Students' maths self-efficacy exceeds their predicted achievement: Initial findings of an ongoing study

Linda Bonne and Elliot Lawes

NZCER
Rangahau Mātauranga o Aotearoa

Students' maths self-efficacy exceeds their predicted achievement: Initial findings of an ongoing study

Linda Bonne and Elliot Lawes

In this New Zealand study, the maths self-efficacy and achievement of Year 4–10 students is being tracked over 3 years. A particular strength of this study is that maths self-efficacy is being measured in relation to items that have been psychometrically located on a difficulty scale, enabling students' self-efficacy responses to be interpreted in relation to the same scale.

The clear picture emerging from an analysis of the first round of data was that, on average, students' expectations of success on a range of mathematics items exceeded what could reasonably be predicted based on their actual achievement. This applied across all students, regardless of their characteristics (gender, ethnic group, year level) and school decile. However, the extent to which students' maths self-efficacy exceeded their predicted achievement varied between groups of students, with those in low-decile schools tending to report self-efficacy levels that exceeded their predicted achievement by more than their peers in mid and high-decile schools.

Introduction

Indications are that student achievement in maths has plateaued or declined in this country over the past decade. For example, in the 2014/15 round of the TIMSS (Caygill, Singh, & Hanlar, 2016), the mean maths achievement of New Zealand Year 5 students had not changed significantly since the 2002/03 round and was lower than the mean score of 33 participating countries, including the other predominantly English-speaking countries. Additionally, the range of Year 5 student achievement was wider in 2014/15 than in the 2010/11 round. The results for Year 9 students echoed these patterns.

In this project, we deliberately shifted the focus away from being solely on achievement in maths to include a non-cognitive factor (self-efficacy), the importance of which was highlighted in Anthony and Walshaw's (2007) synthesis of New Zealand and international research into effective maths pedagogy. They concluded that teachers establishing participation processes and expectations with students' input and nurturing their confidence as part of establishing their identity as maths learners, enhance students' engagement and achievement in maths.

Framing the study

In the Maths self-efficacy and achievement project we have taken a specific focus on maths self-efficacy, as well as achievement, and aim to understand how the relationship between these changes over time for students. In line with Bandura's (1986) social cognitive theory, we conceptualised maths self-efficacy as the extent to which a student believes they can successfully solve specific maths problems.

The findings of two cross-sectional studies that have included questions seeking New Zealand students' views about their experiences of learning mathematics (Caygill, Kirkham, & Marshall, 2013; Educational Assessment Research Unit & New Zealand Council for Educational Research, 2015) suggested the relationship between achievement and self-efficacy is likely to vary for different groups of students. This project will test whether this holds for a large sample of students, whether the relationship changes over time for some of the same students, and how closely maths self-efficacy and achievement are associated for various sub-groups of learners.

Findings from the same two studies also indicated that Māori students' and Pasifika students' expectations of success in mathematics are likely to exceed their actual achievement to a greater degree than those of Asian students. The current project will expand what is known about Māori students' and Pasifika students' beliefs about their abilities in maths, and how these relate to their actual achievement. It will also build knowledge about any differences attributable to students' age, gender, or socio-economic situations by investigating the following research questions.

- How do distributions of students' maths self-efficacy vary according to year level and other key demographic factors?
- How closely are maths self-efficacy and achievement aligned for different groups of students?
- How does students' maths self-efficacy change over time?
- How does the relationship between students' maths self-efficacy and achievement change over time?

Research design

A strength of the research design is the connection between the maths self-efficacy and achievement items. We followed Bandura's recommendation that self-efficacy judgements should be specific to the performance variable in relation to which they are made. So, students' maths self-efficacy judgements in relation to a set of problems were compared with their actual performance on parallel problems (rather than to maths as a general domain).

In addition to the maths self-efficacy and achievement measures being connected by using parallel problems, the difficulty level of problems was a consideration. The estimated difficulty of each mathematics problem has previously been located on a Rasch measurement scale (the $patm$ scale), enabling us to interpret students' self-efficacy judgements with greater meaning and precision than in previous studies. For example, a positive self-efficacy judgement made in relation to a difficult problem typically indicates greater self-efficacy than a positive judgement in relation to an easy problem.

Following a small pilot in 2015, we conducted a trial of the mathematics self-efficacy items at the start of the school year in February 2016. A total of 1,373 students in Years 3 to 10 at six

schools participated in the trial.[1] Our analysis indicated the maths self-efficacy items performed well enough in the trial to proceed with the research project with no further changes to the items themselves.

The first round of data was collected over the first school term in 2017 and is the focus for this summary report. A follow-up report later this year will include findings from the second round of data from the start of 2018, with a third and final round to be gathered in the first term of 2019.

Maths self-efficacy instrument

Each student responded to four maths self-efficacy items at the start of an online Progressive Achievement Test (PAT): Maths assessment (Darr, Neill, Stephanou, & Ferral, 2007). The self-efficacy items paralleled achievement items in the series of seven age-appropriate assessments (28 unique self-efficacy items in all). Students were asked not to solve the problems but to decide whether they think they could. In response to the question, "Do you think you could solve the problem?", they chose from four response options: "I definitely couldn't", "I might not be able to", "I might be able to", or "I definitely could".

Mathematics achievement measure

PAT: Maths is a series of age-appropriate assessments, widely used in New Zealand schools. The assessments align with the New Zealand Curriculum and include problems designed to assess students' understanding in number and algebra, geometry and measurement, and statistics. The PAT: Maths assessments can be completed online and are provided at different levels of difficulty. Teachers select the assessment that best matches their students. All schools that pay to use these online assessments were given the option of using the PAT: Maths with the self-efficacy instrument included as a pre-assessment activity.

Procedure

In the first school term of 2017, the first of three rounds of data was collected from 2,364 Years 4 to 10 students. Details of these students' year levels are shown in Table 1. The second round of data was collected in Term 1 of 2018 and is currently undergoing analysis. The third and final data collection will occur in Term 1 of 2019.

Data analysis

A total of 27 schools contributed data to this analysis. To analyse students' responses, we divided students into a number of groups according to their gender, ethnic group, the level of test they completed, and the decile of their school.

For students who completed the easiest test we compared the proportion of responses in each self-efficacy category across achievement quartiles. We repeated this comparison for each

---

[1]   A report on the trial is available on request.

test level. This provided us with a within-test-level perspective on the relationship between mathematics self-efficacy and achievement.

Then, for each of these student groups determined by gender, ethnic group, year level, and school decile grouping, we estimated two percentages.

The first percentage we refer to as the group's self-efficacy rate. This is the number of times that students from the group made a self-efficacy judgement that was "I definitely could" (solve the problem) or "I might be able to" (solve the problem) as a percentage of the total number of self-efficacy judgements made by students in that group.

The second percentage we refer to as the group's predicted achievement rate. Here, we imagine that the self-efficacy items are simply mathematics items that the students will attempt. We then predict the number of times that students from the group would be able to correctly answer an item as a percentage of the total number of self-efficacy judgements made by students in that group. We make this prediction using the Rasch model together with each student's measured mathematics achievement score and the measured difficulty scores of items parallel to the self-efficacy items that that student encountered.

The difference between the self-efficacy rate and the predicted achievement rate for a group quantifies the extent to which the group's average self-efficacy and average achievement differ. For example, the difference between these two rates for a given group would be small when students in the group typically had an accurate idea of whether or not they could correctly answer mathematics items.

Initial findings

Maths self-efficacy and predicted achievement were correlated

Consistent with previous research, students with higher maths self-efficacy tended to have higher achievement.[2] The relationship between maths self-efficacy and achievement is illustrated in Figures 1 and 2. Figure 1 shows, for each achievement quartile in Test 1 (the easiest test, appropriate for typical Year 4 students), the proportion of each possible self-efficacy judgement made across all four self-efficacy items that each student encountered. Figure 2 shows the same information for Test 5 (appropriate for typical Year 8 students). The proportion of students who expressed positive self-efficacy increased with their achievement on the *patm* scale for both these tests. A similar trend was evident for all tests.

---

[2] For example, suppose that two students experienced the same self-efficacy items, and responded to these self-efficacy items identically except that on one self-efficacy item the first student's response was one category more positive than the second student's. Given the relationship between self-efficacy and achievement, we would expect the first student's mathematics achievement to be approximately 2 *patm* higher than the second student's.

Figure 1 **Students' maths self-efficacy responses according to achievement quartile on the *patm* scale, Test 1.**
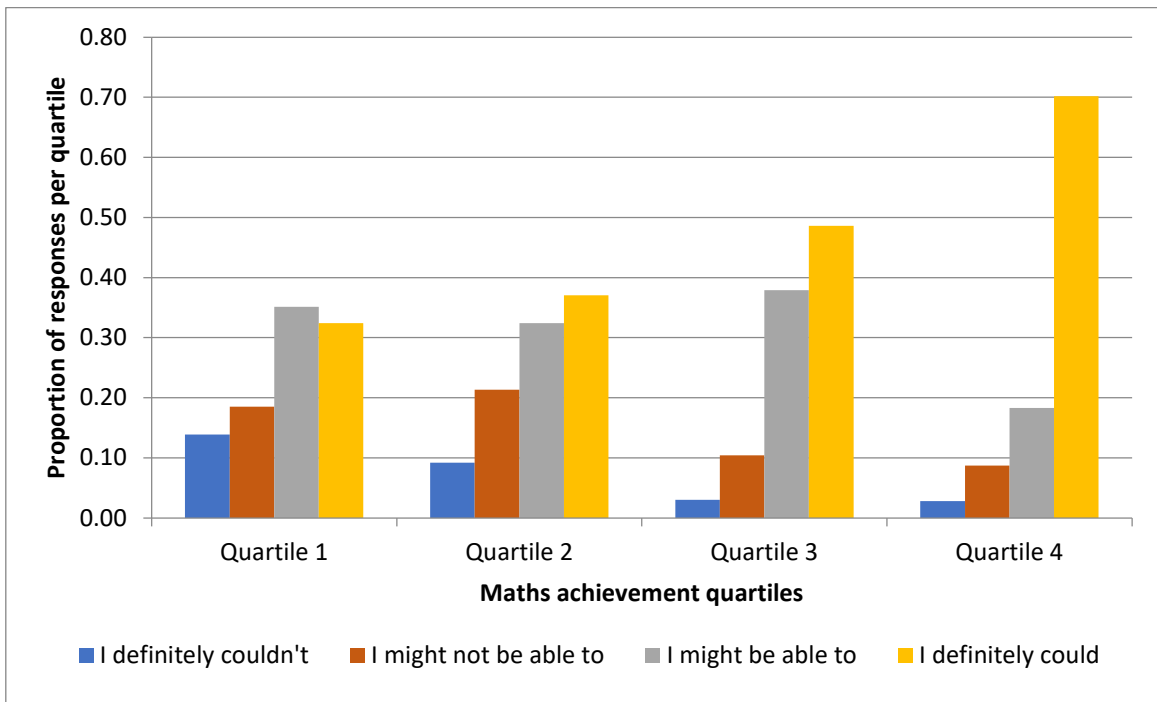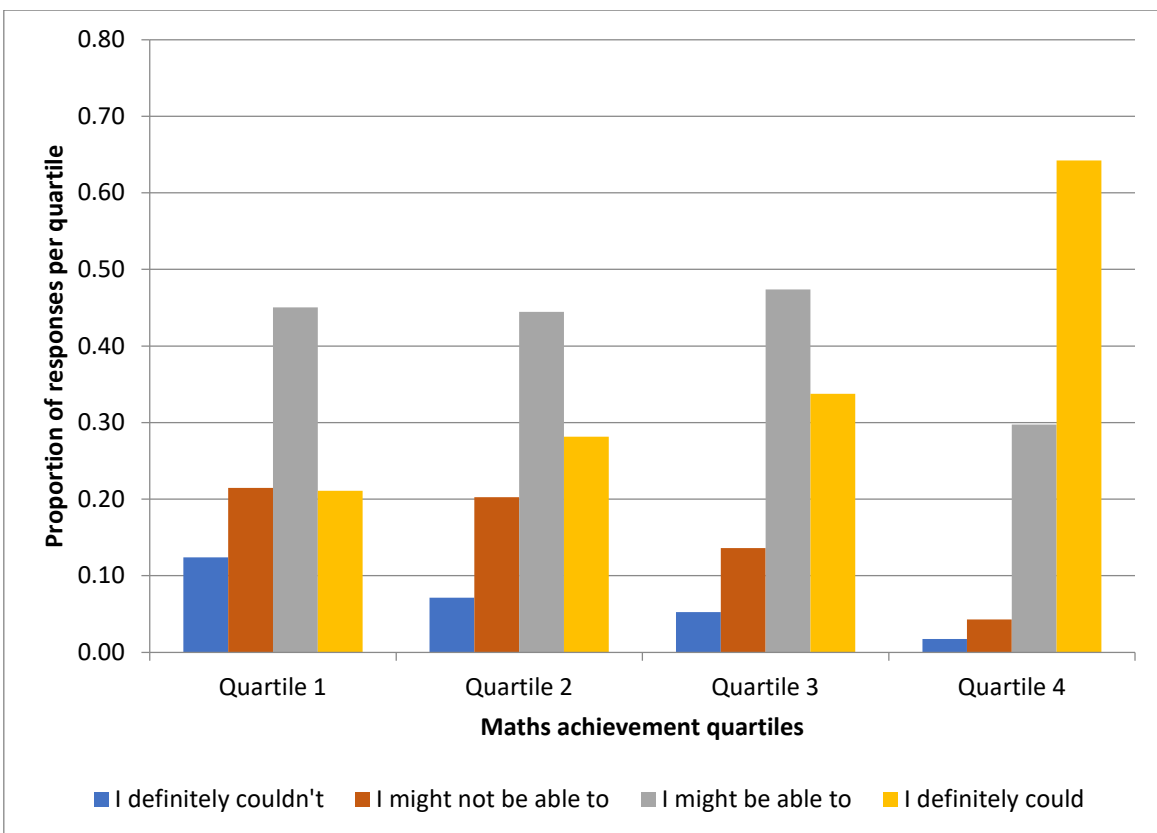

Figure 2 **Students' maths self-efficacy responses according to achievement quartile on the *patm* scale, Test 5.**

Maths self-efficacy exceeded what we would have expected, given achievement

Comparing the self-efficacy and predicted achievement rates for groups of students (see Table 1, Table 2, and Table 3), we were surprised that maths self-efficacy, on average, exceeded students' predicted achievement, regardless of student characteristics (gender, ethnic group, year level) and school decile. This was more widespread than we had anticipated. For all students combined, the average self-efficacy rate was 82% and the average predicted achievement rate was 59%.

Table 1 **Student predicted achievement and self-efficacy rates by gender and ethnic group**

Group	Number of group members	Number of SE assessments experienced	Number of model-predicted correct answers	Predicted achievement rate (%)	Number of positive SE responses*	Self-efficacy rate (%)	Difference between predicted achievement rate and self-efficacy rate (percentage points)
Boys	1248	4472	2746	**61**	3676	**82**	**21**
Girls	1116	3993	2241	**56**	3251	**81**	**25**
Pākehā	1451	5090	2939	**58**	4137	**81**	**24**
Māori	354	1260	526	**42**	964	**77**	**35**
Pasifika	91	337	112	**33**	247	**73**	**40**
Asian	502	1902	1417	**75**	1649	**87**	**12**

*Positive self-efficacy responses were "I definitely could" and "I might be able to".

Table 2 **Student predicted achievement and self-efficacy rates by year level**

Group	Number of group members	Number of SE assessments experienced	Number of model-predicted correct answers	Predicted achievement rate (%)	Number of positive SE responses*	Self-efficacy rate (%)	Difference between predicted achievement rate and self-efficacy rate (percentage points)
Year 4	406	1362	924	**68**	1078	**79**	**11**
Year 5	472	1697	1162	**68**	1463	**86**	**18**
Year 6	502	1827	1196	**65**	1521	**83**	**18**
Year 7	160	595	336	**56**	498	**84**	**27**
Year 8	173	651	350	**54**	544	**84**	**30**
Year 9	336	1242	492	**40**	987	**79**	**40**
Year 10	315	1091	527	**48**	836	**77**	**28**

*Positive self-efficacy responses were "I definitely could" and "I might be able to".

Table 3 **Student predicted achievement and self-efficacy rates by school decile grouping**

Group	Number of group members	Number of SE assessments experienced	Number of model-predicted correct answers	Predicted achievement rate (%)	Number of SE assessed "correct" answers	Self-efficacy rate* (%)	Difference between predicted achievement rate and self-efficacy rate (percentage points)
Decile 1, 2, 3	135	491	132	**27**	341	**69**	**43**
Decile 4, 5, 6, 7	457	1587	793	**50**	1289	**81**	**31**
Decile 8, 9, 10	1772	6387	4063	**64**	5297	**83**	**19**

*Positive self-efficacy responses were "I definitely could" and "I might be able to".

Differences between self-efficacy and predicted achievement rates varied very little by student gender. Although girls' and boys' positive self-efficacy rates, on average, were very similar, girls, on average, had a slightly lower predicted achievement rate.

Some of the between-group variations we identified in the difference between students' positive maths self-efficacy and predicted achievement rates were consistent with previous research. Differences between self-efficacy and predicted achievement rates varied by school decile. Of all of the groups of students that were compared in Table 1, Table 2, and Table 3, students attending decile 1–3 schools showed the biggest difference, on average, between their positive self-efficacy and predicted achievement rates (43 percentage points). This group also had the lowest predicted achievement and the lowest positive self-efficacy rates, on average.

Students' ethnic group was associated with differences between self-efficacy and predicted achievement. The difference between the predicted achievement rate and positive self-efficacy rate was 40 percentage points for Pasifika students (who also tend to be disproportionately represented in decile 1–3 schools). Māori students showed a slightly smaller difference (35 percentage points). In contrast, the group with the highest predicted achievement and the highest positive self-efficacy rates, on average, was Asian students. There was a relatively small difference of 12 percentage points between these rates.

Differences between self-efficacy and predicted achievement rates increased with year level. Students' predicted achievement rates tended to decrease with year level. This decrease in predicted achievement rates with year level was not echoed in the positive self-efficacy rates. Instead, the latter remained within a 77–86% range.

Looking ahead

When we analyse the data from Term 1 in 2018 and 2019, we hope to be able to identify how relationships between maths self-efficacy and achievement change over time for groups of the same students.

In the meantime, this year's National Monitoring Study of Student Achievement (NMSSA) which took place in Term 3 has maths as a focus. Several items have been included in students' and teachers' questionnaires about their roles in formative assessment and feedback that may illuminate the initial findings of the current research.

Acknowledgments

References

Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/pāngarau: Best evidence synthesis iteration [BES]*. Wellington: Ministry of Education.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Caygill, R., Kirkham, S., & Marshall, N. (2013). *Year 9 students' mathematics achievement in 2010/11: New Zealand results from the Trends in International Mathematics and Science Study (TIMSS)*. Wellington: Ministry of Education.

Caygill, R., Singh, S., & Hanlar, V. (2016). *TIMSS 2014/15 key findings: Mathematics Year 5*. Available at: https://www.educationcounts.govt.nz/publications/series/2571/timss-201415

Darr, C., Neill, A., Stephanou, A., & Ferral, H. (2007*). Progressive achievement test: Mathematics* (2nd ed.), Revised. Wellington: New Zealand Council for Educational Research.

Educational Assessment Research Unit & New Zealand Council for Educational Research. (2015). *National monitoring study of student achievement: Mathematics and statistics 2013*. Wellington: Ministry of Education.

NZCER

Rangahau Mātauranga o Aotearoa