NMSSA • CYCLE 2

NMSSA Report 18 : TECHNICAL INFORMATION 2017 – Health & Physical Education • Science

Wānangatia te Putanga Tauira
National Monitoring Study of Student Achievement

Technical Information 2017

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and
New Zealand Council for Educational Research

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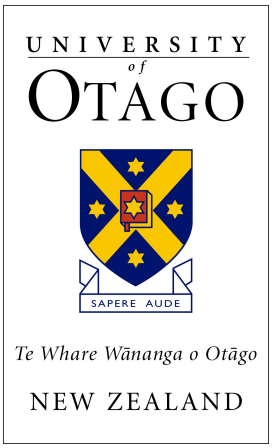

Technical Information 2017 Health and Physical Education, Science
(all available online at http://nmssa.otago.ac.nz/reports/index.htm)

National Monitoring Study of Student Achievement Report 18: Technical Information 2017 – Health and Physical Education, Science
published by Educational Assessment Research Unit, University of Otago, and New Zealand Council for Educational Research
under contract to the Ministry of Education, New Zealand

ISSN: 2350-3238 (Online) ISBN: 978-1-927286-45-6 (Online only)

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Contents

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Acknowledgements

The NMSSA project team wishes to acknowledge the very important and valuable support and contributions of many people to this project, including:

- members of the reference groups: Technical, Māori, Pacific and Special Education
- members of the curriculum advisory panels in learning languages and technology
- Principals, teachers and students of the schools where the tasks were piloted and trials were conducted
- principals, teachers and Board of Trustees' members of the schools that participated in the 2017 main study including the linking study
- the students who participated in the assessments and their parents, whānau and caregivers
- the teachers who administered the assessments to the students
- the teachers and senior initial teacher education students who undertook the marking
- the Ministry of Education Research Team and Steering Committee.

Appendix 1:
Sample Characteristics for 2017

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Samples for 2017

A two-stage sampling design was used to select nationally representative samples of students at Year 4 and at Year 8. The first stage involved sampling schools; the second stage involved sampling students within schools.

A stratified random sampling approach was taken to select 100 schools at Year 4 and 100 schools at Year 8. A maximum of 25 students were randomly selected from each school to form national samples at Year 4 and Year 8.

The Ministry of Education July 2016 school roll returns for Year 3 and Year 7 were used to inform the selection of Year 4 and Year 8 schools in 2017.

1. Sampling of schools

Sampling algorithm

From the complete list of New Zealand schools select two datasets – one for Year 3 students and the other for Year 7 students.

For the Year 3 sample:

- Exclude:
    - schools which have fewer than eight Year 3 students
    - private schools
    - special schools
    - Correspondence School
    - Kura Kaupapa Māori
    - trial schools
    - Chatham Island schools.
- Stratify the sampling frame by region and quintile[1].
- Within each region-by-quintile stratum, order the schools by Year 3 roll size[2].
- Arrange the strata alternately in increasing and decreasing order of roll size[3].
- Select a random starting point.
- From the random starting point, cumulate the Year 3 roll.
- Because 100 schools are required in the sample, the sampling interval is calculated as:

$$\frac{\text{Total number of Year 3 students}}{100}$$

- Assign each school to a 'selection group' using this calculation:

$$Selection\ group\ =\ ceiling\left(\frac{cumulative\ roll}{sampling\ interval}\right)$$

- Select the first school in each selection group to form the final sample.

Follow the same process for the Year 7 sample.

If a school is selected in both the Year 3 and Year 7 samples, randomly assign it to one of the two samples. Locate the school in the unassigned sample and select a replacement school (next on list). Repeat the process for each school selected in both samples.

[1] Decile 1 and 2 comprises quintile 1; Decile 3 and 4 comprises quintile 2; Decile 5 and 6 comprises quintile 3; Decile 7 and 8 comprises quintile 4; and Decile 9 and 10 comprises quintile 5.

[2] Roll size refers to the year level in question e.g. roll size for Year 3 students.

[3] This is done so that when replacements are made across stratum boundaries the replacement school is of a similar size to the one it is replacing.

2017 NMSSA sample

The sampling frames constituted 1486 schools for Year 3 and 931 schools for Year 7 after exclusions had been applied. No schools were listed in both samples.

Selected schools were invited to participate in 2017. Therefore 'Year 3 schools' became 'Year 4 schools' and similarly 'Year 7 schools' became 'Year 8 schools'. Those that declined to participate were substituted using the following procedure:

- From the school sampling frame, select the school one row below the school withdrawn.
- If this school is not available, re-select by going to one row above the school withdrawn.
- If this school is not available, select the school two rows below the school withdrawn. Continue in this sequence until a substitute is found.

In total, 35 schools at Year 4 and 49 schools at Year 8 declined to participate. One Year 8 school was not replaced, due to insufficient time to seek consent from a replacement school and parents.

Achieved samples of schools

The achieved sample of 100 schools at Year 4 and 99 schools at Year 8 represented a response rate of 74 percent at Year 4 and 66 percent at Year 8.[4]

2. Sampling of students

After schools agreed to participate in the programme, they were asked to provide a list of all Year 4 (or Year 8) students, identifying any students for whom the experience would be inappropriate (e.g. high special needs (ORS), very limited English language (ESOL), Māori Immersion Level 1, would be absent during the visit, had left the school, health or behavioural issues).

Three intersecting samples were required for the assessment programme:

- A group-administered task (GAT) sample for science that included up to 25 students per school who completed the assessment in science and questionnaires in science, and health and physical education (HPE).
- A subset of (up to) 12 of these students per school formed the group-administered task (GAT) sample for health and PE. These students completed the health and PE computer-based assessments.
- A subset of (up to) eight of these students formed the in-depth (InD) sample that participated in movement game-based activities and interviews in HPE and science.

The procedure for selecting students for the GAT and InD samples was as follows:

- Each school provided a list of all students in their school at Year 4 or Year 8 in 2017. A computer-generated random number between 1 and 1 million was assigned to each student. Students were ranked in order of their random number from lowest to highest.
- The first 25 students in the ordered list were identified as belonging to the GAT science sample. The first 12 students were identified as also belonging to the GAT HPE sample, and the first eight students also belonging to the InD sample.
- The draft school lists of selected students were returned to schools for approval. Principals or contact people were given a second opportunity to identify students for whom the NMSSA assessment would be inappropriate. Any identified students in the GAT sample were replaced with students ranked 26 onwards from the initial list, with earlier rankings 'bumped up', so there were no missing ranks and the maximum GAT sample remained at 25. The resultant list was confirmed and letters of consent were sent to the parents of selected students, via the schools, on our behalf.
- The children of parents who declined to have their child participate were withdrawn from the list and were replaced in the same way as above (if there were sufficient eligible students) – until lists were 'locked in' to the master laptop. After this, further replacement students were numbered 26+,

[4] School response rate is defined as the number of schools that participated (the achieved sample) as a percentage of the total number of schools invited to participate including those accepted for the study.

with the withdrawn student keeping their existing number, but having a notation that they had been withdrawn. The multiTXT system was used to advise the relevant TA pair that the student list had changed since the one provided at the training week. No replacements were added within two weeks of the date of the school visit, as there was insufficient time to seek parental permission.

- On the day before arrival in each school, TAs checked the final student list.
- On-site replacements of students by TAs were made if:
    - Any of students 1-8 (the InD sample) were absent or withdrawn (e.g. by the principal) on the first day, prior to the start of assessments. They were replaced by students ranked 9-25, on a best-match basis (e.g. using our gender/ethnicity replacement priorities).
    - All other students (up to 25) participated in the GAT science assessments and questionnaire. Twelve students participated in the HPE assessments and questionnaire.

  If students were absent or withdrawn (e.g. by the principal) after the start of the assessment programme, no replacements were made.
- The criteria for replacing a student were ethnicity and gender. These criteria were prioritised, so that the replacement student was as closely matched to these criteria as possible. An order of priorities to replace a student was applied. If possible, a replacement student had (i) the same gender and ethnicity. If that was not possible, a student of the (ii) same ethnicity was sought; if that was not possible, then a student of the (iii) same gender and finally, (iv) any student.

GAT and InD samples

The following sections describe the achieved GAT and InD samples of students at Year 4 and Year 8, and contrast their demographic characteristics with those of their respective national populations. This allows us to determine the national representativeness of the samples.

Achieved samples at Year 4

Table A1.1 shows that at Year 4 the intended science sample was 2624 randomly selected students. Principals identified 228 students for whom the experience would be unsuitable. The 'eligible' sample was reduced to 2396. The principal or parents withdrew a further 221 students after the sample was drawn. Substitute (replacement) students numbered 172. A further 254 students withdrew late, were absent or did not respond for other reasons during the assessment period. The achieved GAT science sample included 2093 students, representing a participation rate of 66 percent[5]. The achieved GAT HPE, and InD movement and science samples included 1186; 798 and 791 students, respectively.

Table A1.1 The selection of Year 4 students for the GAT and InD samples from 100 schools

	GAT		InD	
	Science	**HPE**	**Movement**	**Science**
Max per school:	25	12	8	8
Intended sample of students	**2624**	**1191**	**800**	**800**
Students withdrawn by principal before sample selected	-228	-	-	-
Eligible sample	**2396**	**1191**	**800**	**800**
Students withdrawn by parents or principal after sampling	-221	-	-	-
Substitute students used (replacements for above)	172	-	-	-
Late withdrawals	-33	-3	-	-
Absences/non-responses during assessment period	-221	-2	-2	-9
Achieved sample	**2093**	**1186**	**798**	**791**

[5] Student response rate is defined as the number of students that participated (the achieved sample) as a percentage of the total number of students in the eligible sample, students withdrawn, substitutes, withdrawals and absences.

Table A1.2 contrasts the characteristics of the samples with the population.

Table A1.2 Comparison of the achieved GAT and InD samples with the expected population characteristics at Year 4

		GAT		InD
	Population (%)	**Science sample *N = 2093* (%)**	**HPE sample *N = 1186* (%)**	**Movement/ Science sample *N = 798* (%)**
Gender				
Boys	51	50	51	51
Girls	49	50	49	49
Ethnicity				
European	52	51	51	50
Māori	24	23	25	26
Pacific	10	10	10	10
Asian	10	13	12	12
Other	1	3	2	3
School Quintile				
1	17	16		
2	17	17		
3	16	16		
4	22	20		
5	28	30		
School Type				
Contributing (Year 1-6)	61	65		
Full Primary (Year 1-8)	36	34		
Composite (Year 1-10 & 1-13)	3	1		
MOE Region				
Auckland	36	36		
Bay of Plenty/Rotorua/Taupo	7	7		
Canterbury	12	12		
Hawkes Bay/Gisborne	5	5		
Nelson/Marlborough/West Coast	4	2		
Otago/Southland	6	6		
Tai Tokerau (Northland)	4	4		
Taranaki/Whanganui/Manawatu	7	6		
Waikato	9	9		
Wellington	11	12		

Notes: Ministry of Education July 2016 school roll returns for Year 3.
Rounding to integers means that percentages do not always add up to 100 percent.

Achieved samples at Year 8

Table A1.3 shows that at Year 8 the intended sample was 2866 randomly selected students. Principals identified 520 students for whom the NMSSA assessment experience would be unsuitable. This reduced the 'eligible' sample to 2346. The principal or parents withdrew 196 students after the sample was drawn. Substitute (replacement) students numbered 166. A further 276 students withdrew late, were absent or did not respond for other reasons during the assessment period. The achieved GAT science sample of 2040 students represented a participation rate of 77 percent. The achieved HPE GAT and InD movement, and science samples included 1173; 791 and 784 students, respectively.

Table A1.3 The selection of Year 8 students for the GAT and InD samples from 99 schools

	GAT		InD	
	Science	**HPE**	**Movement**	**Science**
Max per school:	25	12	8	8
Intended sample of students	**2866**	**1181**	**792**	**792**
Students withdrawn by principal before sample selected	-520			
Eligible sample	**2346**	**1181**	**792**	**792**
Students withdrawn by parents or principal after sampling	-196	-	-	-
Substitute students used (replacements for above)	166	-	-	-
Late withdrawals	-26	-1	-	-
Absences/non-responses during assessment period	-250	-7	-1	-8
Achieved sample	**2040**	**1173**	**791**	**784**

Table A1.4 contrasts the characteristics of the samples with the population.

Table A1.4 Comparison of the achieved GAT and InD samples with population characteristics at Year 8

		GAT		InD
	Population (%)	**Science sample *N = 2093* (%)**	**HPE sample *N = 1186* (%)**	**Movement/ Science sample *N = 798* (%)**
Gender				
Boys	49	49	50	50
Girls	51	51	50	50
Ethnicity				
European	56	55	55	54
Māori	22	23	26	26
Pacific	10	9	7	8
Asian	9	10	9	10
Other	1	2	2	2
School Quintile				
1	14	13		
2	17	17		
3	22	20		
4	24	24		
5	24	25		
School Type				
Full Primary (Year 1-8)	35	32		
Intermediate	46	44		
Secondary (Year 7-15 & 7-10)	14	20		
Composite (Year 1-10, 1-15)	5	3		
MOE Region				
Auckland	34	33		
Bay of Plenty/Rotorua/Taupo	8	10		
Canterbury	12	11		
Hawkes Bay/Gisborne	5	6		
Nelson/Marlborough/West Coast	4	3		
Otago/Southland	6	6		
Tai Tokerau (Northland)	4	5		
Taranaki/Whanganui/Manawatu	6	7		
Waikato	9	10		
Wellington	12	11		

Notes: Ministry of Education July 2016 school roll returns for Year 7.
Rounding to integers means that percentages do not always add up to 100 percent.

At both year levels the national GAT and InD samples closely matched the characteristics of the population. We have confidence in their national representativeness.

Appendix 2:
Methodology for the 2017 NMSSA Programme

Contents:

Tables:

This appendix outlines the methodology for the 2017 health and physical education (HPE) and science study undertaken by the National Monitoring Study of Student Achievement (NMSSA).

1. The 2017 Health and Physical Education assessment programme

The 2017 HPE assessment programme built upon the assessment framework and associated assessment programme developed for the 2013 HPE study. In 2017, we sought to develop a set of group-administered tasks (GAT) for assessing critical thinking in HPE to be administered via laptop to 1200 students at Year 4 and 1200 students at Year 8. We also sought to include a greater number of tasks assessing movement skills in order to construct a separate measurement scale focused on these skills. Table A2.1 summarises the key differences between the assessment programmes in 2013 and 2017. See Appendix 10 for the 2017 assessment framework.

Table A2.1 The key features of the 2013 and 2017 HPE assessment programmes

	2013	2017
Assessment approaches	The Critical Thinking in Health and Physical Education (CT) assessment was made up of in-depth (InD) tasks using interviews and individual or group activities. The tasks used mainly health contexts. Responses from the CT tasks were used to create an IRT measurement scale. A small number of movement skills in authentic game contexts were developed and reported descriptively. All assessments were videoed. A separate interview task was focused on students' understandings of well-being. Results for the well-being task were reported descriptively.	The CT scale was expanded to include more health and movement contexts. The assessment combined new group-administered tasks (GAT) administered on laptops and InD tasks (interviews and movement tasks). The number of tasks assessing movement skills was increased and responses used to form a new measurement scale called Learning Through Movement (LTM). The well-being task was retained and once again the results reported descriptively.
Number of students	Eight students per school participated in the InD tasks, giving a total of 800 students at Year 4 and 800 students at Year 8.	Up to 12 students per school participated in the GAT. Eight students per school participated in the movement tasks and eight students per school participated in CT (and science) interviews.

2. Development and trialling of tasks

The NMSSA team reviewed all 2013 tasks for possible inclusion in the 2017 assessment programme. Some tasks were retained in their original format to be used as link tasks, necessary for making comparisons between 2013 and 2017. Tasks were based on the focus of the HPE learning area, which is defined as: 'the well-being of the students themselves, of other people and of society through learning in health-related and movement contexts' (NZC[6], p.22). The assessment frameworks for critical thinking in HPE, and movement skills are described in Appendix 7. New and modified tasks were piloted in local schools before being used in a NMSSA trial involving schools in Auckland and Otago. The student responses from the pilots and the trial were used to refine the tasks and support the development of appropriate scoring guides. An Item Response Theory (IRT) model[7] was applied to the trial data to help refine the tasks, inform the selection of tasks for the main study and explore the development of two reporting scales – one in Critical Thinking in Health and Physical Education (CT) that paralleled and extended the 2013 scale, and one in Learning Through Movement (LTM).

Administration of the assessment tasks

Twenty-four teacher assessors were trained in the administration of tasks during a five-day training programme prior to the main study. Teacher assessors were carefully monitored and received feedback to ensure consistency of administration. During the study, up to 12 students in each school responded to the HPE GAT. Up to eight out of the 12 students participated in the movement tasks and in the interview tasks (for HPE and Science). Student responses were captured on video and paper, and stored electronically for marking.

Critical Thinking in Health and Physical Education

The CT assessment included a computer-presented assessment component (GAT), where students responded independently on paper. About 1200 students at each year level answered one of four linked GAT versions of the assessment. In addition, 800 students at each year level participated in a number of InD one-to-one interviews that were video recorded. These tasks probed students' ability to explore aspects of HPE where their ability to demonstrate what they know and understand might be compromised if they were expected to write their responses. The CT assessment consisted of 16 tasks, four of which were link tasks from the 2013 study.

Learning Through Movement

The LTM assessment included seven tasks conducted in authentic game contexts; two tasks were retained from the 2013 study, and one of these tasks was modified.

[6] Ministry of Education (2007). *The New Zealand Curriculum*. Wellington: Learning Media.

[7] IRT is an approach to constructing and scoring assessments and surveys that measure mental competencies and attitudes. IRT seeks to establish a mathematical model to describe the relationship between people (in terms of their levels of ability or the strengths of their attitude) and the probability of observing a correct answer or a particular level of response to individual questions. IRT approaches provide flexible techniques for linking assessments made up of different questions to a common reporting scale. The common scale allows the performance of students to be compared regardless of which form of the assessment they were administered.

3. 2017 Science assessment programme

The 2017 science assessment programme built upon the science programme used in 2012. The biggest change was a move from two reporting scales to one. The programme retained many of the tasks used in 2012 and included a range of new tasks. Table A2.2 compares the assessment programmes for 2012 and 2017.

Table A2.2 The key features of the 2012 and 2017 Science assessment programmes

	2012	2017
Assessment approaches	Two separate assessments: • a 45-minute group-administered paper-and-pencil assessment involving selected response and short answer questions called the Knowledge and Communication of Science ideas • a selection of individual one-to-one interview tasks and individual and team performance activities called the Nature of Science assessment. Two separate scales were constructed	One assessment made up of two types of tasks: • a 45-minute, paper-and-pencil group-administered component involving selected response and short answer questions • a selection of in-depth tasks involving student interviews and independent 'station' tasks. Responses from both components were used to construct one scale: the science capabilities (SC) scale.
Number of students	Up to 25 students per school participated in the paper-and-pencil assessment. Eight of these students per school participated in the in-depth tasks.	Up to 25 students per school participated in the paper-and-pencil assessment. Eight of these students per school participated in the in-depth tasks.

Development of the group-administered part of the SC assessment

The group-administered part of the SC assessment was based on the questions developed for the group-administered assessment used in the 2012 study. Assessment development staff within the NMSSA project reviewed the existing items in order to identify areas where new items could be added to support the assessment framework and broaden the pool of questions. They then wrote a collection of new questions to cover these areas. All new questions were carefully reviewed, before being piloted in a range of schools in the Wellington area. The results from the piloting were used to select and fine-tune questions for a larger national trial.

The national item trial was held in March of 2017. The trial involved about 400 students at each of Year 4 and Year 8 and enabled the development team to refine the new items as needed and then select a final bank of questions for use in the main study.

Twelve group-administered assessment forms were constructed for the 2017 study, based on the final pool of questions (seven forms at Year 8 and five at Year 4). Each form was linked to the other forms through the use of common questions.

Development of the in-depth tasks for science

A selection of in-depth tasks was also developed as part of the SC assessment. These were designed to be more open-ended than the group-administered tasks and to stimulate extended responses from students.

Development began with a review of in-depth tasks used in 2012. Some of these tasks were adapted for use in 2017. A selection of new tasks was also developed. Most of the tasks were designed to be administered as part of a one-to-one interview with a teacher assessor, while some were designed to be completed independently as part of a group of 'stations' activities. Many of the in-depth tasks required students to use equipment or consider a rich stimulus.

An initial group of in-depth tasks were piloted in local schools in Wellington and Auckland in late 2016 and early 2017. Some of these were then used in a larger item trial held in March 2017 that involved a selection of schools in Auckland and Otago. Data from the pilots and trials were used to refine the tasks and their associated scoring rubrics. As a result of the development process, six in-depth tasks were selected for use in the main 2017 study. Five of the final tasks were interview tasks and one was a stations task.

Use of the SC assessment in the 2017 NMSSA study

Teacher assessors were instructed on how to administer the SC assessment during a five-day training session prior to the main study.

The group-administered part of the SC assessment was administered to up to 25 students in each school. The students in each school did the same assessment form. Up to eight students in each school completed the in-depth tasks.

Linking Year 4 and Year 8 results in Science

To enable achievement to be linked across Year 4 and Year 8, three additional group-administered assessment forms were constructed using a mix of questions from both year levels. These were administered to a sample of about 600 Year 6 students from schools across the country. The Year 6 schools used were additional schools not already involved in the NMSSA study.

4. Marking

Teacher markers, some of whom had been teacher assessors, and third-year University of Otago College of Education students were employed to mark the tasks. All markers were trained, and quality assurance procedures were used to ensure consistency of marking. The marking schedules were refined as necessary to ensure they reflected the range of responses found in the main study. Students' scores were entered directly by the markers into the electronic database.

The inter-rater reliability (intra-class correlation coefficient) for 66 percent of the questions was 'excellent' (greater than 0.75) and for 34 percent, it was 'good' (between 0.60 and 0.74) (Cicchetti, 1994[8]).

5. Creating the achievement scales

The Rasch IRT model was applied to all student responses from the items in the CT, LTM and SC assessments. This approach included analysing the items used in the assessments for any differential item functioning with respect to year level, gender and ethnicity.

The IRT approach allowed a set of plausible values to be generated for each student involved in the study. Plausible values take into account the imprecision associated with scores on an assessment, which can produce biased estimates of how much achievement varies across a population. Each set of plausible values represents the range of achievement levels a student might reasonably be expected to attain given their responses to the assessment items. Plausible values provide more accurate estimates of population and subgroup statistics, especially when the number of items answered by each student is relatively small.

Standardising the scales

For ease of understanding, each scale was standardised so that:

- the mean of Year 4 and Year 8 students combined was equal to 100 scale score units
- the average standard deviation for the two year levels was equal to 20 scale score units.

Achievement on the scales ranged from about 20 to 180 units.

The scales locate both student achievement and relative task difficulty on the same measurement continuums using scale scores.

Scale descriptions

The scales for HPE and science were described to indicate the range of knowledge and skills assessed.

To create the scale descriptions, the scoring categories for each item (e.g. 0, 1 or 2) in the CT, LTM and SC assessments were located on the respective scales. This meant identifying where the students who scored in each category were most likely to have achieved overall on the scale. Once this had been done for all items, the NMSSA team identified the competencies exhibited as the scale locations associated with the different scoring categories increased, and students' responses became more sophisticated. The result was a multi-part

[8] Cicchetti, D. V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological assessment, 6(4)*, 284. NMSSA used SPSS to calculate inter-marker reliability using one-way random effects model, absolute agreement, average-measures ICC.

description for each scale, providing a broad indication of what students typically know and can do when achieving at different places on the scale.

The descriptions were provided to give readers of NMSSA reports a strong sense of how science and HPE were assessed through the assessments. The scale descriptors were not written to necessarily 'line up' with curriculum levels or achievement objectives. They were a direct reflection of what was assessed and how relatively hard or easy students found the content of the assessment.

6. Linking results from cycle 1 to cycle 2

In order to compare results from cycle 1 with those from 2017 separate scale linking exercises were carried out for science and HPE. The exercises involved comparing the scale locations of the common questions used in the assessments at the different points of time. As part of the exercises, the cycle 1 scales were reconstructed using the same plausible values approach that was used in 2017 (plausible values were not used in 2012 and 2013 when science and HPE were first assessed). The linking exercises indicated that transformations could be used to link the scales. These transformations were applied allowing results from both cycles to be compared. Further information about the linking processes can be found in Appendix 6 (HPE) and Appendix 7 (science).

7. Reporting achievement against curriculum levels

For science, a curriculum alignment exercise in 2013 was used to determine achievement expectations (cut-scores) on the 2012 science scale associated with achievement at different curriculum levels. Linking the 2012 scale to the 2017 SC scale allowed these cut-scores to be located on the SC scale. A similar curriculum alignment for HPE was carried out in 2014 for HPE. This, along with the scale linking exercise for HPE allowed achievement on the 2017 CT scale to be reported against curriculum levels.

A committee of learning area experts was convened in early 2018 to carry out a curriculum alignment exercise related to the LTM scale. The exercise was used to determine cut-scores related to achieving curriculum level objectives at level 2 and 4 of the HPE curriculum.

8. Development of questionnaires for examining contextual information

In order to gain a better understanding of student achievement in New Zealand, NMSSA collects contextual information through questionnaires to students, teachers and principals. A conceptual framework for describing the contextual information to be collected by NMSSA during cycle 2 sought to:

- build (and improve) on the contextual information collected in the first cycle
- learn from the literature about important factors that influence achievement and consider them for including in NMSSA
- address the thematic contextual questions set out in the respective assessment plans[9].

One new development in cycle 2 was the creation of additional measurement scales to report on different aspects of the contextual information.

For the student questionnaire, items were developed to construct the following scales:

- Attitude to Health
- Attitude to PE
- Attitude to Science
- Confidence in Health
- Confidence in PE
- Confidence in Science.

[9] Gilmore, A. (2016). Towards a NMSSA conceptual framework. NMSSA Working Paper.

For the teacher questionnaire, items were developed to construct the following scales:

- Satisfaction with Teaching
- Confidence[10] in Teaching Health
- Confidence in Teaching PE
- Confidence in Teaching Science.

The scales were constructed using the Rasch model. This approach included analysing the items used in the assessments for any differential item functioning with respect to year level, gender and ethnicity. Unlike the achievement measures, plausible values were not generated for the contextual scales. Each scale was standardised in the same way as the achievement scales.

To aid interpretation of the contextual scales, each scale was divided into separate score ranges to provide different reporting categories. For instance, the Attitude to Science scale was broken down into three score ranges. The 'very positive' part of the scale was associated with students mainly using the 'totally agree' category to respond to each of the questionnaire statements related to attitude, the 'positive' section of the scale was associated with students mainly using either 'agree a lot' or 'agree a little', and the 'not positive' part of the scale was associated with students mainly using 'do not agree at all'.

9. Administration of the questionnaires

All students who participated in the Science and HPE assessments were expected to respond to the associated student questionnaire items. Three teachers from each school completed the teacher questionnaire. These were classroom teachers, HPE specialist teachers and science specialist teachers. The principal or a designated school leader (if principal unavailable) from each school completed the principal questionnaire.

[10] In the conceptual framework, we refer to this construct as 'teacher self-efficacy' but we think readers will be more familiar with the term 'confidence'

Appendix 3:
NMSSA Approach to Sample Weighting

Contents:

Figures:

Tables:

1. Introduction

NMSSA reports on achievement levels in different learning areas for Year 4 and Year 8 student populations in New Zealand. The NMSSA sample is drawn so that students in New Zealand have an approximately equal chance of being selected into the sample. To achieve this, NMSSA randomly samples students within randomly-sampled, state and state-integrated schools, using school stratification variables: region, decile and school size.

NMSSA also reports achievement levels for some key subgroups that are not directly accounted for in the initial sample stratification (for instance, gender and ethnicity). These key subgroups may not be properly nationally represented in the achieved sample as they were not included in the original school stratification. Applying post-stratification weights can correct for misrepresentation of subgroups.

Each year NMSSA selects a new sample to assess achievement in up to two learning areas.

This paper describes the general method NMSSA uses to calculate sample weights. Up to the present time, annual investigations into the necessity for incorporating sample weights have resulted in a recommendation that weights are an unneeded addition to analysis.

While NMSSA continues to sample schools and students using the standard NMSSA sample procedure[11], it is unlikely that sample weights will prove necessary to analysis. However, each year the new achievement data is checked for representativeness overall and in key subgroups, and comparisons between using weighted and unweighted data are briefly summarised in the annual technical report.

If, at any time in the future, the use of weights is deemed necessary, the affected technical documents will be updated.

How to assess the need for weights

Where sample weights are seen to make no significant difference to the reported results in any of the key reporting groups or subgroups, NMSSA will report findings without reference to sample weights.

Multiple ethnicities

NMSSA data is reported allowing for students to belong to multiple ethnic groups. In applying sample weights this must be taken into consideration. Tables of numbers of students by gender and by non-prioritised ethnicity for each school are specially provided to NMSSA by the Ministry of Education (MoE) each year. The publically available July school roll returns contain all other information needed to calculate national probabilities of group (and subgroup) membership.

2. Method

The NMSSA sample has two mutually exclusive parts: a Year 4 sample, and a Year 8 sample. The samples are selected to be representative at a national level in each of these year groups. For details of the sampling methodology Appendix 1, *Sample Characteristics for 2017*. The initial sample stratification variables are region, school decile and roll size in the year group of interest. Students are selected randomly from within each selected school.

Post-strata

The achieved NMSSA student sample is post-stratified as follows:

- Quintile (quintiles 1 - 5)
- Gender (female/male)
- Ethnic group(s)
  - NZE/non-NZE
  - Māori/non-Māori
  - Pacific/non-Pacific
  - Asian/non-Asian

[11] *Appendix 1: Sample Characteristics for 2017.*

Each ethnic group is treated separately to allow for students belonging to multiple ethnic groups. Each sample member is initially assigned four separate sample weights, one for each ethnic group.

For **each** ethnic group a sample member belongs to one of 20 possible strata. See Table A3.1.

Table A3.1 Post-strata (20 cells) for one ethnic group

Qunitile	1				2				3				4				5			
Gender	Female		Male		Female		Male		Female		Male		Female		Male		Female		Male	
Ethnic group indicator	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Calculating weights

For each ethnic group weights are calculated as follows:

$$\text{Weight} = \frac{\text{Stratum probability}_{\,national}}{\text{Stratum probability}_{sample}}$$

A **final weight** taking an average over all four weights is then calculated. This final weight is suitable to be used for reporting purposes if recommended.

3. Do the sample weights change the results? An example

What follows is an example of the 2017 results for science achievement. The tables and graphics shown in this section are part of the standard annual weighting investigation procedure.

Figure A3.1 and Figure A3.2 show the overall distributions of science achievement at both Year 4 and at Year 8. They show there is very little difference with respect to unweighted or weighted data.

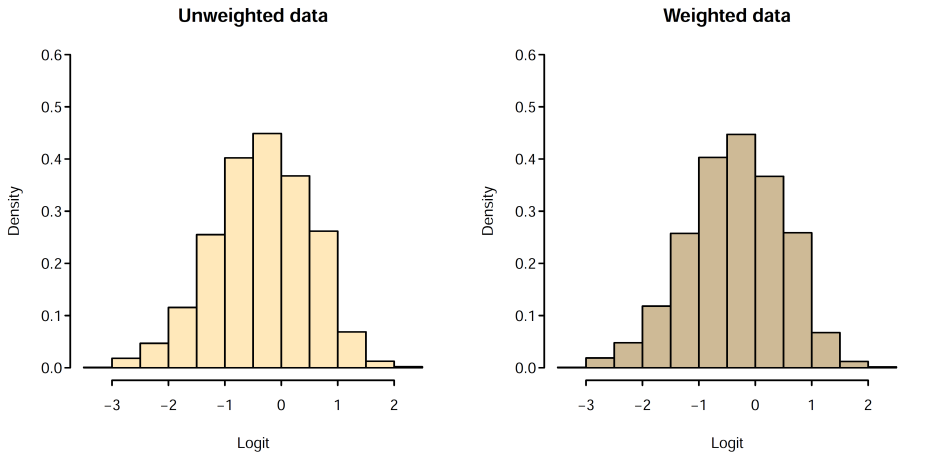

Figure A3.1 Year 4 science achievement

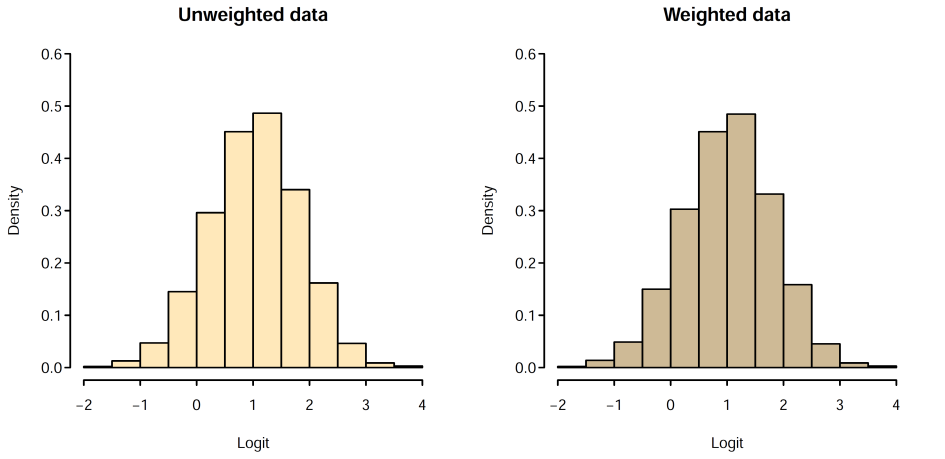

Figure A3.2 Year 8 science achievement

In Table A3.2 and 0 very slight differences can be seen across all sub-groups in the mean and standard deviation estimates. However, since all weighted estimates are well within a standard error of the unweighted estimate, weights are not deemed to be necessary to further analysis.

Table A3.2 Comparison of Year 4 results for NMSSA science achievement: Weighted and unweighted data

	Mean[12] (unweighted)	sd (unweighted)	Mean (weighted)	sd (weighted)	Difference	N
All	82.7	0.6	82.2	0.6	-0.5	2094
Girls	84.5	0.8	84.3	0.8	-0.2	1039
Boys	80.4	0.8	80.3	0.8	-0.1	1055
NZE	87.5	0.6	87.4	0.6	-0.1	1238
NZE girls	89.3	0.9	89.2	0.9	-0.1	615
NZE boys	85.8	0.9	85.7	0.9	-0.1	623
Māori	72.9	1.1	72.7	1.1	-0.2	484
Māori girls	76.3	1.4	76.2	1.4	-0.1	234
Māori boys	69.7	1.6	69.6	1.6	-0.1	250
Pacific	66.3	1.6	66.1	1.6	-0.2	254
Pacific girls	69.0	2.1	68.9	2.1	-0.1	136
Pacific boys	63.1	2.4	62.9	2.4	-0.2	118
Asian	88.6	1.4	88.6	1.4	0.0	287
Asian girls	89.8	1.9	89.6	1.9	-0.2	152
Asian boys	87.4	2.0	87.4	2.0	0.0	135
Quintile 1	64.0	1.3	63.9	1.3	-0.1	334
Quintile 2	78.1	1.3	78.1	1.3	0.0	365
Quintile 3	81.7	1.3	81.7	1.3	0.0	341
Quintile 4	87.6	1.1	87.6	1.1	0.0	420
Quintile 5	91.7	0.9	91.7	0.9	0.0	634

[12] All measures relating to the NMSSA science scale are recorded in NMSSA scale score units in all tables.

Table A3.3 Comparison of Year 8 results for NMSSA science achievement: Weighted and unweighted data

	Mean (unweighted)	sd (unweighted)	Mean (weighted)	sd (weighted)	Difference	N
All	116.7	0.5	116.3	0.5	-0.4	2040
Girls	118.6	0.7	118.2	0.7	-0.4	1034
Boys	114.8	0.8	114.5	0.8	-0.3	1006
NZE	121.0	0.6	120.9	0.6	-0.1	1285
NZE girls	122.6	0.8	122.5	0.8	-0.1	667
NZE boys	119.3	0.9	119.2	0.9	-0.1	618
Māori	107.0	1.0	106.7	1.0	-0.3	473
Māori girls	109.7	1.4	109.5	1.4	-0.2	241
Māori boys	104.2	1.4	104.0	1.4	-0.2	232
Pacific	103.7	1.4	103.5	1.4	-0.2	224
Pacific girls	106.2	2.0	105.8	2.0	-0.4	105
Pacific boys	101.6	2.0	101.6	2.0	0.0	119
Asian	122.1	1.7	121.7	1.7	-0.4	205
Asian girls	123.5	2.4	123.1	2.4	-0.4	97
Asian boys	120.7	2.3	120.5	2.3	-0.2	108
Quintile 1	102.0	1.3	101.9	1.3	-0.1	267
Quintile 2	110.2	1.2	110.1	1.2	-0.1	353
Quintile 3	116.1	1.1	116.0	1.1	-0.1	407
Quintile 4	121.5	1.0	121.4	1.0	-0.1	494
Quintile 5	124.7	0.9	124.7	0.9	0.0	519

Summary graphics

Other standard summary graphics help to arrive at a sensible conclusion.

Figure A3.3 graphs the differences between unweighted and weighted estimates. The magnitude of the differences compared to the 95 percent confidence intervals is very clear. Note that the dotted lines are included as a visual aid only.

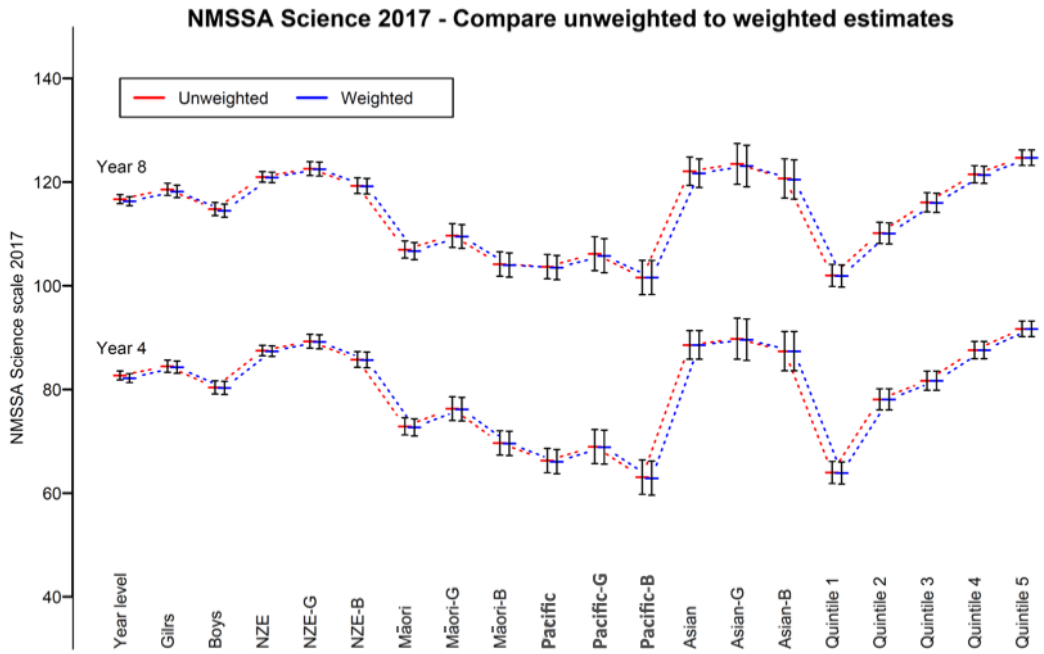

Figure A3.3 Comparison of unweighted to weighted estimates

Figures A3.4 to A3.9 provide more standard comparative plots showing distributions of achievement scales in various key subgroups.

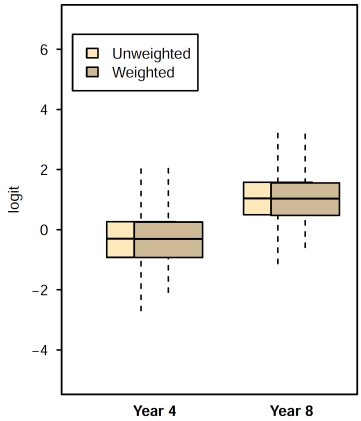

Figure A3.4 Comparison of weighted and unweighted science scores, by year level

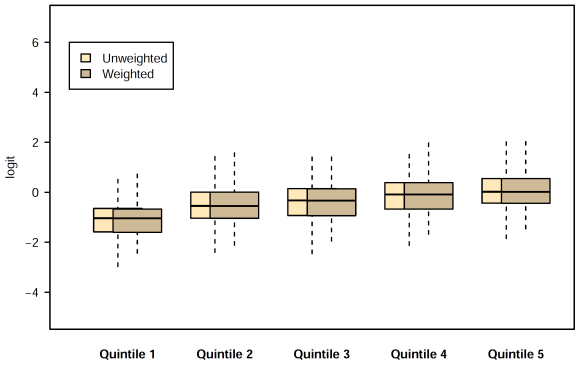

Figure A3.5 Comparison of Year 4 science scores, by quintile

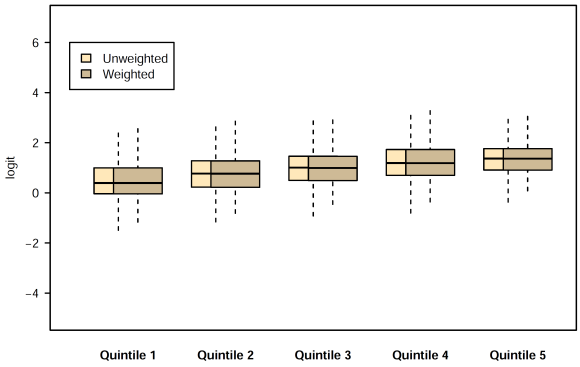

Figure A3.6 Comparison of Year 8 science scores, by quintile

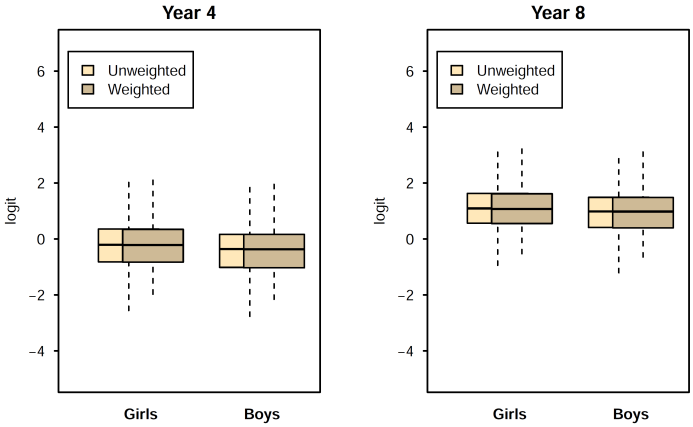

Figure A3.7 Comparison of science scores by gender

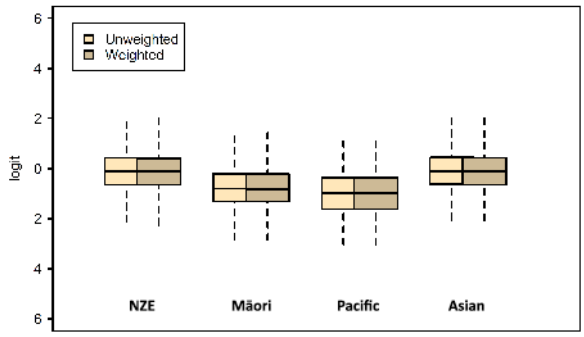

Figure A3.8 Comparisons of Year 4 science scores, by ethnicity

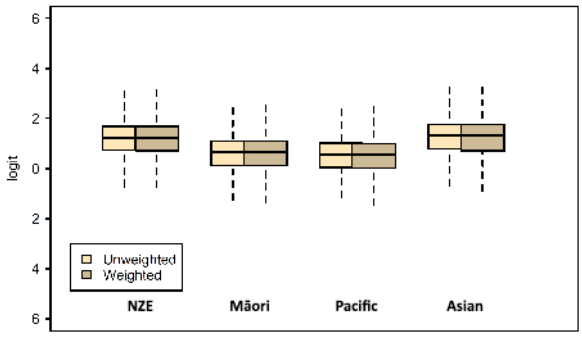

Figure A3.9 Comparisons of Year 8 science scores, by ethnicity

Appendix 4:
NMSSA Sample Weights 2017

Contents:

Tables:

1. Introduction

The methodology for calculating sample weights on an annual basis is detailed in Appendix 3.

Each year NMSSA provides a brief summary of the effect of applying sample weights in the analysis of the current year's data and makes a recommendation as to whether weights should be used or not.

In 2017 NMSSA measured achievement in Science Capabilities (SC), Critical Thinking in Health and Physical Education (CT), and Learning Through Movement (LTM). The 2017 weighting investigation applies to the SC assessment which was completed by the entire NMSSA sample, and the CT assessment completed by a subsample (about half of the complete sample). The LTM assessment was completed by a smaller subsample, and is not included in this analysis. Details of sample and subsample sizes can be found in Appendix 1, Characteristics of the Sample 2017.

All scale locations in the tables that follow are recorded in NMSSA scale score units relating to the learning area in question.

2. Summary

All weighted estimates are well within one standard error of the estimated unweighted mean.

The recommendation is to proceed with the 2017 analysis without sample weights.

Tables of estimates[13] calculated with and without weights follow.

[13] All estimates of means and standard errors in this document are calculated with the full sample size rather than the *effective sample size* defined by the design effect calculations.

3. Science Capabilities

Table A4.1 NMSSA Science Capabilities achievement Year 4: Comparison of estimates with weighted and unweighted data

	Mean (unweighted)	se (unweighted)	Mean (weighted)	se (weighted)	Difference	N
All	82.7	0.6	82.2	0.6	-0.5	2094
Girls	84.5	0.8	84.3	0.8	-0.2	1039
Boys	80.4	0.8	80.3	0.8	-0.1	1055
NZE	87.5	0.6	87.4	0.6	-0.1	1238
NZE girls	89.3	0.9	89.2	0.9	-0.1	615
NZE boys	85.8	0.9	85.7	0.9	-0.1	623
Māori	72.9	1.1	72.7	1.1	-0.2	484
Māori girls	76.3	1.4	76.2	1.4	-0.1	234
Māori boys	69.7	1.6	69.6	1.6	-0.1	250
Pacific	66.3	1.6	66.1	1.6	-0.2	254
Pacific girls	69.0	2.1	68.9	2.1	-0.1	136
Pacific boys	63.1	2.4	62.9	2.4	-0.2	118
Asian	88.6	1.4	88.6	1.4	0.0	287
Asian girls	89.8	1.9	89.6	1.9	-0.2	152
Asian boys	87.4	2.0	87.4	2.0	0.0	135
Quintile 1	64.0	1.3	63.9	1.3	-0.1	334
Quintile 2	78.1	1.3	78.1	1.3	0.0	365
Quintile 3	81.7	1.3	81.7	1.3	0.0	341
Quintile 4	87.6	1.1	87.6	1.1	0.0	420
Quintile 5	91.7	0.9	91.7	0.9	0.0	634

Table A4.2 NMSSA Science Capabilities achievement Year 8: Comparison of estimates with weighted and unweighted data

	Mean (unweighted)	se (unweighted)	Mean (weighted)	se (weighted)	Difference	N
All	116.7	0.5	116.3	0.5	-0.4	2040
Girls	118.6	0.7	118.2	0.7	-0.4	1034
Boys	114.8	0.8	114.5	0.8	-0.3	1006
NZE	121.0	0.6	120.9	0.6	-0.1	1285
NZE girls	122.6	0.8	122.5	0.8	-0.1	667
NZE boys	119.3	0.9	119.2	0.9	-0.1	618
Māori	107.0	1.0	106.7	1.0	-0.3	473
Māori girls	109.7	1.4	109.5	1.4	-0.2	241
Māori boys	104.2	1.4	104.0	1.4	-0.2	232
Pacific	103.7	1.4	103.5	1.4	-0.2	224
Pacific girls	106.2	2.0	105.8	2.0	-0.4	105
Pacific boys	101.6	2.0	101.6	2.0	0.0	119
Asian	122.1	1.7	121.7	1.7	-0.4	205
Asian girls	123.5	2.4	123.1	2.4	-0.4	97
Asian boys	120.7	2.3	120.5	2.3	-0.2	108
Quintile 1	102.0	1.3	101.9	1.3	-0.1	267
Quintile 2	110.2	1.2	110.1	1.2	-0.1	353
Quintile 3	116.1	1.1	116.0	1.1	-0.1	407
Quintile 4	121.5	1.0	121.4	1.0	-0.1	494
Quintile 5	124.7	0.9	124.7	0.9	0.0	519

4. Critical Thinking in Health and PE tables

Table A4.3 NMSSA Critical Thinking in Health and PE achievement Year 4: Comparison of estimates with weighted and unweighted data

	Mean (unweighted)	se (unweighted)	Mean (weighted)	se (weighted)	Difference	N
All	81.1	0.7	80.7	0.7	-0.4	1198
Girls	84.8	0.9	84.7	0.9	-0.1	583
Boys	77.0	1.0	77.0	1.0	0.0	615
NZE	85.7	0.8	85.6	0.8	-0.1	700
NZE girls	90.0	1.1	90.0	1.1	0.0	340
NZE boys	81.6	1.2	81.6	1.2	0.0	360
Māori	74.9	1.4	74.7	1.4	-0.2	298
Māori girls	80.1	1.8	80.0	1.8	-0.1	148
Māori boys	69.8	2.0	69.7	2.0	-0.1	150
Pacific	67.1	2.1	66.9	2.1	-0.2	140
Pacific girls	73.2	2.9	73.0	3.0	-0.2	71
Pacific boys	60.9	2.7	60.8	2.7	-0.1	69
Asian	82.3	1.9	82.2	1.9	-0.1	146
Asian girls	84.9	2.5	84.7	2.5	-0.2	74
Asian boys	79.7	2.7	79.6	2.7	-0.1	72
Quintile 1	66.6	1.7	66.5	1.7	-0.1	193
Quintile 2	78.9	1.6	78.9	1.6	0.0	213
Quintile 3	81.3	1.6	81.3	1.6	0.0	210
Quintile 4	82.5	1.5	82.5	1.5	0.0	234
Quintile 5	88.5	1.1	88.4	1.1	-0.1	348

Table A4.4 NMSSA Critical Thinking in Health and PE achievement Year 8: Comparison of estimates with weighted and unweighted data

	Mean (unweighted)	se (unweighted)	Mean (weighted)	se (weighted)	Difference	N
All	119.0	0.7	118.8	0.7	-0.2	1199
Girls	122.7	1.0	122.5	1.0	-0.2	597
Boys	115.4	0.9	115.2	1.0	-0.2	602
NZE	123.1	0.8	123.0	0.8	-0.1	759
NZE girls	126.6	1.1	126.5	1.1	-0.1	387
NZE boys	119.5	1.2	119.4	1.2	-0.1	372
Māori	111.0	1.3	110.8	1.3	-0.2	308
Māori girls	116.3	1.8	116.2	1.8	-0.1	149
Māori boys	106.1	1.7	105.8	1.7	-0.3	159
Pacific	108.0	2.1	107.8	2.1	-0.2	116
Pacific girls	111.2	3.1	111.2	3.1	0.0	55
Pacific boys	105.1	2.9	104.8	2.9	-0.3	61
Asian	121.6	2.0	121.4	2.1	-0.2	117
Asian girls	124.8	3.4	124.5	3.4	-0.3	50
Asian boys	119.2	2.5	119.2	2.5	0.0	67
Quintile 1	104.8	1.8	104.7	1.8	-0.1	160
Quintile 2	112.7	1.5	112.7	1.5	0.0	210
Quintile 3	118.4	1.5	118.4	1.5	0.0	232
Quintile 4	124.3	1.3	124.3	1.3	0.0	294
Quintile 5	126.3	1.2	126.2	1.2	-0.1	303

Appendix 5:
Variance Estimation in NMSSA

Contents:

1. Introduction

This appendix describes the standard procedures undertaken to calculate design effects in NMSSA on an annual basis.

Design effects

A design effect is the ratio of the variance of an estimate calculated for a complex sample design compared to the variance calculated as if the sample was a simple random sample.

$$d = \frac{Var(\theta)_{Complex}}{Var(\theta)_{SRS}}$$

Design effects are calculated for all key groups and subgroups in NMSSA each year. Calculations are generally restricted to assessment data where the whole NMSSA sample has been involved in the assessment.

Effective sample size

The design effect tells us the extent of the loss of efficiency in variance estimation caused by the complex sample design. This loss of efficiency can be couched in terms of an *effective sample size*. In a simple random sample (SRS) the sample size influences the precision (efficiency) with which estimates can be calculated. A decrease in the sample size leads to a decrease in efficiency, and subsequently an increase in the variance of an estimate. Using the design effect we can calculate the effective sample size, the size of a SRS that would give us the same efficiency as our complex sample.

$$n_{eff} = \frac{n_{complex}}{d(\hat{\theta})}$$

where n_{eff} = the effective sample size

$n_{complex}$ = the sample size selected under the complex design

d = design effect

θ = the estimate in question

2. Variance estimation for complex survey data

The NMSSA sample is a stratified cluster sample, with a new sample being selected each year. Schools are the primary sampling unit and are stratified implicitly by region, decile and size. One hundred schools at each of Year levels 4 and 8 are selected. Within selected schools up to 25 students are systematically (randomly) selected rendering an (approximately) equal probability sample of students representing the New Zealand student population.

For reporting purposes key variables are year level, decile, gender and ethnicity.

Incorporating sample weights

Each year an investigation is carried out to confirm that it is **not** necessary to use sample weights in analysis. The current NMSSA sampling method ensures that the achieved sample represents the NZ student population accurately, and it is unlikely that sample weights will be needed unless the sampling method changes. In the event that sample weights are deemed necessary, they can be readily incorporated into the variance estimation routines.

Post-stratification and collapsing rules

The NMSSA sample is post-stratified by quintile, gender and ethnic group.

Ethnicity grouping: Throughout general analysis and reporting NMSSA allows for individuals to be assigned to multiple ethnicities. In the current context, however, allowing for multiple ethnicities results in many, very small post-strata. Approximately 10 percent of students at Year 4 and at Year 8 are reported as belonging to multiple ethnicities. For the purposes of variance estimation NMSSA uses a 'prioritised' approach to ethnicity. See the stratum collapsing rules below.

The Year 4 and Year 8 samples are treated separately. Small post-strata (less than 15 members) post-strata have to be collapsed[14]. The following collapsing rules are applied, in order, to small post-strata. After each collapsing step, strata are re-assigned and stratum size re-calculated. If there are remaining small strata, the next collapsing step is applied.

1. Remove 'other' classification from students who already belong to any of NZE[15], Māori, Pacific, or Asian.
2. Small strata containing dual ethnicities are collapsed into prioritised ethnicity groups:
   Māori → Pacific → Asian → NZE.
   Example: A small stratum specified by quintile 3-Female-Māori/Asian would be subsumed into the Quintile 3-Female-Māori stratum.
3. Collapse remaining small ethnicity strata into the appropriate gender group.
   Example: A small stratum identified by quintile 4-Male-Pacific would be subsumed into a quintile 4-Male stratum.
4. Remaining small strata are collapsed into the appropriate quintile stratum.
   Example: A small stratum identified by quintile 1-Female would be subsumed into a quintile 1 stratum.
5. Finally any small strata left make up a 'mop-up' stratum, with no specific quintile, gender or ethnic identification.

3. Choosing a variance estimation method for NMSSA

In previous years NMSSA has carried out analyses using a) Jackknife and b) Taylor series linearisation[16] methods for variance estimation, and compared results. These two methods render almost identical results for the NMSSA sample design.

With the introduction of plausible values methodology in NMSSA 2015 to estimate population statistics, it has become practical to use the Taylor series linearisation method for variance estimation in preference to the Jackknife method. Analysis with plausible values involves repeating every analysis multiple times – one for each set of plausible values generated. The Jackknife is a time-consuming, computer-intensive estimation method, whereas the Taylor series approximations can be calculated comparatively quickly.

4. Results and recommendations

In NMSSA design effects generally vary between about 1.0 and 2.5. Even with the larger design effects the confidence intervals do not increase in width very much. A general increase in width of less than 1.0 NMSSA scale score point is usually observed.

It is recommended that, for ease of calculation and to absorb most of the variance bias caused by the NMSSA complex sample design, a factor or multiplier of **0.7** should be used to reduce the sample size in standard error calculations. This assumes a design effect of 1.43, which is close to most design effects calculated.

The factor of 0.7 used to calculate an effective sample size is checked each year, employing the standard procedures set out in this paper. Unless it appears that a very different factor should be used, a standard 0.7 is recommended. While the sample selection methods remain the same, this is unlikely to change. See the example on the following page.

[14] For the purposes of variance estimation, Heeringa, West, & Berglund (2010 p.43) suggest that collapsing post-strata so that each contains a minimum of 15-25 members is advisable.

[15] New Zealand European

[16] Taylor series approximations of complex sample variances for sample estimates of means and proportions have been widely used since the 1950s (Heeringa et al., 2010). It is not a replication method like the Jackknife and the bootstrap, but uses Taylor series approximations to estimate variances. When the sample is reasonably standard the TSL method generally offers similar results to the Jackknife.

Example: Calculate the standard error of a NMSSA mean

m_x = estimated mean of variable x

Under a simple random sample we would use

s_m = standard error of the mean = $\frac{s}{\sqrt{n}}$

Applying the recommended factor to account for a complex sample design we use

s_m* = standard error* of the mean = $\frac{s}{\sqrt{n*0.7}}$

5. References

Heeringa, S. G., West, B. T., Berglund, P. A. (2010). *Applied survey data analysis*. Taylor and Francis Group, LLC.

Lumley, T. (2004). Analysis of complex survey samples, *Journal of statistical software 9*(1), pp. 1-19.

Software

R Core Team (2014). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing: Vienna, Austria. URL http://www.R-project.org/.

Lumley, T. (2014), *survey: Analysis of complex survey samples*. R package version 3.30. https://rdrr.io/rforge/survey/

Appendix 6:
Variance Estimation in 2017

Contents:

Tables:

1. Introduction

This brief summary supports the general NMSSA variance estimation paper[17] with specific findings relating to data in NMSSA 2017.

Design effects were calculated using the data collected for the NMSSA 2017 science assessment. The NMSSA science assessment was completed by the entire NMSSA sample, and therefore provides the most complete information regarding the clustering of students in schools, and consequently the effect on variance estimation.

Design effects for the whole sample, and key subgroups were investigated.

In general, through experience with calculating design effects each year, it has been noted that reducing the sample size by a factor of 0.7 for calculation of population statistics, accounts for most of the design effect related to the clustered nature of the NMSSA sample.

Design effects in 2017 mostly varied between about 1.0 and 2.0. While the design effects in some cases are fairly large (over 2.0 in a few cases), the effect on the width of confidence intervals is small in practice. For the most part the increase in width of the 95 percent confidence intervals is less than 1.0 NMSSA scale score point.

It was recommended that for ease of calculation, and to absorb most of the variance bias caused by the NMSSA complex sample design that the standard multiplier of **0.7** should be used to form an effective sample size in the calculation of statistics dependent on sample size.

Tables showing the effect of the NMSSA complex-sample design on the 2017 science assessment follow.

[17] A standard routine for assessing design effects in NMSSA was developed using NMSSA data over the years 2014 and 2015.

2. Tables of design effects

Table A6.1 Science Year 4 - Comparison of results for different variance estimation methods

Year 4	Mean[18] (SRS[19])	Mean (TSL[20])	SE (SRS)	SE (TSL)	CI (SRS) (lower)	CI (SRS) (upper)	CI (TSL) (lower)	CI (TSL) (upper)	Design effect	CI width increase	CI width increase %	N	Effective N
All Year 4	-0.36	-0.36	0.02	0.03	-0.39	-0.32	-0.41	-0.31	1.94	0.0147	39%	2094	1078
NZE[21]	-0.11	-0.11	0.02	0.03	-0.16	-0.07	-0.17	-0.06	1.69	0.0141	30%	1047	621
Māori	-0.74	-0.74	0.04	0.04	-0.81	-0.67	-0.82	-0.66	1.33	0.0109	15%	484	366
Pacific	-1.26	-1.26	0.07	0.09	-1.40	-1.12	-1.44	-1.08	1.72	0.0430	31%	132	78
Asian	-0.03	-0.03	0.05	0.05	-0.13	0.06	-0.13	0.07	1.11	0.0052	5%	255	231
Female	-0.27	-0.27	0.03	0.04	-0.32	-0.22	-0.34	-0.20	1.86	0.0188	36%	1030	554
Male	-0.44	-0.44	0.03	0.04	-0.49	-0.38	-0.51	-0.36	2.00	0.0223	41%	1050	526
Female NZE	-0.05	-0.05	0.03	0.04	-0.12	0.01	-0.13	0.03	1.63	0.0182	28%	517	318
Female Māori	-0.60	-0.60	0.05	0.05	-0.70	-0.51	-0.71	-0.50	1.22	0.0097	10%	234	194
Female Pacific	-1.23	-1.23	0.10	0.14	-1.42	-1.04	-1.50	-0.96	2.05	0.0825	43%	59	30
Female Asian	0.00	0.00	0.07	0.07	-0.14	0.13	-0.14	0.13	1.08	0.0048	4%	138	130
Male NZE	-0.18	-0.18	0.03	0.04	-0.24	-0.11	-0.26	-0.09	1.72	0.0209	31%	530	309
Male Māori	-0.87	-0.87	0.05	0.06	-0.97	-0.77	-0.98	-0.75	1.28	0.0135	13%	250	197
Male Pacific	-1.28	-1.28	0.10	0.12	-1.48	-1.09	-1.52	-1.05	1.46	0.0407	21%	73	51
Male Asian	-0.06	-0.06	0.07	0.07	-0.20	0.07	-0.20	0.07	1.09	0.0057	4%	117	109
Low decile	-1.11	-1.11	0.04	0.06	-1.20	-1.02	-1.22	-1.00	1.66	0.0254	29%	325	197
Mid decile	-0.53	-0.53	0.04	0.05	-0.61	-0.44	-0.63	-0.42	1.55	0.0212	25%	360	233
High decile	-0.39	-0.39	0.04	0.05	-0.47	-0.31	-0.48	-0.30	1.19	0.0077	9%	341	288

[18] All results in table are quoted in logit units except where indicated
[19] Simple random sample
[20] Taylor series linearisation method
[21] New Zealand European

Table A6.2 Science Year 8 - Comparison of results for different variance estimation methods

Year 8	Mean[22] (SRS[23])	Mean (TSL[24])	SE (SRS)	SE (TSL)	CI (SRS) (lower)	CI (SRS) (upper)	CI (TSL) (lower)	CI (TSL) (upper)	Design effect	CI width increase	CI width increase %	N	Effective N
All Year 8	1.02	1.02	0.02	0.03	0.99	1.06	0.97	1.07	2.17	0.02	47%	2040	943
NZE	1.21	1.21	0.02	0.03	1.17	1.25	1.15	1.26	1.63	0.01	28%	1182	729
Māori	0.63	0.63	0.03	0.04	0.57	0.70	0.54	0.72	1.72	0.02	31%	473	276
Pacific	0.38	0.38	0.06	0.06	0.27	0.49	0.26	0.50	1.13	0.01	6%	147	134
Asian	1.33	1.33	0.06	0.07	1.21	1.45	1.20	1.47	1.25	0.01	12%	149	120
Female	1.10	1.10	0.02	0.04	1.06	1.15	1.04	1.17	2.11	0.02	45%	1021	485
Male	0.95	0.95	0.03	0.04	0.90	1.00	0.87	1.02	2.24	0.03	50%	984	440
Female NZE	1.27	1.27	0.03	0.04	1.21	1.32	1.20	1.34	1.61	0.02	27%	612	381
Female Māori	0.74	0.74	0.05	0.06	0.65	0.83	0.62	0.86	1.71	0.03	31%	241	141
Female Pacific	0.42	0.42	0.08	0.07	0.25	0.58	0.27	0.56	0.78	-0.02	-12%	57	77
Female Asian	1.50	1.50	0.09	0.08	1.32	1.67	1.33	1.66	0.83	-0.02	-9%	56	68
Male NZE	1.15	1.15	0.03	0.04	1.08	1.21	1.06	1.23	1.65	0.02	28%	570	348
Male Māori	0.52	0.52	0.05	0.06	0.42	0.61	0.40	0.64	1.58	0.02	26%	232	148
Male Pacific	0.36	0.36	0.08	0.09	0.21	0.51	0.19	0.53	1.34	0.02	15%	90	70
Male Asian	1.23	1.23	0.08	0.10	1.07	1.39	1.04	1.42	1.44	0.03	20%	93	65
Low decile	0.42	0.42	0.04	0.06	0.34	0.51	0.32	0.53	1.53	0.02	23%	253	167
Mid decile	0.76	0.76	0.04	0.05	0.68	0.84	0.66	0.86	1.40	0.02	18%	353	253
High decile	1.00	1.00	0.04	0.04	0.93	1.08	0.91	1.09	1.34	0.01	16%	397	298

[22] All results in table are quoted in logit units except where indicated
[23] Simple random sample
[24] Taylor series linearisation method

Appendix 7:
Curriculum Alignment of the Learning Through Movement Scale

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Figures:

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1. Introduction and background

The underlying objective of NMSSA is to report on student achievement with respect to the New Zealand Curriculum (NZC). To accomplish this objective, assessment data in relevant learning areas is collected each year, and achievement scales are constructed. The scales are then aligned with the levels of the NZC.

In 2017, the learning areas of interest were science, and health and physical education (HPE). HPE included measures of achievement in Critical Thinking in Health and Physical Education (CT) and Learning Through Movement (LTM). The assessment tasks for achievement in HPE are described in detail in Appendix 2. Curriculum alignment was undertaken for LTM only.

This appendix describes the process followed and presents results for the curriculum alignment of the LTM scale. Many features of a curriculum alignment exercise are the same regardless of the learning area. In NMSSA the goal is the same across all learning areas – to align the relevant scale with the levels of the NZC, paying particular attention to level 2 and level 4.

An alignment of an achievement scale to the NZC has not been attempted before in this learning area. The process described here has generated some useful discussion and learning particularly in regard to how conceptual understanding is 'measured' in a national monitoring context.

Figure A7.1 shows a high-level overview of NMSSA assessment development. This appendix addresses the transition from 'NMSSA Scales' to 'New Zealand Curriculum'.

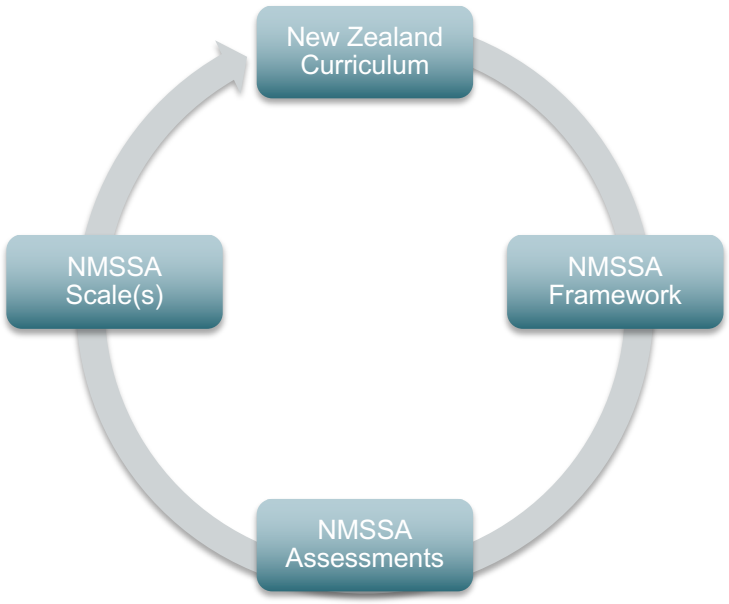

Figure A7.1 Overview of the NMSSA process

2. Learning Through Movement (LTM) assessment

According to the NZC, in health and physical education, the focus is on 'the well-being of students themselves, of other people, and of society through learning in health-related and movement contexts' (p. 22).

The LTM assessment assessed the extent to which students: develop and carry out complex movement sequences; strategise, communicate and co-operate; think creatively – express themselves through movement, and interpret the movement of others; and express social and cultural practices through movement. The LTM assessment focused primarily on two strands of the HPE learning area: movement and motor skills, and relationships with other people. Contexts for assessment tasks using authentic game situations were taken from key areas of learning for HPE: physical activity, outdoor education and sport studies. Collectively, this assessment was called Learning Through Movement (LTM) and a scale was created for the first time in 2017.

Administration

Experienced, specially trained classroom teachers conducted the assessments during Term 3. Up to eight students in each school completed these assessments by participating in games and activities in groups of four supervised by two teacher assessors and in one-to-one interviews. About 800 students at each of Year 4 and Year 8 completed the LTM assessment.

Six sets of forms were created at Year 4 and Year 8 each consisting of three stimulus tasks and a selection of questions to accompany each task. The forms were linked to allow the construction of the LTM scale describing progress according to the NZC. Each school had a combination of two of these forms.

The LTM scale was constructed from student performances and responses to these assessments.

3. Alignment to the NZC

A group of curriculum experts was invited to participate, as part of a panel, in the alignment exercise. The panel was made up of eight members who provided curriculum expertise, together with research, classroom and teaching experience in HPE, particularly physical education. The alignment exercise took the form of a day-long workshop. NMSSA researchers and psychometricians also formed part of the alignment team.

Knowledge of the scale

The panel was presented with detailed information to help them gain a thorough understanding of the assessment framework and its relationship to the LTM scale. Questions and discussion were encouraged at all times. This discussion was a critical step in the alignment exercise and considerable time was spent ensuring that the panel was equipped to make consistent and informed judgements about the relationship of the scale to the relevant curriculum levels.

Experiencing the assessments

The panel had the opportunity to experience assessments as students had experienced them in the NMSSA main study. Resources and exemplars used during the LTM assessment were provided and assessment tasks were presented on laptops. The relative difficulty, cognitive and movement skills demands of each item were examined and discussed.

Structure

The curriculum alignment exercise was undertaken in four sessions. To allow every member of the panel to share their ideas with everybody else, tasks and group membership were altered across sessions. Table A7.1 shows the structure for the day. A panel member is referred to as a 'judge'.

Table A7.1 Structure for the alignment exercise

	GROUP 1		GROUP 2	
Session 1	Judge 1	Judge 2	Judge 5	Judge 6
	Judge 3	Judge 4	Judge 7	Judge 8
	Task 1, Task 2		*Task 1, Task 2*	
MORNING BREAK				
Session 2	Judge 1	Judge 5	Judge 3	Judge 7
	Judge 2	Judge 6	Judge 4	Judge 8
	Task 3, Task 4		*Task 4, Task 3*	
LUNCH BREAK				
Session 3	Judge 1	Judge 7	Judge 2	Judge 8
	Judge 3	Judge 5	Judge 4	Judge 6
	Task 5, Task 6		*Task 6, Task 5*	
AFTERNOON BREAK				
Session 4	Judge 1	Judge 4	Judge 2	Judge 3
	Judge 6	Judge 7	Judge 5	Judge 8
	Task 7		*Task 7*	

Due to time constraints, judges did not discuss and work on Task 7. This possibility had been anticipated and Task 7 had been selected prior to the workshop as a task we could leave out of the alignment process.

4. Alignment process

LTM units (tasks and all related items) were presented to the panel on laptops one by one along with an active demonstration in which they participated. Marking schedules and student examplars were also provided. Judgements were made by the panel, as to how pre-defined groups of students would have performed and/or responded to each item.

Each panel member was asked to estimate a distribution of responses to each question. This method of alignment requires defining minimal competence, and consideration of the influence of assessment conditions on student performance. These are discussed below, followed by an outline of the unique elements of the alignment method.

Minimal competence at different curriculum levels

In NMSSA we report the percentage of students who have achieved curriculum level 2 and above at Year 4 and curriculum level 4 and above at Year 8.

In order to do this we have to work with groups of learning area experts to determine what is a minimally sufficient level of performance on a range of NMSSA tasks for a student to be categorised as having shown enough knowledge and skills to have achieved each level.

We are then able to convert these minimum performance estimates to locations (cut-scores) on the NMSSA scales we use to report achievement.

The cut-points represent the minimum scale scores where students, on balance, can be considered to have achieved the achievement objectives associated with each of the curriculum levels.

When we consider an NMSSA task as part of a curriculum alignment exercise we need to have two things in mind:

- what is expected at the curriculum level we are interested in
- how would students who, overall, have done just enough to have achieved that level perform if they were administered the task.

Assessment conditions

It was important for panel members to understand the circumstances under which students completed the NMSSA assessments. The operational constraints of NMSSA assessments meant that, in some ways, the demands of this assessment were not completely in line with normal classroom activities. When students are less familiar with a process, and are less supported by teachers and classroom activities, they will tend to perform at a lower level than they would if the supports were in place.

When thinking about question difficulty and how the conceptualised group of minimally competent students would respond to each question, the panel was reminded to consider the following points.

- Students had no teaching support for this assessment.
- There was no classroom discussion to help students develop their thoughts or moves.
- Students had no 'scaffolding' in the form of a class PE focus unit.

In judging the difficulty of a question for various groups of minimally competent students, the panel was asked to think about:

- how a primary school student **moves, thinks** or **processes information**
- the types, levels, and complexity of the movement expected
- the knowledge, experience and skills expected
- the depth of thought required when answering questions about the strategies they used
- whether the context is familiar and/or engaging
- the experience students may have had with equipment provided.

5. Estimating response distributions

Curriculum alignment required panel members to fill in a grid for each item showing their estimate of the distribution of scores that a group (e.g. they could consider 100) of minimally competent students (at the appropriate curriculum level) would get on that item. Judges provided their judgements using the 'Curriculum Alignment Software (CAS)' which was developed by EARU in 2017 specifically for standard setting purposes. Figures A7.2 and A7.3 show the screenshots of an example grid before and after being filled in. The possible scores for this fictitious item of a demo task were: 0, 1, 2 and 3.

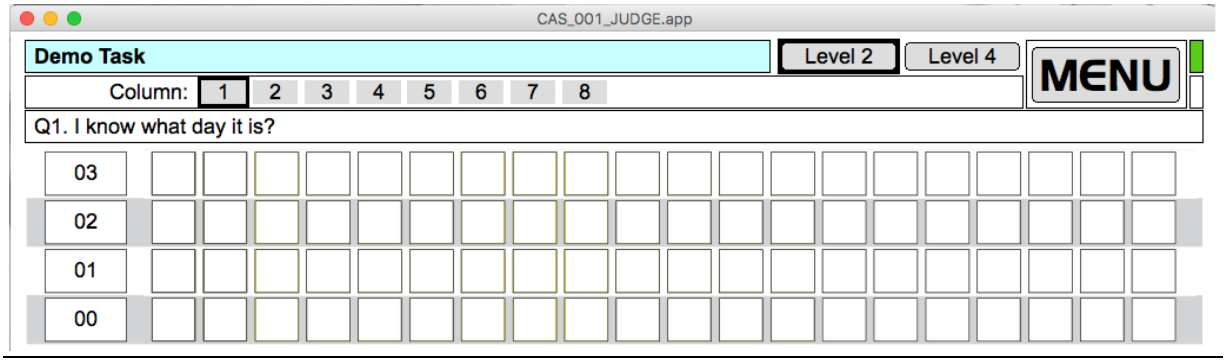

Figure A7.2 Estimating response distribution grid example

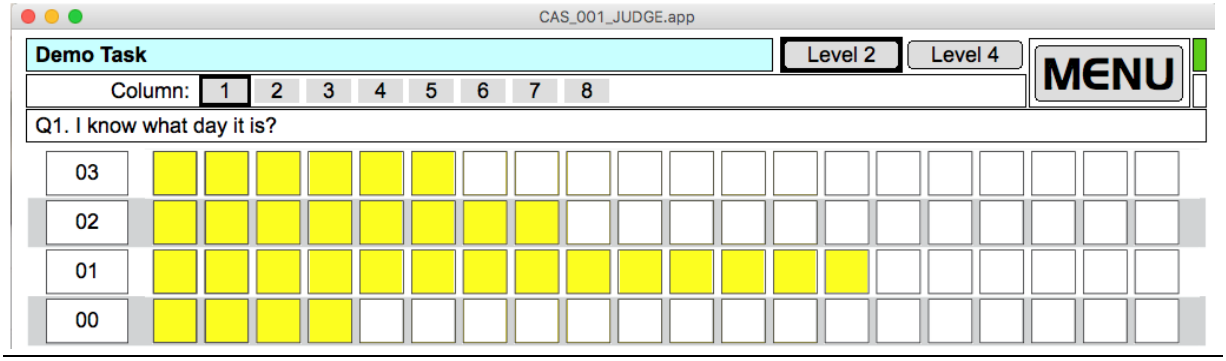

Figure A7.3 Estimating response distributions - example of grid filled in

From the grids, raw scores were calculated for each item and then averaged across all panel members. The resultant raw scores were transformed into scale scores, which represented the cut-scores on the scale where curriculum level 2 and level 4 started.

Establishing the cut-scores

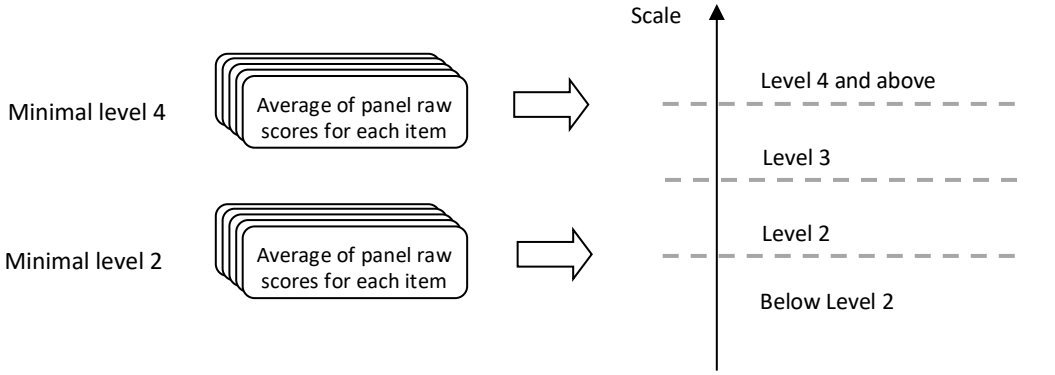

Figure A7.4 Transforming estimated response distributions to scale cut-scores

The curriculum alignment procedure is a relatively high-stakes exercise for NMSSA assessments. Therefore, before collecting scores, feedback was given to panel members regarding what their judgements meant in terms of the percentage of students achieving at or above various curriculum levels.

Panel members worked in groups of four, but made individual judgements on the distribution grids. This was followed by a more general discussion and a chance to reconsider their estimated distribution of scores. There was no requirement for complete agreement between panel members. However, throughout the day, care was taken to challenge judgements that varied widely, or that appeared to be wildly inconsistent with assessment results. Justifying their thinking to each other assisted panel members in deciding whether to update their original judgements.

Level 3

Panel members were satisfied that level 3 would be appropriately placed half way between the level 2 and level 4 cut-scores.

6. Post-hoc review of the LTM alignment

Given the difficulties in precise interpretation of the movement skills in the NZC, the difficulty in applying a consistent concept of 'minimal competence' in this learning area, and concerns about the results of the first workshop, a second session was organised to confirm the first alignment. After careful deliberation the robustness of the first alignment was confirmed and only slight changes were made to the initial alignment to render the final result for NMSSA 2017, shown in Table A7.2.

7. Results

Table A7.2 shows the final locations on the LTM scale for the beginning of level 2, level 3 and level 4.

Table A7.2 Final curriculum level cut-scores for Learning Through Movement (LTM) assessment

	Level 2	Level 3	Level 4
LTM scale cut-scores **(LTM units)**	83.13	97.81	112.50

Appendix 8:
Linking NMSSA Critical Thinking in Health and Physical Education 2013 to 2017

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1. Introduction

In 2017 the National Monitoring Study of Student Achievement collected a second round of data in science, and health and physical education. This provided the first opportunity for NMSSA to carry out analyses that compare results collected at two different time points (cycle 1 and cycle 2).

In order to make comparisons NMSSA carried out an analysis in each learning area to link the assessment results. This appendix summarises the steps conducted to link 2013 and 2017 Critical Thinking in Health and Physical Education (CT) scales.

As with NMSSA science, it was decided to link the 2013 critical thinking scale to the newly constructed 2017 scale, the 2017 scale describing a 'thicker' variable than the 2013 scale. In 2013 the CT assessments consisted solely of one-to-one interview tasks administered to a subsample of the main NMSSA sample—about 800 students at each year level. In 2017 some of the tasks developed in 2013 were used again to form a group of link items. New tasks were added to the item bank in 2017, and NMSSA also introduced a written response component to the assessment which was completed by a larger subsample—about 1200 students at each year level.

The 2013 assessment was constructed so that Year 4 students did not complete as many task items as Year 8 students. Some items were common to both year groups, but had been treated as separate items due to year-level differential item functioning (DIF). This led to NMSSA deciding to link Year 4 and Year 8 data from 2013 **separately** to the 2017 scale. This is shown in Figure A8.1.

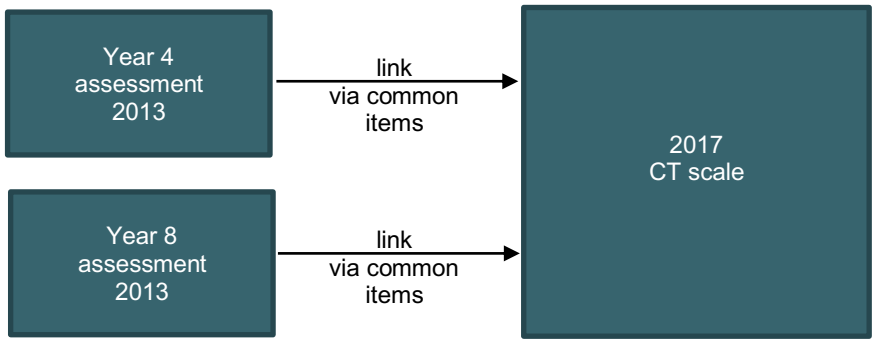

Figure A8.1 Overview of linking process for NMSSA Critical Thinking (CT)

2. Technical differences 2013 to 2017

As with NMSSA science, some technical aspects of estimation have undergone development since the first cycle of CT. For instance, plausible values have been introduced as a means of improving estimation of population statistics. The changes in estimation techniques mean that the 2013 data needed to be re-analysed in line with the 2017 analysis techniques in order to make legitimate comparisons.

It is important to note that the re-analysis of the 2013 data was done solely for the purposes of the trend analysis. Direct comparisons between published findings in the 2013 NMSSA report and the 2017 report cannot be made. Meaningful comparisons across time are restricted to those reported in the trend analysis sections of the 2017 report.

3. Reconstruction of the 2013 CT scale

The 2013 data was analysed with a process that replicates the 2017 analysis as closely as possible. As described in the science linking paper, a slightly different method[25] was used to estimate item parameters, rendering a set of item parameters very strongly correlated with the original[26] item parameters, but with which it was possible to generate sets of plausible values for students.

For each of Year 4 and Year 8 datasets separately, 2013 and 2017 item calibrations of link items were examined and compared. To create a strong link between scales, the two sets of item calibrations at different time points ideally require:

- as many items as possible
- a good spread of items across the scale
- strong correlation between the two sets
- similar standard deviation in the two sets.

Some linking issues

First, the number of items available for linking was small at both year levels and the spread of link items was not very wide, particularly for Year 8.

Some items did not correlate well and had to be eliminated, making the link item sets even smaller. After eliminations the linking sets had only nine items at Year 4, and 12 items at Year 8.

Four items at Year 4 and six items at Year 8 had to be re-coded differently from how they had been re-coded in 2013 in order to align with the 2017 scale. These items were retained for linking rather than eliminated since the linking sets were already very small.

The correlation between final sets of link items was strong at 0.96 for both Year 4 and Year 8 item sets. However, the standard deviations of the 2013 and 2017 linking sets varied considerably. Table A8.1 shows that the 2017 link items had a wider spread than the 2013 link items. This is at odds with the behaviour of the complete item sets where the standard deviation of the 2017 items is **smaller** than the standard deviation of the 2013 items.

Figure A8.2 Comparison of standard deviations of linking item sets

Link items	Year 4	Year 8
sd 2013 (logits)	1.67	1.58
sd 2017 (logits)	1.76	1.74

These observations lead to the conclusion that the linking item sets were not representing their respective full item sets very well. Applying a transformation to the 2013 scale resulted in both the Year 4 and Year 8 distributions appearing to be considerably wider than the 2017 distributions.

An underlying assumption is that each of the assessments (2013 and 2017) is measuring the same latent trait. The representative basis of the NMSSA sample is essentially the same at both time points, and whereas we might expect to see some fluctuations in mean achievement scores, we would not expect to see large fluctuations in the spread of those scores. A decision was taken to accept the estimated differences in mean achievement scores, but (on the basis that NMSSA is measuring the same latent trait at the two time points) to add a shrinking factor to the 2013 data on the 2017 scale so that the population standard deviations matched.

[25] Marginal maximum likelihood (MML)

[26] Joint maximum-likelihood estimation (JMLE).

Final transformations

The transformation which takes 2013 items and puts them on the 2017 scale for Year 4 items is

$$d_i^{2017} = d_i^{2013} - 1.09$$

and for Year 8 items is

$$d_i^{2017} = d_i^{2013} + 0.46$$

EAP[27] estimates were calculated for the 2013 data using the transformed data item parameters, and sets of plausible values generated.

The estimated Year 4 and Year 8 2013 distributions were then 'shrunk' as follows.

$$b^*_{2013} = \left(\left(b_{2013} - \bar{b}_{2013} \right) * \frac{\sigma_{2017}}{\sigma_{2013}} \right) + \bar{b}_{2013}$$

where b is the estimated student achievement score, and $\bar{b}$ the relevant observed mean achievement score.

4. Trend analysis

Very briefly, trend analysis using these transformations revealed a very small downward movement in the Year 4 mean achievement score, and a slightly larger downward movement in the Year 8 mean achievement score. Interpretation of these movements across time should be cautious. The linking of these two scales presented several technical challenges which had to be approached with a certain amount of pragmatism. Each challenge and each solution will have reduced the certainty with which NMSSA can make claims about movement in achievement scores in this learning area across time. Details of the trend analysis can be found in the main 2017 Health and PE report.

Errors and confidence intervals

Linking error

When linking two scales such as this, a linking error should always be considered in the analysis. The size of the linking error is dependent on the differences between pairs of link item parameters. The linking error for Year 4 was 0.1139 logits and 0.0985 logits for Year 8. The linking error is calculated as

$$linking\ error = \sqrt{\sum_{i=1}^{L} (\delta_i - \delta_i')^2 * \frac{L}{L-1}}$$, where L is the number of link items

Standard error on differences between means

The trend analysis involves examining differences between means at the two time-points for complete year levels and for key subgroups. The general formula for calculating confidence intervals around an observed difference is

$$1.96 * \sqrt{se^2_{pooled} + linking\ error^2}$$

with

$$se^2_{pooled} = \left(\frac{s^2_{cycle\ 1}}{n_{cycle\ 1}} + \frac{s^2_{cycle\ 2}}{n_{cycle\ 2}} \right)$$

[27] An expected a posteriori (EAP) estimate refers to the expected value of the posterior probability distribution of latent trait scores in a given case.

5. Alignment of the 2017 CT scale to the NZ Curriculum

The 2013 curriculum alignment exercise generated boundaries on the 2013 scale to indicate curriculum level cut-points. These cut-points need to be transferred onto the 2017 scale for comparison. The cut-points were developed by a group of teachers and health and physical education curriculum specialists in a curriculum alignment exercise described in the 2013 NMSSA report.

Due to the various technical issues raised above another pragmatic approach has been taken in order to transfer the 2013 curriculum level cut-points to the 2017 scale.

Process

1. Re-calculate 2013 achievement scores with MML item parameters but with original re-coding on all items.
2. Re-calculate the curriculum cut-points on the distribution given by (1) from the raw scores provided by the curriculum alignment panel in 2013.
3. Re-calculate 2013 achievement scores with MML item parameters, but this time with item re-codes aligned with the 2017 re-codes. With appropriate transformations, these distributions become the estimated 2013 distributions on the 2017 scale as described above.
4. Use percentile equating (percentiles calculated in (2)) to put curriculum cut-points on the distributions defined in (3).
5. The curriculum cut-points calculated in (4) can be used on the 2017 scale to estimate the proportion of the Year 4 and Year 8 student populations performing at expected curriculum levels.

Details of results are reported in *Health and Physical Education 2017 – Key Findings*. Table A8.2 sets out the final estimated curriculum cut-points on the 2017 scale.

Figure A8.3 Final curriculum cut-points on the 2017 NMSSA Critical Thinking (CT) scale

Curriculum levels	logits	NMSSA units
Level 1/2	-1.47	56.7
Level 2/3	-0.36	92.4

Appendix 9:
Linking NMSSA Science Capabilities 2012 to 2017

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1. Introduction

In 2017, NMSSA entered a second cycle. That is, achievement in learning areas which have been assessed before have now been assessed for a second time. This has created the opportunity for trend analysis in NMSSA science by linking the science scale constructed in 2012 to the science scale constructed in 2017.

In NMSSA science, the scale constructed in 2017 is considered to be richer (wider/thicker) than the 2012 scale, although measuring the same trait. Many new tasks were added to the 2017 item bank for both the paper-and-pencil, and the interview parts of the science assessment, making the scale more robust. The 2017 analysis also undertook to join both parts of the assessment (written and interview) to construct a single shared scale, whereas in 2012 two separate scales were formed—one for the written part and one for the interview part.

For these reasons NMSSA decided to link the 2012 scale to the existing 2017 scale (rather than the other way round) using only the paper-and-pencil part of the 2012 assessment. This is shown in Figure A9.1.

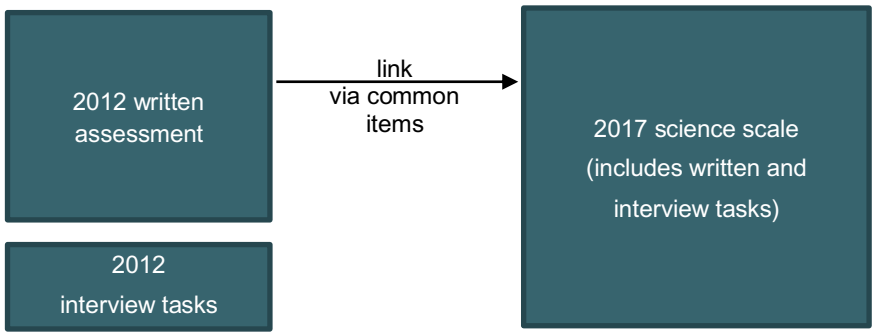

Figure A9.1 Overview of linking process for NMSSA science

2. Technical differences 2012 to 2017

Some technical details regarding estimation have changed between 2012 and 2017. Primarily, plausible values have been introduced (since 2015) for calculating population estimates. Generating sets of plausible values for the student sample requires a slightly different estimation technique from that used in 2012 for calculating item parameters. These technical changes necessitated a re-analysis of the assessment data from 2012 so that it can be properly compared with the 2017 data.

The re-analysis of 2012 data has been done solely for the purposes of the NMSSA trend analysis. It means that estimates recorded in the 2012 NMSSA science report **cannot be directly compared** with those in the 2017 report. Meaningful comparisons across time are restricted to those reported in the trend analysis sections of the 2017 reports.

3. Reconstruction of the 2012 scale

The 2012 science data was analysed with a process that replicates the 2017 analysis as precisely as possible. In 2012 NMSSA used joint maximum likelihood estimation (JMLE) procedures to estimate both item and person parameters. The reconstruction of the data involved using marginal maximum likelihood (MML) to estimate item parameters. Both estimation methods apply the Rasch model. The main difference between the two estimation procedures is that MML assumes an underlying normal distribution for the student population, whereas JMLE does not.

MML item parameters were generated for the 2012 data, and link item calibrations at both time-points were examined.

A high correlation between calibrations of link items at 2012 and 2017 is required for a strong link. Of the 28 items chosen for linking, four items did not correlate well enough to be included in the link calculation. These items were eliminated from ensuing calculations. The remaining 24 items had a correlation of 0.97, and showed a good spread across the NMSSA science scale. The two sets of item parameters also recorded a similar standard deviation at both time points: 1.18 logits and 1.09 logits at 2012 and 2017 respectively.

The standard deviations were sufficiently similar to warrant a simple shift on the science scale to bring the 2012 calibrations in line with the 2017 calibrations.

The transformation which takes the 2012 MML item parameters to the 2017 scale is:

$$\delta_i^{2017} = \delta_i^{2012} - 0.0333\ logits,$$ where δ_i is the estimated parameter of *item i*

EAP[28] person estimates were generated for the 2012 data using transformed MML item parameter estimates, and the usual procedure for generating plausible values was carried out.

The result was a dataset of 2012 data which could be legitimately compared with the 2017 dataset.

4. Trend analysis

In brief, the patterns of science achievement across subgroups are very similar in 2012 and 2017. Year level differences are similar, and girls' and boys' results differ in similar patterns. Differences between decile groups and ethnicity groups also follow similar patterns. The finer details of the trend analysis are included in the main report *Science 2017 – Key Findings*.

Linking error

When linking two scales such as this, a linking error should always be considered in the analysis. The size of the linking error is dependent on the differences between pairs of item parameters. In this case, since the correlation between the items parameters is very strong, the linking error is small (0.0612 logits). The linking error is calculated as

$$linking\ error = \sqrt{\sum_{i=1}^{L}(\delta_i - \delta_i')^2 * \frac{L}{L-1}}$$, where L is the number of link items

Standard error on differences between means

The trend analysis involves examining differences between means at the two time-points for complete year levels and for key subgroups. The general formula for calculating confidence intervals around an observed difference is

$$1.96 * \sqrt{se_{pooled}^2 + linking\ error^2}$$

5. Alignment of the 2017 science scale to the NZ Curriculum

NMSSA has a particular interest in the achievement level of Year 4 students against Level 2 of the New Zealand Curriculum, and the achievement level of Year 8 students against level 4 of the curriculum.

The 2012 curriculum alignment generated boundaries on the 2012 science scale to indicate curriculum level cut-points. The cut-points were developed by a group of teachers and science curriculum specialists in a book-marking exercise described in the 2012 NMSSA science report. These cut-points were then used to estimate how the Year 4 and Year 8 student population were achieving against year level appropriate curriculum expectations.

[28] An expected a posteriori (EAP) estimate refers to the expected value of the posterior probability distribution of latent trait scores in a given case.

The 2012 curriculum cut-points were located on a scale which had been constructed using JMLE estimation. There is no direct transformation from the 2012 JMLE scale to the 2017 MML scale. NMSSA decided to take an heuristic, but nevertheless logical, approach to place the 2012 curriculum cut-points on the 2017 science scale.

Noting that the correlation between MLE and MML item estimates is very strong (i.e. the ranking of the items from both estimation procedures is almost the same), and taking into account that the original curriculum cut-points were generated with a book-marking procedure, cut-points on the 2017 science scale were simply placed between the same items as they had been on the 2012 scale (Table A9.1).

The NMSSA science team examined the placement of the cut-points to ensure that the locations seemed reasonable when seen alongside the additional 2017 items.

Table A9.1 Final curriculum cut-points on the 2017 NMSSA science scale

Curriculum levels	logits	NMSSA units
Level 1/2	-1.72	50.5
Level 2/3	0.46	103.1
Level 3/4	1.71	133.2

Appendix 10:
NMSSA Assessment Framework for Health and Physical Education 2017

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1. Introduction

This appendix describes the assessment approach that the National Monitoring Study of Student Achievement (NMSSA) took to assess health and physical education (HPE) in 2017. It describes how HPE is set out in the New Zealand Curriculum[29] (NZC) and outlines the conceptual framework that guided the development of the Critical Thinking in HPE (CT) and Learning Through Movement (LTM) assessments used by NMSSA to assess HPE.

2. Health and physical education in the New Zealand Curriculum

The focus of the HPE learning area is on 'the well-being of the students themselves, of other people and of society through learning in health-related and movement contexts' (NZC, p. 22). Four underlying and interdependent concepts are at the heart of this learning area: hauora, attitudes and values, a socio-ecological perspective and health promotion. Learning activities in HPE arise from the integration of these four concepts with four strands (and their achievement objectives) and seven key learning areas.

The four strands are:

- personal health and physical development
- movement concepts and motor skills
- relationships with other people
- healthy communities and environments.

The seven key areas of learning are: mental health, sexuality education, food and nutrition, body care and physical safety, physical activity, sports studies and outdoor education. HPE encompasses three different but related learning areas: health education, physical education, and home economics.

The NZC (p. 23) states:

> In health education, students develop their understanding of the factors that influence the health of individuals, groups and society: lifestyle, economic, social, cultural, political, and environmental factors.
>
> In physical education, the focus is on movement and its contribution to the development of individuals and communities. By learning in, through and about movement, students gain an understanding that movement is integral to human expression and that it can contribute to people's pleasure and can enhance their lives.

3. Assessing health and physical education

The 2017 NMSSA assessment programme in HPE was based around students' understanding of well-being, and two achievement measures: Critical Thinking in Health and PE (CT) and Learning Through Movement (LTM). The CT measure is a continuation and expansion of the measure used in 2013. The LTM measure elaborates on the descriptive assessments that were used in 2013 to assess movement skills and reports achievement in this area using a separate scale.

The Critical Thinking in Health and PE (CT) assessment

The CT assessment encompasses the three areas of thinking important to HPE: critical thinking, critical action and creative thinking.

Critical thinking includes thinking about:

- *self and others*: understanding different perspectives and points of view relating to health and well-being, (including inclusiveness and diversity), justifying one's opinions and attitudes
- *information*: examining, analysing, critiquing and challenging information
- *society*: understanding the impacts of the (social, environmental, political, cultural) determinants on well-being.

[29] Ministry of Education. (2007). *The New Zealand Curriculum.* Wellington: Learning Media.

Critical action includes action for:

- *self*: an understanding of strategies and the ability to manage healthy lifestyles and relationships, risk and resilience
- *others*: the ability to plan and engage in health promotion to bring about change as individuals and collectively.

Creative thinking supports and enhances well-being for oneself and others and includes:

- an understanding of visioning and big picture thinking
- the ability to engage in problem solving and finding solutions[30] .

Table A10.1 sets out the indicators of student achievement in relation to the three areas of thinking developed by the NMSSA team to assess the achievement objectives at curriculum levels 1 to 4 of the HPE learning area. The development of the indicators were informed by the *NZC* (2007), *NZC exemplars*[31], Ministry of Education (2016) *Draft progressions in HPE*[32], Ministry of Education (2016) *Curriculum in Action*[33] and Ministry of Education (2017) *Sexuality education: A guide for principals, boards of trustees, and teachers*[34].

Table A10.1 Indicators of student achievement in three areas of thinking in HPE at levels 1 to 4 of the NZC

	Critical thinking	Critical action	Creative thinking
	Students can:	*Students can:*	*Students can:*
NZC Level 1	• Use personal knowledge • Locate/retrieve simple information from a single source • Communicate ideas using everyday language • Describe a personal feeling or idea • Describe changes to self and others	• Use personal knowledge/ experience to inform decision-making • Recognise issues of personal significance: suggest possible actions • Relate to others	• Convey an imaginative idea about how to solve a problem, but with little relationship to efficacy
NZC Level 2	• Locate/ retrieve basic information from a single source and align it with prior knowledge to show a more developed understanding • Communicate ideas using everyday language to describe objects and events • Describe benefits to well-being/hauora • Express an opinion and elaborate with simple reasons • Describe different values and viewpoints • Identify a message and make inferences • Identify main ideas and some details • Recognise factors that influence choices	• Decide on and justify an action to address an issue; identify some possible positive and negative impacts of proposed actions • Consider and demonstrate respect, manaakitanga, aroha and responsibility • Suggest strategies to support others	• Offer solutions to health-related problems and consider how to convey these

30 *NMSSA Report 3: Health and Physical Education 2013*, p. 13
31 http://www.tki.org.nz/r/assessment/exemplars/hpe/matrices/matrix_phpd_e.html
32 http://hpeprogressions.education.govt.nz/
33 http://nzcurriculum.tki.org.nz/Curriculum-stories/Media-gallery/Learning-areas/Curriculum-in-action
34 http://health.tki.org.nz/Teaching-in-HPE/Policy-guidelines/Sexuality-education-a-guide-for-principals-boards-of-trustees-and-teachers/Sexuality-education-in-The-New-Zealand-Curriculum

	Critical thinking	Critical action	Creative thinking
	Students can:	*Students can:*	*Students can:*
NZC Level 3	• Make inferences and provide evidence • Identify another's point of view • Look at a proposition from a range of perspectives • Agree / disagree with a view and provide a convincing justification • Describe the impact of social and cultural determinants on well-being/hauora; understand and describe models of well-being/hauora • Recognise discrimination and assumptions e.g. gender stereotypes and body image messages • Recognise media and consumer influences e.g. persuasive messages, target audiences	• Compare and demonstrate ways of establishing and managing relationships • Identify and affirm the feelings and beliefs of self and others • Decide on and justify an action to address an issue; identify some possible positive and negative impacts of proposed actions • Propose possible actions to mitigate discrimination • Identify risks and plan safety strategies	• Accommodate big picture issues – combine prior knowledge, new knowledge and imaginative thinking to come up with tentative solutions to problems. Ideas are practical and are built on logical reasoning • Describe personal strategies for enhancing well-being/hauora, and coping with social and physical changes e.g. managing competition
NZC Level 4	• Describe the complexities of an issue and possible impacts of actions e.g. changing relationships, discrimination • Reflect on social, cultural, environmental, and economic factors that impact on the well-being of self, others and society • Recognise that people can be deliberately positioned and analyse how that has been developed • Explore and identify a range of cultural perspectives • Critique the influence of the media on people's lives e.g. gender stereotypes, relationships, body image, discrimination	• Decide on and justify an action to address an issue and effect change; identify and evaluate positive and negative impacts of actions • Access and use information to make and action safe choices • Identify and demonstrate positive and supportive relationships • Recognise ways to manage healthy lifestyles • Plan strategies to support self and others in a range of environments e.g. online • Recognise how to take individual and collective action to promote community well-being	• Accommodate big picture solutions – combine prior knowledge, new knowledge and imaginative thinking to come up with tentative solutions to problems. Ideas have merit and are rationally justified • Transfer learning to other situations

4. Curriculum coverage in the CT assessment

Table A10.2 presents the curriculum coverage matrix for the CT assessment tasks by strand, component, question, curriculum level and thinking focus.

For example, the entry for *Fitness tracker*, is Strand A (Personal health and development), Q3a+b *L3/4* (CT/CA). This indicates that Q3a and Q3b of this task were written to cover NZC levels 3 and 4, and assessed critical thinking and critical action. The tasks that provide the link with 2013 HPE assessments are indicated in the task title (LINK).

Table A10.2 Coverage matrix of the Critical Thinking in Health and Physical Education (CT) assessment by strand, component, question, curriculum level and thinking focus

Task Title	Strand A: Personal Health and Physical Development				Strand B: Movement Concepts and Motor Skills[1]	Strand C: Relationships with Other People				Strand D: Healthy Communities and Environments		
	Personal growth and development	Regular physical activity	Safety management	Personal identity	Science and Technology	Challenges and social and cultural factors	Relationships	Identity, sensitivity and respect	Interpersonal skills	Societal attitudes and values	Community resources	Rights, responsibilities, and laws / People and the environment
Community Places	Q3a+b *L3/4* (CT/CA)[2]										Q1+2 *L2/4* (CT/CA) Q4 *L2/4* (CT)	
Gaming Y8	Q2 *L2/3* (CA/CT)			Q7+8 *L2/3* (CRT)					Q3+4 *L3/4* (CA)	Q1 *L2/4* (CT/CRT)		
Kai	Q1 *L2/3* (CT) Q3 *L3* (CT)		Q4 *L4* (CT)					Q4 *L3/4* (CT)	Q3 *L3* (CT)			Q2 *L3* (CT/CA)
Keeping Safe			Q1a+2+3 *L2/3* (CT) Q1b+c *L4* (CT/CA)								Q1b+c *L2/4* (CT/CA)	
Margaret Mahy Playground		Q1 *L2/3* (CT)							Q3 *L2/4* (CA)		Q2 *L2/4* (CT)	Q4 *L4* (CT) Q5+6 *L4* (CA)
Mrs Lee	Q3 *L3* (CT)	Q1 *L1/2* (CT) Q2 *L2/3* (CT)					Q1 *L2* (CT)					Q4 *L4* (CA)
Powerade	Q4 *L2/3* (CT)									Q1+2+4 *L3/4* (CT)		
Tough Boris				Q1 *L3/4* (CT)			Q2b *L4* (CT) Q3 *L2/3/4* (CA)					
Charlotte's Letter				Q1+2b *L4* (CT)						Q1+2b *L3/4* (CT)		Q3 *L3/4* (CA)

Task Title	Strand A: Personal Health and Physical Development				Strand B: Movement Concepts and Motor Skills[1]	Strand C: Relationships with Other People				Strand D: Healthy Communities and Environments		
	Personal growth and development	Regular physical activity	Safety management	Personal identity	Science and Technology	Challenges and social and cultural factors	Relationships	Identity, sensitivity and respect	Interpersonal skills	Societal attitudes and values	Community resources	Rights, responsibilities, and laws / People and the environment
An Important Message[4] (LINK)												Q1+2 *L2/3/4* (CT) Q3 *L1/4* (CA)
New School Y8/Y4[4] (LINK)							Q1/2/3 *L4* (CT) Q5 *L4* (CT)		Q1+2+3 *L2* (CT) Q5 *L2* (CT) Q8+9 *L2/4* (CRT)			
Fair Play[3,4] (LINK)						Q1+2+3+4+5 *L2/3* (CT) Q6+7+8+9 *L3* (CT)						
Bar the Door[3]						Q1 *L2/3* (CRT)						
Stepping Patterns[3]					Q4 *L4* (CRT)							
Rua Tapawha[3,4]					Q7 *L3/4* (CT)							Q8+9 *L1/2/3/4* (CT)
Fitness tracker[3]		Q1+2 *L2/3* (CT)		Q4 *L2/3/4* (CT)	Q1+2 *L2/4/5* (CT)			Q3a+b *L2/3/4* (CT)		Q4 *L3/4* (CT)		

[1] Movement skills and Positive attitudes aspects of Strand B were not assessed in CT
[2] CT = Critical thinking, CA = Critical action, CRT = Creative thinking
[3] From performance tasks also assessing LTM
[4] Tasks used in 2013 and 2017 (LINK)

Well-being[5] (LINK)	Q1 *L2/3*											

[5] Well-being was reported descriptively and did not form part of the CT scale

5. Marking rubric for CT assessment task: *Fitness tracker*

This section sets out the marking rubric used to assess students' performance on the CT task: *Fitness tracker*.

Table A10.3 Marking rubric for CT assessment task: *Fitness tracker*

Title:	**Fitness tracker Y4**	**Level:**	4
Task Info:	**picture, video clip, graph**	**Approach:**	GAT

Col 1	Question 1. Why might your school say it is a **good idea** for students to have a *Fitness tracker?*		CONSTRUCT: Critical thinking in Health and PE Strand A: Personal Health & Physical Development Strand B: Movement Concepts and Motor Skills
SCORE:	**0**	**1**	**2**
Criteria:	**Inappropriate response**: • Describes what a Fitness tracker does, e.g. to collect information; to measure steps, physical activity, how much energy is used, how much sleep, track weight	**General reasoning:** • Monitoring to check physical activity and health, & track health/exercise levels, so they can be fit • To get better/improve • Fun way to check health just once	**Deeper reasoning:** Able to monitor self to show development over time; Personal responsibility; School concerned about health and physical activity of students; Schools can plan programmes to suit physical needs of students; To encourage students to be more active
Critical Thinking Identifies: the main problem & subsidiary embedded or implicit aspects; relationships between aspects; issues and nuances		Can identify a message and elaborate with simple reasons Regular Physical Activity – Describes the personal benefits to well-being of regular physical activity (Level 2) Science and Technology – Identify how equipment enhances movement experiences (Level 2)	Can identify a message and make inferences Regular Physical Activity – Explains how activity, self-care and well-being are related (Level 3) Science and Technology – Describes ways in which regular physical activity is influenced by technology (Level 4/5)

Col 2	Question 2. Why might your school say it is **not a good idea** for students to have a *Fitness tracker?*		CONSTRUCT: Critical thinking in Health and PE Strand A: Personal Health & Physical Development Strand B: Movement Concepts and Motor Skills
SCORE:	**0**	**1**	**2**
Criteria:	Inappropriate response e.g. hurts wrist	**General reasoning:** • Cost (expensive); You might lose it/break it; It might be stolen • Distracting; A gimmick; It might not work; Might overdo activity – competition; It may not be accurate	**Deeper reasoning (justification):** • Privacy/sensitivity issues - don't want others to know (information involved); not an accurate measure of well-being • Discrimination - bullying overweight people; not school's responsibility (should not have to do this) • Affects people – embarrassing
Critical Thinking Identifies the main problem and subsidiary embedded or implicit aspects; can identify relationships between aspects; can identify the issues and nuances		Can identify a message and elaborate with simple reasons Regular Physical Activity – Describes the personal benefits to well-being of regular physical activity (Level 2) Science and Technology – Identify how equipment enhances movement experiences. (Level 2)	Can identify a message and make inferences Regular Physical Activity – Explains how activity, self-care and well-being are related. (Level 3) Science and Technology – Describes ways in which regular physical activity is influenced by technology (Level 4/5)

Col 3	Question 3. One school decided **not** to give students a *Fitness tracker* because of the feelings people in their school had about it. a) Name a feeling those people may have had. b) Why might they feel this way?		CONSTRUCT: Critical thinking in Health and PE Strand C: Relationships With Other People
SCORE:	**0**	**1**	**2**
Criteria:	Feeling with no justification, e.g. jealous OR no feeling mentioned Inappropriate response e.g. too tight, can't afford it	Feeling (related to self) with **general** justification: • Embarrassed because they have few steps • Disappointed because they are not fit • Anxious because they feel like they might break it or be distracted (sense of responsibility) • Annoyed because no money left for other sports gear	Feeling (beyond self) with **deeper** justification: • Embarrassed/feel exposed – feel worse about their body – effect on self-esteem – others will know about their steps or weight – privacy issues • Scared for students who will get bullied/made fun of about their weight or lack of fitness • Self conscious/nervous as they may not feel as active as others (making comparisons with others' health)
Critical Thinking Identifies: the main problem & subsidiary embedded or implicit aspects; relationships between aspects; issues and nuances		Identity, Sensitivity and Respect – Describes the feelings of others (Level 2)	Can recognise feelings from another perspective and suggest reasons for this Identity, Sensitivity and Respect – Recognises ways people can discriminate against each other (Level 3/4)

Col 4	Question 4. What does this advert want you to believe about having a *Fitness tracker*?		CONSTRUCT: Critical thinking in Health and PE Strand A: Personal Health & Physical Development Strand D: Healthy Communities and Environments Literacy Across the Curriculum
SCORE:	**0**	**1**	**2**
Criteria:	Inappropriate response e.g. what a *Fitness tracker* does/tells you: colours, sizes, comfortable, number of steps, buy it	**Literal** messages from the video: • You'll be fit/active • It's good for you • You will know more about your health • Everyone has one • You'll be cool • You'll be healthy • You can take it anywhere • You can exercise in many different ways	Gives a **deeper** message: • Happy (self-esteem, feelings) • Balanced and better life • You can do anything • You will want to do MORE exercise (links to motivation/ challenge) • Age doesn't matter • It will make you MORE active • Everyone has their own fit
Critical Thinking Identifies: the main problem and subsidiary embedded or implicit aspects; relationships between aspects; issues and nuances		Recognises media images Personal Identity: Identify qualities that contribute to a sense of self-worth (Level 2/3) Societal Attitudes and Values: Identify how community/media factors influence physical activity practices (Level 3)	Recognises the influence of media images and subtle messages e.g. stereotyping Considers how the advert's verbal, visual and audio-visual elements support inferences that the advertisers want customers to make Personal Identity: Recognises how social messages and stereotypes in the media can affect feelings of self-worth (Level 4) Societal Attitudes and Values: Describe lifestyle factors and media influences that contribute to the well-being of people (Level 4)

6. The Learning Through Movement assessment (LTM)

The LTM assessment used authentic movement contexts (games) to assess students' ability to do things such as:

- develop and carry out complex movement sequences
- strategise, communicate and co-operate
- think creatively – express themselves through movement, and interpret the movement of others
- express social and cultural practices through movement[35].

The LTM assessment focused primarily on the strand: Movement concepts and motor skills. Contexts for assessment tasks were taken from the key areas of learning for HPE of physical activity, outdoor education and sport studies. Some of the tasks used in 2013 were part of the LTM assessment in 2017.

Table A10.4 sets out the indicators of student achievement in relation to achievement objectives from levels 1 – 4 of the HPE learning area, and the movement skills and indicators, across the NZC levels 1 – 4. Indicators of students' achievement were developed by the NMSSA team in association with PE experts. The indicators were informed by:

- Ovens, A. & Smith, W. (2006) *The components of skills* (p. 80)[36]
- Sport New Zealand (2017) *Developing fundamental movement skills*[37]
- Ministry of Education *Draft progressions in HPE*[38]
- Athletics New Zealand (2017) *Get set go: Fundamental movement skills for kiwi kids.*[39]
- Ministry of Education *Curriculum in Action*[40]
- Ministry of Education (2016) *Sexuality education: A guide for principals, boards of trustees, and teachers*[41].

[35] NMSSA Report 3: Health and Physical Education 2013, p. 13.
[36] Ovens, A. & Smith, W. (2006) Skill: Making sense of a complex concept. *Journal of Physical Education New Zealand*, *39*(1), 72-82.
[37] https://sportnz.org.nz/managing-sport/search-for-a-resource/guides/fundamental-movement-skills
[38] hpeprogressions.education.govt.nz
[39] http://www.athletics.org.nz/Get-Involved/As-a-School/Get-Set-Go
[40] health.tki.org.nz/Key-collections/Curriculum-in-Action-series
[41] health.tki.org.nz/Teaching-in-HPE-/Policy-guidelines/Sexuality-education-a-guide-for-principals-boards-of-trustees-and-teachers

Table A10.4 Movement skills and indicators for the Learning Through Movement (LTM) assessment across the NZC levels 1 – 4

	Students can:		Skills	Indicators:
NZC Level 1	• play together in positive ways • engage in games and physical activities and include others	**Across the New Zealand Curriculum levels**	**Movement: Object Control (catch/pass/strike)**	• Demonstrate good posture • Technique is appropriate and quick
			Movement: Locomotion (run/step/jump/dodge/evadehop/land)	• Movement dynamics are efficient, fluid and balanced • Movements are successful
			Strategies/tactics/follow rules	• Identify, describe and justify game strategies – own and opponents • Follow rules of a game
			Creativity/adaptability	• Show ability to create or perform a range of complex novel movements or movement sequences fluidly/rhythmically and successfully – with and without equipment • Suggest and justify equipment/resource additions
			Teamwork/co-operation/ communication	• Work collaboratively • Express and accept ideas • Communicate well • Take direction • Show leadership • Be inclusive • Justify ideas • Critique and analyse e.g. give feedback
			Perceptiveness	• Identify and describe PE resources and enhancements • Identify and describe environmental characteristics • Identify and describe personal or social influences • Identify adaptive, responsive and effective behaviour • Describe multiple specific movements and movement opportunities

7. Curriculum coverage in the LTM assessment

Table A10.5 presents the curriculum coverage matrix for the LTM assessment tasks by component of Strand B and task, while Table A10.6 presents the curriculum coverage matrix by movement focus of each task.

For example, the first entry for 'Obstacle Course', P1+2+4+5 *L2/3/4* indicates that Performance elements 1, 2, 4 and 5 of this task were written to cover NZC levels 2, 3 and 4, and assessed movement skills. The Rua Tapawhā task provided the link with 2013 movement skills assessments.

Table A10.5 Coverage matrix of the Learning Through Movement assessment by component of Strand B, performance (P) and curriculum level

Task Title	Strand B: Movement Concepts and Motor Skills			
	Movement skills	Positive attitudes	Science and technology	Challenges / social & cultural factors
Obstacle Course	P1+2+4+5 *L2/3/4*	P1+3 *L2/3/4*	P4+5 *L2/3/4*	P4+5 *L4*
Noodle Strike	P1+2 *L2/3/4*	P2 *L2/3/4*		
Pass and Catch	P1+2+3+4 *L2/3/4*		P3+4 *L1/2/4*	
Rippa Tag	P1+2 *L2/3/4*	P2 *L3/4*		
Stepping Patterns	P1+2+3+5 *L2/3/4*		P3 *L1/2/4*	P5 *L4*
Stop Ball	P1+2+3 *L2/3/4*	P3 *L3/4*		P2 *L2*
Rua Tapawhā (LINK)	P1+2+3+4+7+8+9+10 *L2/3/4*	P1+2+3+4 *L3/4*		P10 *L2*

Table A10.6 Coverage matrix of the movement skills focus of the Learning Through Movement tasks

Task	Movement skills focus					
	Technical skills		Strategies/ tactics/ follow rules	Creativity/ adaptability	Teamwork/ co-operation/ communication	Perceptiveness of movement
	Object control	Locomotion				
Obstacle Course		run/walk		✓	✓	✓
Noodle Strike	strike		✓		✓	
Pass and Catch	pass/catch			✓		
Rippa Tag		run/evade/dodge	✓			
Stepping Patterns		step/run/hop/land	✓		✓	✓
Stop Ball		run/walk		✓		✓
Rua Tapawhā	pass/catch					

8. Marking rubric for LTM assessment task: *Stop Ball*

Students' performance on each task was using a movement analysis scale that defined 'high-range skills', 'mid-range skills', 'low-range skills' and 'insufficient/did not participate'. Specific definitions that applied to a particular task and the movement skills involved.

This section sets out the marking rubric and the movement analysis scale used to assess students' performance on *Stop Ball*.

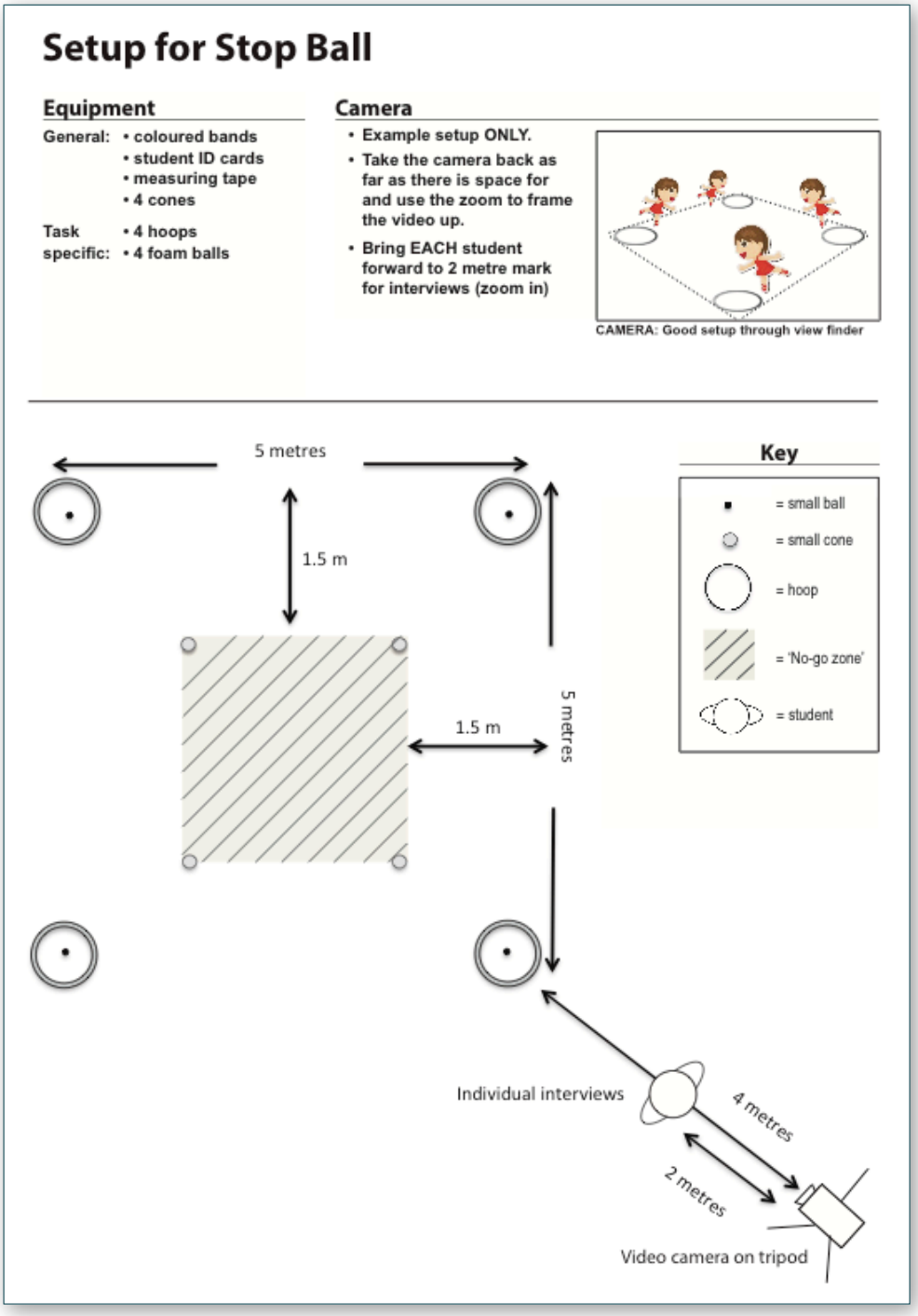

Figure A10.1 Setup for task *Stop Ball*

Table A10.7 Marking rubric for *Stop Ball*

Title:	**Stop Ball**	**Level:**	4 & 8
Task Info:	**Gear: 4 small hoops, 4 foam balls** Marking: mark 2 students at a time for Col 1 and Col 2, then mark students individually for interview		

Col 1	**Locomotion (Walking / Running)**			CONSTRUCT: Movement skills Locomotion
SCORE:	**0**	**1**	**2**	**3**
Criteria:	Inappropriate response Student displays **insufficient** movements	Student displays **low-range** movements	Student displays mainly **mid-range** movements	Student displays all/almost all **high-range** movements
		L2 Practise movement skills	L3 Develop more complex movement sequences and strategies in a range of situations	L4 Demonstrate consistency and control of movement in a range of situations

High-range	• Hips, knees, ankles bent consistently throughout game (crouched stance) • Consistently moves on the balls of the feet (toes / mid-foot strike pattern when moving) • Consistently leans in direction of desired movement / leads with leg closest to direction of desired movement / arms and legs in opposition (running) • Movements consistently fluid / looks balanced / no extra movements / quick change of direction	**Low-range**	• Little bending of hips, knees and ankles during game (upright stance) • Infrequently (if at all) leans in direction of desired movement / leads with leg furthest away from direction of desired motion • Jerky or stiff movements / frequently overbalances / frequent extra movements / movements slow • Flat footed when moving
Mid-range	• Hips, knees and ankles usually bent throughout game • Occasionally on the balls of the feet when moving • Occasionally leans in direction of desired movement, arms and legs mostly in opposition • Movements usually fluid and quick, occasional extra movement	**Insufficient**	• Lack of engagement / Removes themselves from activity / Stops mid-game.

Locomotion (walking/running)					
	Working analysis terms	**Student's performance**		**Working analysis terms**	**Student's performance**
High-range	Consistently good posture		**Low-range**	Generally poor posture	
	Technique consistently appropriate and quick			Technique usually poor and slow	
	Movement dynamics consistently efficient, fluid and balanced			Movement dynamics not efficient, fluid and balanced	
Mid-range	Mostly good posture		**Insufficient**	Lack of engagement / Removes themselves from activity / Stops mid-game	
	Technique mostly effective and quick				
	Movement dynamics sometimes efficient, fluid and balanced				

Col 2	Student follows rules of the game		CONSTRUCT: Movement skills Follow Rules
SCORE:	**0**	**1**	**2**
Criteria:	Inappropriate response Lack of engagement/Removes themselves from activity/Stops mid-game Student doesn't follow game rules	Student **mostly** follows the rules of the game	Student **consistently** follows rules of the game e.g. takes ball from either side of hoop, places (not throws) ball in hoop, takes balls one at a time
		L2 Practise movement skills	L3 Develop more complex movement sequences and strategies in a range of situations

Col 3	Q1. What strategies did you use to play stop ball? Q2. Did they work? Q3. Why / why not? Q4. What strategies did the others use?			CONSTRUCT: Movement skills Strategies/Tactics
SCORE:	**0**	**1**	**2**	**3**
Criteria:	Inappropriate response e.g. running Not able to identify a strategy with respect to game play or describes how the game is played	**Low-range:** Able to identify general strategies but with no/limited justification e.g. run fast, get to a hoop quickly	**Mid-range:** Able to identify ONE strategy with respect to game play and justify why it was effective or not e.g. wait to see where others are going; run fast as others slow	**High-range:** Able to identify TWO or more strategies with respect to game play and justifies why it was effective or not - must include one strategy based on own skills and one strategy based on opponents' game play, e.g. watch where others are moving so that I can take balls from hoops; the others ran fast so they could get to the hoop before me
		L2 Practise movement skills	L3 Develop more complex movement sequences and strategies in a range of situations	L4 Demonstrate consistency and control of movement in a range of situations

Strategies / Tactics		
	Working analysis terms	**Student's performance**
High-range	Identifies 2 or more strategies and justifies – own and opponents' game play	
Mid-range	Identifies 1 strategy and justifies – observing others' behaviour	
Low-range	Identifies 1 strategy and justifies – own actions	
Insufficient	Unable to identify a strategy	

Appendix 11:
NMSSA Assessment Framework for Science 2017

Contents:

Tables:

1. Introduction

This appendix outlines the conceptual framework used to support the development of the 2017 science assessment.

2. Science in The New Zealand Curriculum

Science in *The New Zealand Curriculum (*NZC) is about exploring how the natural world, the physical world and science itself work so that students can participate as critical, informed and responsible citizens in a society in which science plays a significant role.[42]

Within the NZC the science learning area is organised under two types of strands: The Nature of Science (NOS) strand, which is about "what science is and how scientists work"[43], and four context strands, which provide guidance about appropriate science knowledge to be developed.

Four **science capabilities**: critical inquiry, making meaning in science, taking action, and knowing science, have been identified as being important to learning science. These are not named in Science in *NZC*, but they do encapsulate the statements about the science learning area and achievement objectives, as well as incorporating key competencies.

Table A11.1 The relationship between the Nature of Science substrands and the science capabilities

Nature of Science substrands	Understanding about science	Investigating in science	Communicating in science	Participating and contributing
Matching science capabilities	• Gather and interpret data • Use evidence • Critique evidence	• Gather and interpret data • Use evidence • Critique evidence	• Interpret representations	• Engaging in science

3. The relationship of the framework to The New Zealand Curriculum

The **science claim** that heads up the NMSSA 2017 science framework provides a 'big picture' view of the expectations of about what students can do in science, and is closely aligned to the 'doing' part of the science essence statement.

In NZC, the core strand of NZC, the Nature of Science (NOS), is divided into four substrands, although these divisions are somewhat arbitrary as the substrands overlap and interact. Three of the science capabilities identified in this framework – critical inquiry, making meaning in science, and taking action – cross over the four NOS substrands.

The first three aspects that make up the framework below are linked to the science capabilities (shown in brackets). The science capabilities have been developed to clarify for teachers how the Nature of Science might look in their classrooms. They are shown in the framework to support the Ministry's work in this area.

For each of the first three aspects, the **sub-claim** at each level has been derived from the Nature of Science achievement objectives, identifying the elements pertaining to the particular science capability.

The **indicators** were developed with the intention of capturing the complexity of progress in learning science. The numbering is used to denote the level of complexity, **not** curriculum levels. A dotted line has been used, however, to indicate a possible alignment of the indicators with the curriculum levels. In developing the indicators evidence was drawn from many sources, both national and international research and assessment programmes, and including the scale descriptions and other analyses from the 2012 NMSSA science assessment.

[42] *The New Zealand Curriculum*, p. 17
[43] *The New Zealand Curriculum*, p. 28

The fourth aspect of the framework, **knowing science**, has been approached in a slightly different way. The sub-claims have been derived from an overview of the context strands' achievement objectives. Signalled science concepts were identified, and these were then written as more specific knowledge statements. International and national research about important ideas in science was also considered.

4. Continuity between the 2012 and 2017 science frameworks

Table A11.2 Comparison between the 2012 and 2017 science frameworks

2012	2017
Two frameworks were developed, leading to two scales; *Knowledge and Communication of Science Ideas,* and *Nature of Science*. The correlation between the two scales was strong (students performed similarly on each scale).	The two frameworks have been combined and reorganised, but retain the same elements. Existing assessment tasks, both paper and pencil and in-depth, will fit the new framework.
The NOS substrands were considered individually.	The NOS strand has been considered holistically, with three science capabilities common to each sub-strand identified. Links have been made to the science capabilities (developed since 2012).
Different assessment approaches were used for each framework; paper-and-pencil tasks for *Knowledge and Communication of Science Ideas*, and in-depth tasks for *Nature of Science*.	The framework covers both pencil-and-paper and in-depth tasks.
A knowledge component was described.	The knowledge component is unchanged, except for a sub-claim added for each level.

Table A11.3 The NMSSA science framework (2017)

Science claim: Students can communicate their developing science ideas about the natural physical world, and how science itself works.			
	Aspect (science capabilities)	**Sub claims:** Students can –	**Indicators**
Nature of Science Understanding about science • Investigating in science • Communicating in science • Participating and contributing	**Critical inquiry** (Gather and interpret data, Use evidence, Critique evidence)	**L1/2** Ask and investigate simple science questions.	1. Ask questions based on observations and experiences; test items for yes/no responses; identify obvious patterns; describe similarities and differences; make simple inferences from data; compare their ideas with others' ideas.
		L3/4 Design, carry out and critique simple science investigations.	2. Develop questions that can be investigated; plan and carry out a straightforward investigation relevant to the question being asked; check unexpected results; describe simple causal relationships; use similarities and differences to sort and classify. 3. Select an appropriate method for investigating a question; predict a possible outcome; design and carry out a simple but systematic science investigation; use evidence to develop an explanation; identify easily-observable patterns related to time and change, and use these to make predictions; make judgements about how well an investigation answered the question.
		Above L4	4. Design investigations that involve multiple variables; identify which data are relevant to answering a science question; use evidence to describe multi-step causal relationships; suspend judgement if there is insufficient evidence to answer the investigated question; evaluate the suitability of investigative methods used.
	Meaning making in science (Interpret representations, Critique evidence)	**L1/2** Shape simple descriptions and explanations to communicate their science ideas.	1. Locate basic information from simple representations and text; communicate their ideas using their own non-scientific representations; use everyday language to describe objects and events. 2. Accurately restate what data in simple representations and texts shows; compare, contrast and make simple inferences about data, based on personal experience; use precise descriptive language; communicate understanding of a science idea using informal conventions.
		L3/4 Shape simple science texts for specific purposes, using a range of appropriate science symbols, conventions and vocabulary.	3. Use and interpret a range of science texts, conventions and vocabulary to: describe patterns and trends in data and observations; develop science explanations with some links to accepted science knowledge; locate and interpret information in others' explanations; identify the author's purpose in using a particular representation.
		Above L4	4. Select representations that are fit for purpose; identify strengths and weaknesses of representations and written text; develop descriptions and explanations that draw on available evidence and science knowledge.

Science claim: Students can communicate their developing science ideas about the natural physical world, and how science itself works.			
	Aspect (science capabilities)	**Sub claims:** Students can –	**Indicators**
	Taking action (Engage with science, Critique evidence)	**L1/2** Suggest actions in response to an issue, based on personal ideas and experiences.	1. Recognise science capabilities of an issue of personal importance; suggest possible actions.
		L3/4 Draw on their emerging science ideas to discuss issues and suggest actions, and critique their and others' ideas	2. Decide on and justify an action to address an issue; identify some possible positive and negative impacts of proposed actions. 3. Describe some complexities of an issue and possible impacts of actions, drawing on their science understandings.
		Above L4	4. Evaluate competing perspectives about an issue; use evidence from science to argue for or against a proposed action.

Science claim: Students can communicate their developing science ideas about the natural physical world, and how science itself works.			
	Aspect (science capabilities)	**Sub claims:** Students can –	**Indicators**
Context strands • Living World • Planet Earth and Beyond • Physical World • Material World	**Knowing science**	**Sub-claims** **Students know and can use:** **L1/2** Some basic science ideas about their everyday experiences and observed world.	**Living World** • All living things need food, water, air, warmth and shelter to survive. • Living things are adapted to live in a particular environment. • There are lots of different living things in the world. **Planet Earth and Beyond** • Planet Earth provides living things with air, water and shelter. • Planet Earth's features are changed by weather, earthquakes, volcanic eruptions, water, erosion and people. Any changes that occur to or in an environment affect everything living there. • Planet Earth's light and heat come from the sun. **Physical World** • A shadow forms on a surface when an object is between a light source and the surface. • Heat travels from one place to another. It travels through some materials more quickly than others. • Pushes and pulls make objects move. **Material World** • Different materials have different properties. • Water exists in three states – solid, liquid and gas. The state is dependent on its temperature. • A material's properties affect how it interacts with other things.

Science claim: Students can communicate their developing science ideas about the natural physical world, and how science itself works.			
	Aspect (science capabilities)	**Sub claims:** Students can –	**Indicators**
		L3/4 Some simple science concepts, including beginning understandings of abstract science concepts	**Living World** • All living things need food, water, air, warmth and shelter to survive, and have different ways of meeting these needs. • Living things have strategies for responding to changes, both natural and human induced, in their environment. • Living things on Planet Earth change over long periods of time and evolve differently in different places. Scientists have particular ways of classifying living things. **Planet Earth and Beyond** • Planet Earth is made up of water, air, rocks and soil, and life forms, and these are our planet's resources. • Water is a finite resource that is constantly recycled. The water cycle impacts on our weather, the landscape and life on Earth. • Planet Earth is part of a vast solar system that consists of the Sun, planets and moons. **Physical World** • The sun is the original source of all energy on Planet Earth. • Heat, light, sound, movement and electricity are forms of energy. Energy can transform from one form to another. • Contact forces (e.g. frictional) and non-contact forces (e.g. gravity and magnetism) affect the motion of objects. **Material World** • Materials can be grouped in different ways according to their physical and chemical properties. • Matter is made up of tiny particles that behave differently as heat is added or removed. • When materials are heated or mixed with other materials the resulting changes may be permanent or reversible.

Appendix 12:
Plausible Values in NMSSA

Contents:

1. Introduction

At the end of 2013, NMSSA carried out an investigation[44] as to the practical implications of introducing plausible values (PV) methodology into the NMSSA data analysis. Following on from this investigation, the NMSSA Technical Reference Group that met in December 2014 recommended that plausible values should be used in future NMSSA analyses. Plausible values were used for the first time in NMSSA 2015.

Plausible values methodology has been in use for some time in larger national and international studies of student achievement (e.g. NAEP[45], PISA[46], TIMMS[47]). Plausible values can recover population statistics more accurately than other methods especially where assessments are necessarily very short and individual scores subsequently form estimated population distributions with imprecise standard deviations.

Plausible values are now incorporated into all NMSSA achievement analysis and estimation. This appendix provides a generic description of how NMSSA uses plausible values methodology. It begins with a brief description of what plausible values are, and why NMSSA now uses this approach. This is followed by some discussion on issues considered by NMSSA with respect to plausible values. Finally, some aspects of relevant estimation methods are laid out and examples of formulae to calculate population statistics from plausible values are provided.

Software

NMSSA uses the Test Analysis Modules (TAM) package (Kiefer, Robitzsch & Wu) in *R* (*R* Core Team, 2015) to generate sets of plausible values.

While plausible values methodology has been in use for some time internationally, smooth and efficient ways of generating and working with plausible values has not been readily available. The *TAM R*-package is relatively new software and offers very straightforward solutions for programming processes, and working with multiple sets of plausible values.

2. Plausible values

What are plausible values?

The purpose of NMSSA is to monitor New Zealand population achievement standards in Year 4 and Year 8 across the New Zealand Curriculum (NZC). The statistics of interest are population means, standard deviations, percentages of student populations achieving at various curriculum levels, and standard errors associated with these statistics. To estimate these statistics NMSSA constructs assessments in the learning area under investigation for a nationally representative sample of students to complete. Each student in the sample is subsequently assigned an achievement estimate on a Rasch measurement scale (Rasch, 1960). Each of these estimates contains a degree of uncertainty. One way to express the degree of uncertainty of measurement at the individual level is to provide several estimates for each student reflecting the magnitude of the measurement error of the individual's estimate. If the measurement error is small, then multiple scores for a student will be close together. If the measurement error is large, then multiple scores for a student will be further apart. These multiple scores for an individual, sometimes known as multiple imputations, are *plausible values.* In other words, plausible values represent a **range of scores** that a student might reasonably have, given that student's responses to the assessment.

Why use plausible values?

When individual students complete assessments that contain only a small number of questions the proficiency estimates generated for the students are relatively imprecise. In this situation traditional Item Response Theory (IRT) methods suitable for calculating individual level results can produce biased variance estimates for groups. This bias increases as the number of questions asked of each individual decreases (Wu, 2005).

[44] Internal NMSSA paper: *Plausible Values - An Investigation*
[45] https://nces.ed.gov/nationsreportcard/tdw/analysis/est_pv_individual.asp
[46] https://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-9-Scaling-PISA-Data.pdf
[47] https://nces.ed.gov/timss/timss15technotes_weighting.asp

A plausible values approach generates multiple values to represent the probable distribution of a student's achievement. These plausible values can be used to produce an unbiased view of the spread and location of achievement for a group of students (von Davier et al., 2009). This is particularly important when group results are being compared. For example, if we want to estimate the effect size of the difference in means between Year 4 and Year 8 achievement in a particular learning area, an over-estimated variance will under-state the effect size, and an under-estimated variance will over-state the effect size.

Advantages and disadvantages of plausible values in NMSSA

Advantages

Advantages include, but are not necessarily limited to:

- shorter assessments leading to reduced burden – for schools, students and administrators
- accurate population statistics with very short assessments – perhaps around 10 items
- greater coverage of learning areas within a fixed assessment time through the use of large item banks
- generation of less 'granulated' scale scores, making estimation of percentages above and below curriculum level cut-points more accurate
- amelioration of the effects of an off-target assessment i.e. ceiling and floor effects.

Disadvantages

Possible disadvantages are:

- change of analysis methods across cycles of NMSSA where comparisons are needed
- inconsistency of scale construction methodologies across NMSSA scales, between (and possibly within) cycles
- increased complexity of analysis methodology
- extra resource required to extend frameworks and construct larger item banks
- extra resource required for using and reporting more complex analysis methods.

Plausible values and NMSSA assessment design

The NMSSA objective is two-fold:

1. Construct valid and reliable measurement scales in the relevant learning areas
2. Report population achievement statistics as accurately, and as precisely as practicable.

Plausible values methodology allows us to implement any of the following to one degree or another:

- shorter assessments (10 – 20 items/score points)
- simultaneous assessment of a wider selection of learning areas than previously possible
- more in-depth coverage of a single curriculum learning area.

There is, however, a limit on the extent to which any of these can be applied.

Achieving a balance

Some aspects of the NMSSA design are fixed:

- sample size – cannot be increased
- time allowed on site in schools – cannot be increased, though it is possible that time in schools may be more efficiently allocated in the future with the use of online assessments tools
- minimum number of responses per item – ideally this should be around 500 to obtain precise item parameter estimates
- high quality linkage between forms and year groups must be maintained.

Within these limitations we can vary:

- assessment length
- number of forms
- item bank size.

The following formula shows the relationship between sample size (fixed), number of responses per item required (fixed minimum), assessment length and item bank size.

$$\frac{\text{sample size}}{\text{number of responses per item}} = \frac{\text{number of items in bank}}{\text{number of items per assessment}}$$

The idea of having much shorter assessments and being able to cover larger curriculum areas in greater depth is very appealing. However, while this formula is useful for rough calculations, there are some additional practical constraints that need to be considered in the context of NMSSA.

- The fewer items per assessment form, the more forms NMSSA needs to construct.
- Designing a set of well-linked forms becomes increasingly complex the more forms there are.
- The structure of the NMSSA sample is fixed. Up to 27 students from each of 100 schools are selected at each of Year 4 and Year 8. While it is often practical for students in each school to complete a variety of different forms, sometimes (as in the case of a group-administered assessment like English: listening) it is not.
- Individual items may not be delivered in isolation. Often items are organised in units, with several items belonging to one stimulus for example. These items have to move together making linking and even spreading of items across forms more difficult.
- Many items or units will only be suitable for certain year groups. That is, it is often the case that some units or items are not allowed to appear in some forms.
- Each form must constitute a realistic stand-alone assessment, even if it is short.

As an example, both the English: listening and English: viewing assessments in 2015 required a design involving 25 linked forms with each form contributing between 13 and 17 score points. In 2014, English: reading required only 10 linked assessment forms, with each form contributing 30 or more score points.

3. Estimation methods and processes relevant to NMSSA

This section contains short descriptions of estimation techniques related to this paper. These descriptions guide the reader through the processes employed by NMSSA to arrive at population estimates of achievement using plausible values.

Joint maximum likelihood estimation (JMLE)

The joint maximum likelihood estimation (JMLE) method was used in NMSSA analysis from 2012 to 2014. The method was devised by Wright & Panchapakesan (1969). The estimate of the Rasch parameter occurs when the observed raw score for the parameter matches the expected raw score. 'Joint' means that the estimates for the persons and items are obtained simultaneously. While JMLE person parameters generate unbiased estimates of population means, population standard deviations are generally **over**-estimated with JMLE. This bias in the estimates of standard deviation increases the fewer items each individual completes (Wu, 2005).

Marginal maximum likelihood estimation (MMLE)

With marginal maximum likelihood estimation (MMLE) item difficulties are structural parameters. Person abilities are incidental parameters, integrated out for item parameter (difficulty) estimation by imputing a person measure distribution. The item difficulties can then be used for estimating EAP person abilities (see below) in a subsequent step (Linacre, 2015).

Expected a posteriori estimation (EAP)

Expected a posteriori (EAP) person estimation is derived from Bayesian statistical principles. It requires assumptions about the expected parameter distribution – usually a normal distribution (Linacre, 2015). As a consequence, EAP person estimates are usually more normally distributed than person estimates derived using JMLE which have no distributional assumptions applied. EAP person estimates provide unbiased estimates of population means as do JMLE person estimates. However, estimates of population standard deviations are **under**-estimated. The bias in the estimates of population standard deviations becomes more marked as assessments become shorter (Wu, 2005).

Plausible values

To generate plausible values we use MMLE to estimate item parameters and EAP estimation to estimate person parameters. An EAP person estimate represents the mean of an individual's estimated score distribution. To generate a set of plausible values a random draw is taken from each individual's estimated score distribution. In NMSSA, 50 such sets of plausible values are generated.

Latent regression

If there is an interest in estimating statistics for population subgroups of students, such as year level, gender, or ethnic group, the generation of plausible values needs to take these group structures into account (Wu, 2005). For example, for an assessment administered to students in Year 4 and Year 8, it is most likely the case that the combined sample of Year 4 and Year 8 students is really a mixture of two underlying normal distributions with different means.

Any population sub-group which is to be reported on in the main NMSSA reports must be accounted for in the latent regression analysis. These variables (defining subgroup membership) are sometimes called 'conditioning variables'. The subgroup population estimates are conditional on subgroup membership.

In NMSSA, the variables defined in the latent regression are year level, gender, ethnic group membership and school decile group.

4. Calculating population statistics from plausible values

When calculating population statistics, the statistic of interest (a mean, or a standard deviation for example) is calculated 50 times, once for each set of plausible values. To achieve the final population estimate, the mean over all 50 results is taken. In this way both sampling error and measurement error are accounted for (Beaton et al., 1995).

For example a population (or subpopulation) mean would be estimated by

$$m = \frac{1}{P}\sum_{p=1}^{P}\left(\frac{1}{N}\sum_{i=1}^{N}X_{pi}\right)$$

Where P = number of sets of plausible values being used

N = number of persons in the sample

X_{pi} = the achievement estimate, X, of person *i* in the p^{th} set of plausible values

A population standard deviation is estimated by:

$$s = \frac{1}{P}\sum_{p=1}^{P}\sqrt{\left(\frac{1}{N-1}\sum_{i=1}^{N}(\bar{X}-X_{pi})^2\right)}$$

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UNIVERSITY of OTAGO
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NEW ZEALAND

NZCER
Rangahau Mātauranga o Aotearoa

ISSN: 2350-3238 (Online only)

ISBN: 978-1-927286-45-6 (Online only)

New Zealand Government