Appendix A: What Do We Know About Science? A Summary of Research Evidence about Science Attainment and Engagement in New Zealand

Introduction

During 2008 the Research Division has been working through a programme of research integration which focuses on science. The aim of this work has been to draw together everything we know from current and recent research about science attainment and engagement and from this produce a set of findings and key questions which can contribute to future policy development.

These appendices attempt to summarise the available evidence from a key set of research strands. These include results from international studies as well as findings from internal New Zealand research. Appendix B contains brief summaries of the evidence in relation to paragraphs in the science paper. Appendix C summarises the information present in Appendices E to K by year group while Appendix D summarises the same information by outcome. The main studies used are:

- TIMSS (Trends in International Mathematics and Science Study) – see Appendix E {T}
- PISA (Programme for International Student Assessment) – see Appendix F {P}
- NEMP (National Education Monitoring Project) – see Appendix G {N}
- Competent learners study – see Appendix H {C}
- Transitions study – see Appendix I {Tr}
- Analysis of NCEA data – see Appendix J {NC}
- Findings from the NZCER Primary 2007 national survey – see Appendix K {NS}.

The red code letters following each study are used to identify evidence from the study in the summary which follows. Details of each study, and a brief overview of the relevant findings from the study, are to be found in the relevant appendix.

Dimensions of Analysis

In principle, the research needs to be looked at in at least four different dimensions:

1. School year, grouped as Mid-Primary (Years 4 and 5), Late Primary (Years 7 and 8) and Secondary (Years 9 to 13)
2. Type of outcome, mainly broken down into attainment and engagement
3. Different kinds of factors which may impinge on outcomes, grouped as student and school/class factors
4. Time: changes from cohort to cohort in outcomes or relationships.

Appendix L shows a schematic overview of the data based on the first two dimensions above, with a brief key to some of the abbreviations. However, this is rather cryptic for general use, so this needs to be read in conjunction with the other information.

Each source of evidence is identified by code letters in red, as indexed above.

Appendix B

(1) Relativity to other countries

- TIMSS 2006/07, science, Year 5 students: Significantly lower than 21 out of 36 countries; about the same as 1 out of 36; significantly higher than 13 out of 36 countries. At the primary level, New Zealand students perform significantly lower than all English-speaking countries except Scotland.

- TIMSS 2002/03, science, Year 9 students: Significantly lower than 8 out of 44 countries; about the same as 11 out of 44; significantly higher than 24 out of 44 countries. At the Year 9 level, Singapore and England significantly outperform New Zealand students, but the United States, Australia, and Scotland are about the same.[1]

- PISA 2006, Scientific Literacy, 15-year-olds: Significantly lower than 2 out of 57 countries; about the same as 8 out of 57; significantly higher than 46 out of 57 countries. In scientific literacy at the 15-year-old level, no English-speaking countries outperform New Zealand and only Australia performs similarly, although Singapore does not participate in this assessment.

(2) Information on ranges from the 5th to 95th percentile

- TIMSS Y5: The range of scores for New Zealand was greater than for many other high-performing countries (but less than Singapore). The range decreased from 1994 to 2002, but increased slightly in 2006.

- TIMSS Y9: The range of achievement in New Zealand was comparable to many other countries including Australia, England, Hungary, Scotland, and smaller than the United States and Singapore.

- PISA 2006: The mean range of scores across all the OECD countries was 311[2] score points (range 340 to 652), which is significantly narrower than New Zealand's range. It is important to note that New Zealand's top-performing students contribute to our wide range.

(3) Information on benchmarks and proficiency levels

- TIMSS Y5: Compared with other countries, the proportion of New Zealand students reaching the advanced benchmark (8%) was around the international median (7%) and similar to some of the countries that performed significantly higher than New Zealand. The proportion not reaching the low benchmark (13%) was much larger than the international median (7%).

- TIMSS Y9: Compared with other countries, the proportion of New Zealand students reaching the advanced benchmark (7%) was around the international mean (6%). The proportion not reaching the low benchmark (6%) was much smaller than the international mean (22%) and comparable to the highest performing country, Singapore.

---

1 New Zealand did not administer TIMSS Year 9 in the 2006/07 cycle.

2 Because the results are rounded to the nearest whole number this difference appears inconsistent.

- PISA 2006: New Zealand and Finland had the largest proportion (4%) at the highest level of proficiency. However, proportionally more New Zealand students were at the lowest level (4% below level one), than many of the high-performing countries.

(4) Relative strengths and weaknesses across content and cognitive domains

- TIMSS Y5 2006/07: At the primary level, Year 5 students achieved better at earth science questions and worse at physical science questions (which includes aspects of chemistry and physics). In terms of the cognitive skills students use when they answer questions, Year 5 students achieved better in questions requiring them to apply their scientific knowledge, compared to questions that required reasoning or reproducing knowledge.

- TIMSS Y9 2002: Chemistry is generally an area of weakness relative to other domains.

- NCEA: Biology is the most popular specialist science at years 12 and 13, while physics is the least. However, physics is the specialist science that participants are most likely to attain.

(5) Information on variances between and within schools

- TIMSS Y5 2006/07: Between-school variance around 22% and within-school variance around 78%. Students from higher decile schools had higher scores on average than those from lower decile schools.

- TIMSS Y9 2002: Because of the type of sampling, this type of analysis is not meaningful as variation between classes cannot be separated out from variations between schools.

- PISA 2006: Between school variance around 7% and within school variance around 93%.

- NEMP: Between school variance around 23% and within school variance around 77%. Students from higher decile schools had higher scores on average than those from lower decile schools.

(6) Information on ethnic differences

- NEMP Y4: Pākehā/European students performed on average higher than Māori and Pasifika students. Māori and Pasifika students performed most similarly to Pākehā/European students on tasks that involved practical work and a team approach.

- TIMSS Y5: Māori (459) and Pasifika (431) perform significantly lower than Pākehā/European (528) and Asian (529). The proportion of students reaching the advanced benchmark for Pākehā/European (10%) and Asian (14%) were higher than Māori (2%) and Pasifika (1%). The proportion of students not reaching the lowest benchmark for Pasifika (36%) and Māori (24%) were higher than Asian (8%) and Pākehā/European (7%). The ethnic composition of the group of students below the low benchmark (13% overall) was Pākehā/European (4.1%), Māori (4.6%), Pasifika (3.6%), Asian (0.5%), and Other (0.5%).

- NEMP Y8: Māori and Pasifika performed significantly lower than Pākehā/European 1999 – 2007. Māori, Pasifika, Pākehā/European most similar on “practical” tasks that do not require prior knowledge.

- TIMSS Y9 2002: Māori (487) and Pasifika (465) perform significantly lower than Pākehā/European (540) and Asian (543). The proportion of students reaching the advanced benchmark for Pākehā/European (10%) and Asian (8%) were higher than Māori (2%) and Pasifika (1%). The proportion of students not reaching the low benchmark for Pasifika (16%) and Māori (12%) were higher than Asian (3%) and Pākehā/European (2%).

- PISA 2006: The means for Pākehā/European (554) and Asian (541) were higher than Māori (480) and Pasifika (454). The proportion of students reaching the highest proficiency level for Pākehā/European (5%) and Asian (6%) were higher than Māori (1%) and Pasifika (1%). The proportion of students not reaching the lowest proficiency level for Pasifika (13%) and Māori (8%) were higher than Asian (5%) and Pākehā/European (1%).

(7) Information on differences among students from non-English speaking homes

- TIMSS Y5 2006/07: Those with low use of English in the home tend to have weaker performance relative to those who mainly use English at home.

- NEMP both Y4 and Y8: Those with low use of English in the home tend to have weaker performance relative to those who mainly use English at home.

- TIMSS Y9 2002: Those who spoke English at home regularly had higher achievement than those that did not. The difference in achievement related to home language decreased over the period 1994 – 2002 although the difference was still significant.

(8) Gender differences

- TIMSS Y5 2006/07: The mean science score for both girls and boys was not significantly different. Proportionally more boys (15%) than girls (11%) did not reach the lowest benchmark. In the content areas, girls were higher than boys in *life science*, boys higher than girls in *earth science* and both equal in *physical science*.

- NEMP both Y4 and Y8: Little difference between boys and girls in overall performance.

- TIMSS Y9 2002: No significant overall difference between boys and girls. Similar proportions of boys (5%) and girls (6%) did not reach the lowest benchmark. Gender differences in sub-domains show boys better at *earth science* and *physical science* and girls better at *life science*.

- PISA 2006: Girls and boys showed similar mean scientific literacy performance and girls were as likely to achieve the highest level of scientific literacy as boys. More New Zealand boys (15%) than girls (12%) demonstrated low levels of proficiency (Level 1 and below). At secondary level, boys outperform girls in earth and space systems and physical systems while girls and boys are about the same on living systems.

(9) Gender differences on cognitive skills

- TIMSS Y5 2006/07: New Zealand Year 5 students achieved relatively better in the *applying* domain, compared to *knowing* or *reasoning*. Girls were better than boys at the *reasoning* tasks; there was no difference in *knowing* or *applying*.

(10) Trends at the primary level in NEMP

- NEMP Y4 1995, 1999, 2003, 2007: Little change in overall performance between 1995 and 2007. Small decline in *physical* and *material world* compared with *living world* and *planet earth and beyond*, which stayed constant

- NEMP Y8 1995, 1999, 2003, 2007: Little overall change in science performance 1995 to 2007. Small decline in *physical* and *living world* compared with *material world*, which stayed constant

(11) Trends at the primary level in TIMSS

- TIMSS Y5 1994, 1998, 2002, 2006: For New Zealand Year 5 students there was a substantial increase in science scores between 1994 and 2002 (17 scale score points - ssp) which was offset by a decline between 2002 and 2006 (18 ssp). In 2002, the growth since 1994 in mean science achievement was largely attributable to the growth amongst Māori and Pasifika students. The results for 2006 show a large drop for these two groups since 2002, back to approximately 1994 levels. In contrast, Pākehā/European students have remained relatively stable over time, while scores for Asian students have increased.

(12) Trends at the secondary level

- TIMSS Y9 1994, 1998, 2002: No significant change in mean score from 1994 to 2002.

- NCEA 2004, 2005, 2006: The average number of science learning area standards gained per student has increased at NCEA level 1 and 2 but decreased at NCEA level 3 from 2004 to 2006. Thus in 2006, lower proportions of students are gaining science standards at the higher levels needed for tertiary study.

- PISA 2006: No trend data available.

(13) Attitudes to science in terms of enjoyment and interest

- TIMSS Y5: 75% of students indicate strong positive attitudes towards science (e.g. enjoy science).

- TIMSS Y9: 71% of students agreed that they enjoy learning science. \

- Competent Learners Study: Science and mathematics were the least enjoyed classes at age 16 (Years 11 and 12)

(14) Self-confidence in science

- TIMSS Y5: 50% of students indicate high level of self-confidence for science. There was no difference between girls and boys when self-confidence in learning science is compared.

- TIMSS Y9: 41% had high self-confidence about learning science. 36% of girls and 46% of boys were ‘high’ on the self-confidence in learning science index.

- PISA: More than half were positive about statements on how good they believe they are at science. Self-efficacy is higher for males.

(15) Link between achievement and attitudes to science

- TIMSS Y5: Those students who reported positive attitudes towards science (23 ssp higher than those in the most negative group on the scale) or were confident in their own science abilities (66 ssp higher than those in the most negative group on the scale) had higher achievement than those who were less positive or confident.

- TIMSS Y9: Those students who reported positive attitudes towards science (37 ssp higher than those in the most negative group on the scale) or were confident in their own science abilities (59 ssp higher than those in the most negative group on the scale) had higher achievement than those who were less positive or confident.

- PISA: Higher engagement (enjoyment, interest, motivation) associated with higher achievement. Self-efficacy the strongest relationship.

(16) Ethnic differences in attitudes to science

- TIMSS Y5: Self-efficacy higher for Pākehā (55%), than for Asian (46%), Māori (44%), and Pasifika (42%).

- TIMSS Y9: Asian students were more likely than other ethnic groups to be in the 'high' group in terms of self-confidence (54%).

- PISA 2006: Māori and Pasifika reported lower self-efficacy than Pākehā, who in turn were lower than Asian. Pasifika and Asian expressed higher enjoyment than Pākehā.

(17) Science instruction

- NEMP: Most students liked doing science at school and 71% would like to do more science. There was a reduction in percentages saying they did interesting things in science. There was an increase in percentage saying they had limited opportunities to learn science at school. There were increases in the percentages saying they did science in their own time, wanted to keep learning science, and wanted more science at school.

- TIMSS Y5: New Zealand students had a decrease in the proportion of time spent on science instruction per week from 7 percent to 5 percent. As another measure there was a decrease in the number of yearly hours from 66 hours in 2002 to 45 hours in 2006, a drop of nearly one third.

- NZCER: Of 196 primary principals surveyed, just 2% named science as a curriculum emphasis in 2007, compared with 69% for mathematics, 68% for reading, and 60% for writing. The arts had 6% expressing it as a curriculum emphasis while social studies had only 3%.

(18) Science instruction

- Transitions: Indication that Year 8 students were more likely than they were the following year (Year 9) to say that science was "fun", especially when they could do special projects or be challenged by competitions such as a science fair. Related to this, it seemed that primary teachers may have had a greater emphasis on making science fun and linking it to other aspects of the curriculum and everyday life and to give (some) students more freedom/autonomy in their research projects (compared to what some students in year 9

reported). Some secondary teachers said they have to get students to "unlearn" bad science "habits" they learned at primary school and to ensure they teach students the basic concepts of science. That is why they emphasise a lot of copying work – to get formulae etc across to the students and this then delays the experiments that students expect and want. This meant that some students become bored and turned off science (especially in the lower achieving classes).

Appendix C: Summary of evidence by year group

Mid-Primary (Years 4 and 5) — Achievement

Latest results (TIMSS 2006 results and NEMP 2007):

- New Zealand's mean was not significantly different from the IEA mean (500) {T}
- 21 other countries had mean scores significantly higher than New Zealand's {T}
- The range of scores was greater than for many other high-performing countries {T}
- There was no overall boy/girl difference {T} {N}
- There were lower scores in physical science than in earth science and life science {T}
- Boys out-perform girls in earth science, while girls out-perform boys in life science; there was no difference in physical science {T}
- New Zealand students did better in applying, compared with knowing or reasoning {T}
- Girls out-performed boys in reasoning, with no differences for knowing or applying {T}
- Pākehā and Asian students out-performed Māori and Pasifika on average {T} {N}
- Those with a high use of English in the home tended to out-perform those with a low use of English in the home {T} {N}
- Students from higher decile schools had higher scores on average than those from lower decile schools {T} {N}

Change over time (TIMSS 1994 to 2006; NEMP 1995 to 2007):

- A substantial rise in performance from 1994 to 2002 was offset by an equivalent drop from 2002 to 2006 {T}
- Little overall change in overall performance between 1995 and 2007 {N}
- Small decline in physical and material world compared with living world and planet earth and beyond, which stayed constant {N}
- The range of scores decreased from 1994 to 2002, but increased slightly in 2006 {T}
- The difference between boys and girls has remained non-significant throughout {T} {N}
- Pākehā performance remained static between 1994 and 2006, whereas Asian performance increased {T}

Mid-Primary (Years 4 and 5) — Engagement

Latest results (TIMSS 2006 results and NEMP 2007):

- 75% of students had a positive attitude to science, and 50% had high self-confidence {T}
- There were no ethnic differences in science enjoyment, but Māori had lower self-efficacy than Pākehā {T}
- There were no differences in enjoyment and self-efficacy according to home language {T}
- There was little use of textbooks, but a high use of computers to retrieve science information {T}
- Māori were less likely than Pākehā to say they visited science activities and did experiments with everyday things, but more likely to say they did group work {N}
- Pasifika were more likely than Pākehā to say they did group work and experiments with everyday things {N}
- Students from low decile schools were more likely to say they went on field trips {N}

Change over time (TIMSS 1994 to 2006; NEMP 1995 to 2007):

- Reduction by one-third in teaching time devoted to science {T}
- Reduced percentages saying they do interesting things in science, and learn a lot of science in school {N}
- Increased percentages saying they did science in their own time, wanted to keep learning science, and wanted more science at school {N}

Late Primary (Years 7 and 8) — Achievement

Latest results (NEMP 2007):

- Little difference between boys and girls in overall performance {N}
- Pākehā and Asian students out-performed Māori and Pasifika on average {N}
- Those with a high use of English in the home tended to out-perform those with a low use of English in the home {N}
- Students from higher decile schools had higher scores on average than those from lower decile schools {N}

Change over time (NEMP 1995 – 2007):

- Little overall change in overall performance between 1995 and 2007 {N}
- Small decline in physical and living world compared with material world and planet earth and beyond, which stayed constant {N}
- The difference between boys and girls has remained non-significant throughout {N}

Late Primary (Years 7 and 8) — Engagement

Latest results (NEMP 2007 and Transitions project):

- Pākehā students were less likely to say they went on field trips or did research projects {N}
- Māori students were less likely to say they did experiments with everyday things, while Pasifika students were more likely to say this {N}
- Auckland students more positive about keep learning science than other regions {N}
- Students in Year 8 were more likely than they were next year (Year 9) to say that science was 'fun' {Tr}
- More freedom/autonomy in primary science than in secondary {Tr}

Change over time (NEMP 1995 – 2007):

- Decline in proportions saying they like science, do fun stuff, learn about science, would make a good scientist, and do group work {N}
- No change in science self-efficacy or desire to keep learning about science {N}
- Using science equipment (low decile students) – proportion at both low and high end had increased {N}

Secondary (Years 9, 10 and 11) — Achievement

Latest results (TIMSS 2002, PISA 2006, and NCEA analysis 2004 – 2006):

- New Zealand performed significantly above the OECD mean in scientific literacy, with only two countries significantly higher {P}
- Compared with other high-performing countries, New Zealand had a wider spread of students' scores, both above and below the mean {P}
- Students from higher decile schools had higher scores on average than those from lower decile schools {P}
- New Zealand performed significantly above the international mean {T}
- There was no overall difference between boys and girls {T}
- Boys did significantly better at earth science and physics, and girls did better at life science {T}
- Chemistry was generally an area of weakness relative to other domains {T}
- Māori and Pasifika performed significantly lower than Pākehā and Asian students {T}
- Mari boys achieved higher scores than Māori girls on average {T}
- Year 11 science achieved by around 60% of participants {NC}

- Biology is the most popular subject, with physics least {NC}

Change over time (TIMSS 1994 – 2002, NCEA analysis 2004 – 2006):

- No significant change in overall mean score {T}
- Physics showed a significant improvement {T}
- Significant increase for Asian and Pasifika students {T}
- Unit standards gaining credit increased, especially at Level 1 {NC}
- The number of externally assessed achievement standards results has decreased at Level 3 across all domains {NC}

Secondary (Years 9, 10 and 11) — Engagement

Latest results (TIMSS 2002, PISA 2006, NCEA Analysis 2004 – 2006, Competent Learners Study, and Transitions Study):

- Higher engagement and self-efficacy linked to achievement {P}
- Science enjoyment linked to future science motivation {P}
- Self-efficacy higher for males {P}
- Self-efficacy lower for Māori females and Pasifika, and higher for Asian, than Pākehā {P}
- Science enjoyment higher for Pasifika and Asian than Pākehā {P}
- More than half of students were positive about their science self-efficacy {P}
- Most students agreed that schools provide useful preparation for science careers {P}
- Students said it was less important to do well in science than in mathematics and English {P}
- Decile positively linked to self-efficacy but negatively to science enjoyment {P}
- Around 40% of students scored ‘high’ on valuing science and self-confidence in learning science {T}
- Asian students more likely than others to be ‘high’ on self-confidence {T}
- Science (with mathematics) least enjoyed class {C}
- 25% said they did not like science {C}
- Science teachers less likely to identify ‘having fun’ and ‘group activities and discussion’ as lesson features {C}

- Year 9 teachers said they had to help students 'unlearn' bad science from primary school, leading to more copying of formulae etc. and hence boredom among students in secondary science {Tr}

Change over time (TIMSS 1994 – 2002, NCEA analysis 2004 – 2006):

- Enjoyment of science increased significantly {T}
- Reduction Level 3 participation in NCEA {NC}

Appendix D: Summary of Evidence by Outcomes

Achievement

- New Zealand close to International mean at primary, but amongst highest performing countries at secondary
- The range of achievement (high and low) is greater than most other high-performing countries at both primary and secondary
- Overall there is no significant difference between boys and girls
- Boys tend to do better at earth science, and girls at life science, across year groups
- Māori and Pasifika students tend to under-perform on average relative to Pākehā and Asian students, but there is still a wide overlap in the distributions of achievement for different ethnic groups
- Students in high decile schools tend to perform better on average than those in low decile schools
- Little evidence of significant changes over time in achievement, except for a rise in the performance of Asian students
- However, there has been a rise in achievement at NCEA level 1, coupled with a fall at Level 3

Engagement

- Largely positive attitudes at primary, in terms of enjoyment and self-efficacy
- Attitudes more mixed at secondary, with a significant minority disliking science
- Evidence of more 'fun' in primary science, which changes at secondary to more routine and boring work
- However, proportions of primary students saying they do interesting things in science has fallen
- Reduction by one-third in primary science teaching time, and indications of science having low priority at primary
- Rise in percentage saying they enjoyed science at secondary
- Secondary Pasifika and Asian students are more likely than Pākehā to say they enjoy science
- Primary Māori students tend to have lower self-efficacy then Pākehā

- At secondary, Māori females and Pasifika tend to have lower self-efficacy than Pākehā, while Asian students are higher on average

- Reduction in proportions taking science at NCEA Level 3

Appendix E: TIMSS Science Results

Year 5 2006 Achievement

- The mean science achievement of Year 5 students in 2006 was 504. This score was not significantly different from the TIMSS Scale Average, fixed at 500. This was significantly lower than 21 of the countries that participated at the grade four level in TIMSS.

- The range of scores (5%-95%) for New Zealand was higher than for many other high-performing countries (but less than Singapore). The range decreased from 1994 to 2002, but increased slightly in 2006.

- For New Zealand Year 5 students there was a substantial increase in science scores between 1994 and 2002 (17 ssp) which was offset by a decline between 2002 and 2006 (18 ssp).

- The mean science score for both girls and boys was not significantly different. The decrease in scores between 2002 and 2006 occurred for both boys and girls.

Benchmarks

- Trends in proportions of students at each of the advance and low benchmarks are as follows
  2007: Advanced 8%, low 87%;
  2002: Advanced 9%, low 87%;
  1994: Advanced 11%; low 85%.
  This represents a significant drop at the advanced benchmark since 1994; other benchmarks only show a significant drop since 2002, not significant since 1994.

- Compared with other countries, the proportion of students reaching the advanced benchmark (8%) was around the international median (7%) and similar to some of the countries that performed significantly higher than New Zealand. The proportion not reaching the low benchmark (13%) was much larger than the international median (7%).

Domains

- New Zealand Year 5 students achieved relatively less well in the physical science domain compared with life science and earth science; earth science was the highest, and both life science and earth science were above the international scale average.

- In the content areas, girls were higher than boys in life science, boys higher than girls in earth science and both equal in physical science.

- New Zealand Year 5 students achieved relatively better in the applying domain, compared to knowing or reasoning. Girls were better than boys at the reasoning tasks; there was no difference in knowing or applying.

Ethnicity

- Māori and Pasifika significantly lower than Pākehā and Asian

- In 2002, the growth since 1994 in mean science achievement was largely attributable to the growth amongst Māori and Pasifika students. The results for 2006 show a large drop for these two groups since 2002, back to approximately 1994 levels. In contrast, Pākehā/European students have remained relatively stable over time, while scores for Asian students have increased.

- The proportion of students reaching the advanced benchmark for Pākehā/European (10%) and Asian (14%) were higher than Māori (2%) and Pasifika (1%). The proportion of students not reaching the lowest benchmark for Pasifika (36%) and Māori (24%) were higher than Asian (8%) and Pākehā/European (7%).

- The ethnic composition of the group of students below the low benchmark (13% overall) was Pākehā/European (4.1%), Māori (4.6%), Pasifika (3.6%), Asian (0.5%), and Other (0.5%).

Home language

- Those with low use of English in the home tend to under-perform relative to those who mainly use English at home

School factors

- Students from higher decile schools had higher scores on average than those from lower decile schools

Year 5 2006 Engagement

- Overall: no change 1994 – 2002

- 75% of students indicate strong positive attitudes towards science (e.g. enjoy science)

- 50% of students indicate high level of self-confidence for science

- Those students who reported positive attitudes towards science or were confident in their own science abilities had higher achievement than those who were less positive or confident.

- New Zealand, along with Australia and Hong Kong SAR, had one of the highest proportions of immigrants compared to other countries. No significant change since 2003 here though.

- In comparison to other countries, but similar to Australia, England, Scotland, Singapore, and the United States, New Zealand students reported a relatively large number of books could be found in their homes.

- The use of computers at school appears to be dropping according to student responses.

- An increase in the students at the high level of the self-confidence in learning science index (15 pp increase) but only 4 countries with lower proportions. Note there was no change in the positive affect towards science index.

- There was no difference between girls and boys when self-confidence in learning science is compared.

Ethnicity

- No ethnic differences in science enjoyment

- Self-efficacy higher for Pākehā (55%), than for Asian (46%), Māori (44%), and Pasifika (42%).

Home language

- No differences related to language in the home.

School factors

- New Zealand students had a decrease in the proportion of time spent on science instruction per week from 7 percent to 5 percent. As another measure there was a decrease in the number of yearly hours from 66 hours in 2002 to 45 hours in 2006, a drop of nearly one third.

- New Zealand teachers, along with Australia, Scotland and Alberta Canada reported very little use of textbooks.

- Computers were used most often in New Zealand classrooms to look up information (38% of the students were in classes were they were used in this way about half of the lessons or more). The proportion was the second highest behind Dubai.

- The English-speaking countries had a relatively high use of parents for fund-raising compared to other countries in the study.

- The proportion of students in schools where principals reported that resource shortages do not adversely affect the school's capacity to provide instruction has increased (up 19%).

- New Zealand was one of the countries with a high level of teacher development in the last few years. However as this figure included both maths and science development, the focus on the numeracy project will be influencing this so we need further analysis of this for reporting.

- Relative to other countries, more New Zealand students were in schools where the principals perceived that the school climate was good. Similarly, the teachers' perceptions of school climate were high.

- There has been no change since previous cycles in the low proportion of New Zealand students who express high positive feelings of being safe in school.

Year 9 2002 Achievement

- New Zealand's performance was significantly higher than the international mean

- No significant change in mean score from 1994 to 2002

- The range of achievement in New Zealand was comparable to many other countries including Australia, England, Hungary, Scotland, and smaller than the United States and Singapore.

- Trends in proportions of students at each of the advance and low benchmarks are as follows
  2002: Advanced 7%, low 94%;
  1998: Advanced 10%, low 88%;
  1994: Advanced 9%; low 89%.
  This represents a significant increase at the low benchmark since 1994 and 1998; the intermediate benchmark also shows a significant increase since 1994 and 1998. The other benchmarks showed no significant change.

- Compared with other countries, the proportion of students reaching the advanced benchmark (7%) was around the international mean (6%). The proportion not reaching the low benchmark (6%) was much smaller than the international mean (22%) and comparable to the highest performing country, Singapore.

- No significant overall difference between boys and girls

- Gender differences in sub-domains (boys better at Earth science and Physical science and girls better at life science)

- Chemistry generally area of weakness relative to other domains

- Physics shows an improvement over time

Ethnicity

- No change for Pākehā 1994 – 2002

- Significant increases in the performance of Asian and Pasifika students 1994 - 2002

- Māori and Pasifika significantly lower than Pākehā and Asian

- The proportion of students reaching the advanced benchmark for Pākehā/European (10%) and Asian (8%) were higher than Māori (2%) and Pasifika (1%). The proportion of students not reaching the low benchmark for Pasifika (16%) and Māori (12%) were higher than Asian (3%) and Pākehā/European (2%).

- Māori boys achieved higher scores than Māori girls on average

Home language

- Those who spoke English at home had higher achievement than those that did not. The difference in achievement related to home language decreased over the period 1994–2002 although the difference was still significant.

Year 9 2002 Engagement

- 71% of students agreed that they enjoy learning science and 41% had high self-confidence about learning science.
- 36% of girls and 44% of boys scored 'high' on the 'valuing science' index.
- There was a positive shift in students' enjoyment of science from 1994 to 1998, with 11 percentage points more agreeing in 2002 that they enjoyed learning science a lot.
- The increase in science enjoyment was the same for all ethnic groups
- 36% of girls and 46% of boys scored 'high' on the self-confidence in learning science index.
- Asian students were more likely than other ethnic groups to be in the 'high' group in terms of self-confidence (54%)

Appendix F: PISA 2006

15 year olds 2006 Achievement

- Overall, New Zealand's 15-year-old students performed very strongly in scientific literacy (see Figure 2).

- Of the 57 countries participating in PISA 2006, only two countries, Finland (563) and Hong Kong-China*[3] (542), achieved a significantly better performance than New Zealand.

- The mean performance of New Zealand students (530) is statistically similar to eight other countries: Canada (534), Chinese Taipei* (532), Estonia* (531), Japan (531), Australia (527), the Netherlands (525), Liechtenstein* (522) and Korea (522).

- New Zealand students' mean performance is statistically better than the 46 other countries participating in PISA, including the United Kingdom (515), the United States of America (489) and the 21 other OECD countries.

- Compared with the 10 other high-performing[4] countries, New Zealand has the widest spread of science scores (352 score points) between the 5th and 95th percentile (range 347 to 699).

- The mean range of scores between the 5th and 95th percentile across all the OECD countries was 311[5] score points (range 340 to 652), which is significantly narrower than New Zealand's range. However, it is important to note that New Zealand's top-performing students contribute to this wide range.

- New Zealand and Finland had the largest proportion at the highest level of proficiency. However, more New Zealand students were at the lowest level, below level one, than many of the high-performing countries.

- Girls and boys showed similar mean scientific literacy performance, and girls were as likely to achieve the highest level of scientific literacy as boys.

- The means for Pākehā/European (554) and Asian (541) were higher than Māori (480) and Pasifika (454).

- The proportion of students reaching the highest proficiency level for Pākehā/European (5%) and Asian (6%) were higher than Māori (1%) and Pasifika (1%). The proportion of students not reaching the lowest proficiency level for Pasifika (13%) and Māori (8%) were higher than Asian (5%) and Pākehā/European (1%).

---

[3] * Denotes a non-OECD country, referred to as a partner country or economy.

[4] 'High-performing countries' refers to the two countries that achieved significantly higher than New Zealand and the eight countries that were not statistically different from New Zealand on the *combined scientific literacy* scale.

[5] Because the results are rounded to the nearest whole number this difference appears inconsistent.

15 year olds 2006 Engagement

- Future science motivation links strongly to enjoyment and slightly to self-efficacy:
- Self-efficacy higher for males
- Māori (females) lower self-efficacy than Pākehā
- Pasifika lower self-efficacy than Pākehā
- Asian higher self-efficacy than Pākehā
- Pasifika higher enjoyment than Pākehā
- Asian higher enjoyment that Pākehā
- Higher engagement (enjoyment, interest, motivation) associated with higher achievement.
- More than half positive about statements on how good they believe they are at science
- Most New Zealand students agreed that schools provide useful preparation for science-related careers — this was particularly true of high-performing students
- High achieving students were generally those studying science
- Less important to do well in science than in mathematics and English
- Decile positively linked to self-efficacy but negatively to science enjoyment
- Ability grouping used regularly to provide instruction based on needs of pupils (compare other countries)
- Most 15 year olds were enrolled in some form of science education, and most commonly were in a course for 4 hours a week or more.
- Interactive teaching activities were most frequently used in science
- Most 15 year olds were enrolled in schools that held activities to promote science (e.g. competitions, excursions, field trips)
- Where principals reported teacher and resource shortages impact on instruction – these schools generally had lower science achievement.

Appendix G: NEMP 2007 Science Results

Year 4 Achievement

- Little overall change in overall performance between 1995 and 2007
- Little overall difference between boys and girls

Domains

- Small decline in physical and material world compared with living world and planet earth and beyond, which stayed constant

Ethnicity

- Pākehā students performed on average higher than Māori and Pasifika students
- Māori and Pasifika students performed most similarly to Pākehā students on tasks that involved practical work and a team approach

Home language:

- Those with low use of English in the home tend to under-perform relative to those who mainly use English at home

School factors

- Students from higher decile schools had higher scores on average than those from lower decile schools

Year 4 Engagement

- Most liked doing science at school and 71% would like to do more science
- Reduction in percentages saying they did interesting things in science
- Increase in percentage saying they had limited opportunities to learn science at school
- Increase in percentages saying they did science in their own time, wanted to keep learning science, and wanted more science at school

Ethnicity

- Māori less likely to visit science activities and do experiments with everyday things
- Māori more likely to do group work
- Pasifika more likely to do group work and do experiments with everyday things

School factors

- Students from lower decile schools were more likely to go on field trips

Year 8 Achievement

- Little overall change in science performance 1995 to 2007
- Little difference between boys and girls in overall performance

Domains

- Living World: 1 percentage point decline 2003 to 2007 in trend tasks
- Physical World: 1 percentage point decline 2003 to 2007 in trend tasks
- Material World: No change in trend tasks 2003 to 2007.

Ethnicity

- Māori and Pasifika significantly lower than Pākehā 1999 – 2007
- Māori, Pasifika, Pākehā most similar on "practical" tasks that do not require prior knowledge.

Home language:

- Those with low use of English in the home tend to under-perform relative to those who mainly use English at home

School factors

- Students from higher decile schools had higher scores on average than those from lower decile schools

Year 8 Engagement

- Percentages enjoying science and saying they learned about science declined significantly
- There were significant declines in the percentages saying they did experiments with everyday things or science equipment, took part in science competitions, did group work, did good things in science, or would make a good scientist
- No change in science self-efficacy or desire to keep learning about science
- Auckland students were more positive about keep learning about science than in other regions

Ethnicity

- Pākehā students were less likely to have field trips and do research projects
- Māori students were less likely to do experiments with everyday things
- Pasifika students were more likely to do experiments with everyday things

School factors

- Lower decile students on using science equipment – proportion at both the low and the high ends had increased

Appendix H: Competent Learners Study

- Māori and Pasifika students were more likely to be taking "contextual" or "vocational" courses (i.e. no science subjects) and less likely to be taking "academic" subjects[6]

- Boys more likely to be taking "contextual" or "vocational" subject combinations while girls were more likely to be taking "academic" science combinations.

- Science and mathematics were the least enjoyed classes at age 16 (Years 11 and 12)

- 25% said they did not like science

- Teachers of science (and mathematics) were less likely than teachers of other subjects to identify features of learning in class such as "we have lots of fun" and "students do a lot of group activities and discussions".

[6] Caution about very small numbers of Māori and Pasifika students in this study

Appendix I: Transitions Study

- Indication that Year 8 students were more likely than they were the following year (Year 9) to say that science was "fun", especially when they could do special projects or be challenged by competitions such as a Science Fair.

- Related to the above, it seemed that primary teachers may have had a greater emphasis on making science fun and linking it to other aspects of the curriculum and everyday life and to give (some) students more freedom/autonomy in their research projects (compared to what some students in year 9 reported).

- Some teachers said they have to get students to "unlearn" bad science "habits" they learned at primary school and to ensure they teach students the basic concepts of science. That is why they emphasise a lot of copying work – to get formulas etc across to the students and delay the experiments that students expect and want. This meant that some students become bored and turned off science (especially in the lower achieving classes).

Appendix J: Analysis of NCEA Data

Background

As part of the Ministry of Education's NCEA programme it is necessary to identify 'at risk' NCEA areas/domains so that professional development can be most effectively and appropriately utilised in these areas.

The participation and achievement of students within the differing NCEA areas, and most importantly the change in participation and achievement over time will give an indication of the areas most in need of professional development, with the aim to increase participation and achievement in the identified areas.

The purpose of this report is to provide an overview of participation and achievement in the different domains within the science learning area between 2004 and 2006, across all NCEA levels.

Points to Note

It is not possible to work out the total number of standards attempted by NCEA candidates in any domain because internally assessed achievement standards and unit standards do not report the number of standards that did not gain credit.

Internally assessed achievement standards do not report "not achieved" (NA) grades but they do report the number of "achieved' (A), "merit' (M) and "excellence" (E) grades. Externally assessed achievement standards report all NA, A, M and E grades.

A large majority of students undertaking NCEA are years 11 to 13 students. Between 2004 and 2006, the numbers of years 11 to 13 students on the school roll have increased, so it is logical to assume that the total number of results in any domain would increase accordingly.

In each subject[7], the participation and attainment of candidates[8] based on credits looks at two measures:

- Candidates who participate in a subject; defined as gaining at least one credit (at any level) in the subject; and
- Candidates who achieve in a subject; defined as gaining at least 14 credits within the year, at a typical level or higher.[9]

Analysis is done on an individual subject basis. Candidates may participate in more than one subject. They are counted once for each subject. Scholarship is excluded.

[7] Subject list supplied by Demographic and Statistical Analysis Unit

[8] A candidate is a student who has gained at least one credit (in any subject) on the National Qualifications Framework (NQF) in that year

[9] The typical level of study for year 11 candidates is level 1, for year 12 it is level 2 and for year 13 it is level 3

Findings

This report includes the most recent data from 2004 to 2006 on the major science domains within the science learning area. The key findings are:

- Large proportions of candidates take (80 %), and hence large numbers of standards results are reported in year 11 science, where science is compulsory at the majority of schools. Year 11 science is achieved by around 60 % of participants.

- The average number of science learning area standards gained per student has increased at NCEA level 1 and 2 but decreased at NCEA level 3 from 2004 to 2006. Thus in 2006, lower proportions of students are gaining science standards at the higher levels needed for tertiary study.

- The number of unit standards results gaining credit has increased in every science domain studied in this report at each NCEA level, especially NCEA level 1. Across the science learning area unit standards results made up 16 % of the total number of results in 2004, by 2006 they made up 25 % of results.

- The number of externally assessed achievement standards results has decreased at NCEA level 3 across all science domains in this report since 2004.

- Participation in the three main individual science areas (biology, chemistry and physics) has decreased in year 13 since 2004. Physics has the largest decrease at three percentage points since 2004, but between 2005 and 2006 participation rates have remained constant.

- The number of candidates studying agricultural and horticultural science, and the number of standards results reported has decreased at each NCEA level since 2004. In 2006, only 4 % of year 11, 2 % of year 12 and 1 % of year 13 candidates participated in agricultural and horticultural science.

- In 2006, 42 % of year 13 agricultural and horticultural science participants achieved agricultural and horticultural science (at least 14 credits), thus only around 150 year 13 students attain agricultural and horticultural science.

- Biology is the most popular specialist science at years 12 and 13.

- Participation in biology has remained stable at years 12 and 13 over the last three years, but the number of standards results reported, and gaining credit, has increased at each NCEA level for biology since 2004. This has resulted in an increase in the attainment of participants since 2004.

- In 2006, physics had the lowest participation rates of the three specialist science subjects (biology, chemistry and physics) in year 12 and 13 at 22 % and 19 % respectively. However, physics is the specialist science that participants are most likely to attain. This higher attainment rate has meant that in 2005 and 2006 more students gained physics (at least 14 credits) than chemistry in years 12 and 13.

- In 2006, approximately 5,300 fewer standards results were reported at NCEA level 3 in the domain of physics compared to 2004. This is the largest decrease across the domains and is due to the decrease in participation of year 13 candidates.

- Participation in chemistry has decreased slightly at years 12 and 13 over the last three years. Since 2004 approximately 500 fewer year 12 students attain chemistry, this is due to a decrease in participation and attainment. Even though participation at year 13 has decreased since 2004 around 500 more year 13 students attain chemistry due to increased attainment rates.

- The number of earth science results is lowest across all science domains studied. However, since 2004 the number of earth science results at NCEA level 1 has nearly doubled.

- Attainment rates of year 13 participants in the individual sciences have generally increased since 2004 but due to lower participation rates over this time period, the proportion of year 13 students gaining a science subject at NCEA level 3 has decreased slightly.

Appendix K: NZCER Primary 2007 National Survey

- Of 196 primary principals surveyed, just 2% named science as a curriculum emphasis in 2007, compared with 69% for mathematics, 68% for reading, and 60% for writing. Even the arts had 6% expressing it as a curriculum emphasis.

Appendix L: Schematic Summary Table

Studies

T	TIMSS
N	NEMP
P	PISA
NC	NCEA
C	Competent learners
Tr	Transitions study

Gender

B	Boys
G	Girls

Symbols

~	No change over time
▲	Significant increase over time
▼	Significant decrease over time

Sub-domains

P	Physical science/physical & material world
E	Earth science/earth & beyond
L	Life science
C	Chemistry

Ethnicity

Pak	Pakeha
M	Maori
Pas	Pasifica
A	Asian

Science activities & attitudes

DFS	Doing fun stuff
DSOT	Doing science in own time
EET	Experiments with everyday things
FT	Field trips
GW	Group work
KLS	Keep learning about science
LAS	Learning about science
LS	Liking science
MGS	Would make a good scientist
MSS	Would like more science at school
RP	Research projects
USE	Using Science Equipment
VSA	Visit science activities