills do students have when they enter your class; and what do you want them to have by the end of the year? • What can students do to help themselves? • What can the school do to help students engage with their learning? • If you could give one piece of advice to university teachers, what would it be?

Appendix 4: Relationship between demographic data and questionnaire responses

In each of the tables in this appendix, data are presented as the arithmetic mean (1-5 scales, in which 1 = never and 5 = always) for the individual items making up each scale.

P values are the significance of overall differences within a column (univariate ANOVA). Post-hoc analyses are not shown.

(a) Relationship between gender and the scales of teacher efficacy / student engagement

Gender		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning with Excitement	Discovering Meaning
University students	Male	3.4	3.1	3.4	2.8	3.5	4.0	3.4	3.4
	Female	3.4	3.1	3.3	2.6	3.6	4.2	3.3	3.2
	P	0.53	0.20	0.50	0.20	0.41	0.31	0.99	0.09
University lecturers	Male	4.3	3.2	3.4	2.3	3.7	3.5	3.0	3.1
	Female	4.0	3.0	3.1	2.3	3.5	3.4	2.9	2.8
	P	0.02	0.55	0.49	0.75	0.31	0.18	0.35	0.94
School students	Male	3.2	2.5	3.3	2.4	3.1	3.6	2.8	2.8
	Female	3.3	2.6	3.3	2.3	3.1	3.9	2.9	2.8
	P	0.66	0.70	0.60	0.71	0.62	0.17	0.70	0.59
School teachers	Male	4.3	3.3	3.5	2.5	3.5	3.8	3.1	3.3
	Female	4.3	3.2	3.6	2.5	3.3	3.6	3.1	3.2
	P	0.55	0.90	0.76	0.17	0.49	0.84	0.75	0.72

Boxes with a double outline are significantly higher ($P<0.05$) than other boxes in the column.

P: significance of univariate ANOVA within column

(b) Relationship between ethnicity / whether English is the first language and the scales of teacher efficacy / student engagement

		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning with Excitement	Discovering Meaning
University students	Pakeha-European	3.4	3.1	3.3	2.6	3.6	4.1	3.3	3.3
Ethnicity	Maori	3.5	3.2	3.4	3.1	3.4	3.8	3.4	3.2
	Pasifika	3.7	3.3	3.6	3.2	3.8	3.9	3.7	3.4
	Other	3.4	3.1	3.4	2.9	3.5	4.1	3.4	3.4
	NZ Mix	3.5	3.1	3.6	3.0	3.8	4.0	3.3	3.3
	P	0.82	0.40	0.01	0.01	0.85	0.38	0.26	0.83
School students	Pakeha-European	3.2	2.5	3.4	2.2	3.0	3.7	2.7	2.8
Ethnicity	Maori	2.9	2.3	3.2	2.4	2.9	3.2	2.6	2.6
	Pasifika	4.0	3.3	3.7	3.1	3.8	3.8	3.1	3.4
	Other	3.4	2.6	3.3	2.6	3.3	3.8	2.9	2.9
	NZ Mix	3.2	2.5	3.2	2.1	3.0	3.6	2.8	2.9
	P	0.01	0.01	0.16	0.01	0.07	0.10	0.08	0.04
School students	Yes	3.2	2.5	3.3	2.3	3.0	3.7	2.8	2.8
English as 1st language	No	3.5	2.9	3.2	2.8	3.3	3.7	3.0	3.1
	P	0.95	0.01	0.16	0.01	0.08	0.32	0.91	0.03

Boxes outline in solid black are significantly lower (P<0.05) than other boxes in the column.

Boxes with a double outline are significantly higher (P<0.05) than other boxes in the column.

P: significance of univariate ANOVA within column

(c) Relationship between university student's degree programme / school curriculum previously studied and the scales of teacher efficacy / student engagement

		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning w/ Excitement	Discovering Meaning
University students	BSc	3.4	3.2	3.4	2.7	3.5	4.1	3.4	3.4
Degree programme	BVSc	3.5	3.2	3.4	2.5	3.7	$\boxed{4.5}$	3.5	3.3
	BEng	3.5	3.1	3.5	2.8	3.6	3.9	3.2	3.3
	BInfSci	3.5	3.1	3.4	2.9	3.5	3.8	3.3	3.4
	Other	3.5	3.0	3.2	2.6	3.6	4.0	3.1	3.1
	P	0.45	0.21	0.23	0.53	0.09	0.01	0.05	0.11
University students	NCEA	3.4	3.1	3.4	2.7	3.6	4.1	3.3	3.3
School curriculum	A-Level	3.4	3.0	3.3	2.4	3.2	4.1	3.5	3.3
	International Bac	3.5	3.1	3.2	2.8	3.4	4.1	3.5	3.4
	Other	3.5	3.1	3.3	2.6	3.5	4.2	3.4	3.3
	P	0.34	0.79	0.41	0.69	0.49	0.71	0.15	0.21

Boxes with a double outline are significantly higher (P<0.05) than other boxes in the column.

P: significance of univariate ANOVA within column

(d) Relationship between school student's subject(s) of study / future study intentions and the scales of teacher efficacy / student engagement

		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning w/ Excitement	Discovering Meaning
School students Subjects of study	3 Core Sciences	3.4	2.6	3.4	2.5	3.1	4.2	3.2	2.9
	Chemistry & Biology	3.3	2.8	3.6	2.4	3.1	4.0	3.0	3.0
	Chemistry & Physics	3.5	2.5	3.3	2.4	3.1	3.8	2.9	2.7
	Biology & Physics	3.5	2.8	3.2	2.1	3.0	3.7	2.5	2.8
	Chemistry only	3.3	2.1	3.3	2.2	3.3	3.5	2.6	2.5
	Biology Only	3.3	2.7	3.3	2.4	3.3	3.5	2.6	3.0
	Physics Only	3.0	2.3	3.3	2.2	2.9	3.5	2.6	2.5
	P	0.42	0.41	0.28	0.69	0.35	0.45	0.03	0.81
School students Science at university?	Yes	3.4	2.6	3.4	2.4	3.1	4.1	3.2	3.0
	No	3.0	2.4	3.2	2.3	3.0	3.1	2.4	2.6
	Maybe	3.3	2.5	3.3	2.4	3.1	3.7	2.7	2.8
	P	0.40	0.47	0.30	0.47	0.48	0.01	0.01	0.13

Boxes with a double outline are significantly higher (P<0.05) than other boxes in the column.

P: significance of univariate ANOVA within column

(e) Relationship between university lecturer appointment / hours of teaching / task preference and the scales of teacher efficacy / student engagement

		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning with Excitement	Discovering Meaning
Paper coordinator	Yes	4.2	3.1	$\boxed{3.4}$	2.3	3.8	3.5	3.0	3.0
	No	4.3	3.0	3.0	2.3	3.3	3.5	2.8	3.0
	P	0.85	0.20	0.02	0.89	0.27	0.79	0.31	0.68
Title	Professor	4.3	3.4	3.3	2.1	3.7	3.6	3.0	3.5
	Ass Prof	4.6	3.3	3.7	2.8	4.3	3.8	3.1	3.3
	Senior Lecturer	4.1	3.1	3.3	2.2	3.7	3.5	2.9	2.8
	Lecturer	4.2	3.0	3.2	2.3	3.6	3.3	2.8	2.8
	Other	4.4	3.2	3.5	2.4	3.6	3.6	3.1	3.4
	P	0.74	0.25	0.62	0.85	0.45	0.57	0.03	0.47
Appointment	Full Time	4.2	3.1	3.3	2.3	3.7	$\boxed{3.5}$	2.9	3.0
	Part Time	4.3	3.2	3.5	2.4	3.4	3.3	3.0	3.1
	P	0.95	0.76	0.88	0.94	0.69	0.01	0.11	0.97
Teaching Semester 1	0.5 h	4.2	3.3	3.1	2.1	3.6	3.5	2.9	3.1
	6-10 h	4.2	2.9	3.4	2.3	3.9	3.5	3.0	2.9
	11-15 h	4.3	3.1	3.5	2.3	3.7	3.6	2.8	3.0
	≥16 h	4.3	3.2	3.6	$\boxed{2.9}$	3.8	3.5	3.1	3.1
	P	0.90	0.65	0.62	0.01	0.34	0.72	0.70	0.36
Semester 2	0.5 h	4.2	3.3	3.2	2.3	3.7	3.5	2.9	3.2
	6-10 h	4.2	3.0	3.3	2.1	3.7	3.6	3.0	3.0
	11-15 h	4.3	3.2	3.7	2.3	3.6	3.5	2.7	2.8
	≥16 h	4.4	3.3	3.3	2.6	4.0	3.3	3.1	3.0
	P	0.92	0.80	0.71	0.07	0.39	0.65	0.53	0.66
Information preference	Discovering	4.0	3.1	3.3	2.3	3.7	3.5	2.9	2.9
	Disseminating	4.3	3.0	3.2	2.3	3.7	3.4	2.9	3.0
	P	0.07	0.45	0.23	0.79	0.52	0.72	0.57	0.97

(f) Relationship between school teacher experience / teacher training location and the scales of teacher efficacy / student engagement

		Teacher efficacy					Student engagement		
		Lecturer Qualities	Relevant Contexts	Scientific Methods	Self-directed Learning	Maximizing Technology	Commitment to Performance	Learning with Excitement	Discovering Meaning
Teacher training	NZ	4.3	3.2	3.5	2.5	3.4	3.6	3.0	3.2
	Other	4.4	3.5	3.8	2.6	3.1	4.0	3.3	3.4
	P	0.12	0.89	0.66	0.44	0.92	0.02	0.66	0.03
Teaching time	0-3 y	4.4	3.1	3.8	2.6	4.0	3.6	2.9	2.9
	4-7 y	4.0	3.1	3.1	2.2	3.2	3.5	3.0	3.4
	8-12 y	4.5	3.3	3.8	2.5	3.1	3.8	3.3	3.3
	13-20 y	4.0	3.3	3.2	2.8	3.1	3.3	3.0	3.0
	≥20 y	4.4	3.4	3.6	2.5	3.4	4.0	3.1	3.3
	P	0.65	0.51	0.47	0.13	0.75	0.74	0.72	0.48

Boxes with a double outline are significantly higher (P<0.05) than other boxes in the column.

P: significance of univariate ANOVA within column

Appendix 5*: Means, standard deviations and frequency of scores for teacher performance / student engagement scales.*

(a) Lecturer Qualities

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.44 (0.57)		4.22 (0.46)		3.27 (0.74)		4.29 (0.34)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	7	1.2	0	0.0	24	6.1	0	0.0
2.1 - 3.0	140	23.8	1	1.8	118	30.1	0	0.0
3.1 - 4.0	363	61.6	14	25.5	189	48.2	5	20.0
4.1 - 5.0	79	13.4	40	72.7	61	15.6	20	80.0

(b) Relevant Contexts

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.11 (0.58)		3.11 (0.83)		2.54 (0.69)		3.24 (0.64)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	21	3.4	6	9.5	112	27.7	2	6.7
2.1 - 3.0	283	46.5	24	38.1	208	51.5	10	33.3
3.1 - 4.0	276	45.3	27	42.9	78	19.3	18	60.0
4.1 - 5.0	29	4.8	6	9.5	6	1.5	3	10.0

(c) Scientific Methods

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.33 (0.59)		3.32 (0.84)		3.32 (0.62)		3.55 (0.69)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	12	2.0	6	9.4	10	2.5	0	0.0
2.1 - 3.0	175	29.1	22	34.4	128	32.3	7	23.3
3.1 - 4.0	354	58.9	23	35.9	215	54.3	15	50.0
4.1 - 5.0	60	10.0	13	20.3	43	10.9	8	26.7

(d) Self-Directed Learning

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	2.69 (0.75)		2.28 (0.87)		2.37 (0.76)		2.48 (0.64)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	138	22.4	29	46.0	167	41.1	12	38.7
2.1 - 3.0	313	50.9	22	34.9	174	42.9	15	48.4
3.1 - 4.0	137	22.3	11	17.5	55	13.5	3	9.7
4.1 - 5.0	27	4.4	1	1.6	10	2.5	1	3.2

(e)Maximising Technology

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.57 (0.65)		3.63 (0.91)		3.09 (0.76)		3.38 (0.70)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	13	2.1	5	8.3	48	11.8	0	0.0
2.1 - 3.0	134	21.9	10	16.7	157	38.6	9	28.1
3.1 - 4.0	348	56.9	24	40.0	169	41.5	20	62.5
4.1 - 5.0	117	19.1	21	35.0	33	8.1	1	3.1

(f) Commitment to Performance

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	4.09 (0.60)		3.51 (0.41)		3.71 (0.77)		3.67 (0.42)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	1	0.2	0	0.0	14	3.6	0	0.0
2.1 - 3.0	37	6.2	7	14.9	59	15.3	0	0.0
3.1 - 4.0	218	36.3	38	80.9	168	43.5	18	78.3
4.1 - 5.0	345	57.4	2	4.3	145	37.6	5	21.7

(g) Learning with Excitement

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.33 (0.65)		2.95 (0.35)		2.82 (0.81)		3.07 (0.40)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	15	2.5	1	2.1	83	20.6	0	0.0
2.1 - 3.0	198	32.7	30	62.5	168	41.7	13	52.0
3.1 - 4.0	312	51.5	17	35.4	127	31.5	11	44.0
4.1 - 5.0	81	13.4	0	0.0	25	6.2	1	4.0

(h) Discovering Meaning

Mean score	University students		University lecturers		School students		School teachers	
Mean (± SD)	3.29 (0.63)		3.00 (0.70)		2.82 (0.75)		3.22 (0.72)	
Mean score	N	%	N	%	N	%	N	%
1.0 - 2.0	20	3.3	5	9.6	74	18.2	2	6.7
2.1 - 3.0	212	34.6	20	38.5	192	47.3	13	43.3
3.1 - 4.0	317	51.7	24	46.2	127	31.3	12	40.0
4.1 - 5.0	64	10.4	3	5.8	13	3.2	3	10.0