STUDENTS' MATHEMATICAL WELLBEING DURING A CULTURALLY SUSTAINING MATHEMATICS PEDAGOGY PROFESSIONAL DEVELOPMENT INITIATIVE

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Developing equitable outcomes for all students in mathematics has been an ongoing focus in both research and policy. In New Zealand, a professional learning and development (PLD) initiative, Developing Mathematical Inquiry Communities, supports teachers to use culturally-sustaining mathematics pedagogy with marginalised students. The study presented in this paper investigates student mathematical wellbeing (MWB) in schools undertaking this PLD. We focus on students' MWB across the number of years of school participation in the PLD and following the PLD completion in the fourth year and beyond. Findings showed higher student MWB in schools that had completed the PLD. Implications for PLD programmes in mathematics education are discussed.

INTRODUCTION

Both within New Zealand and internationally, an ongoing challenge has been persistent inequity in a range of outcomes related to mathematics education for marginalised groups of students. New Zealand schools, similar to many other Western countries, have a changing student demographic including a large number of Indigenous Māori students and increasing numbers of students of Pacific descent. People of Pacific descent are a diverse heterogeneous group of people with heritage to the Pacific nations such as Samoa, Tonga, the Cook Islands, Niue, Tokelau, and Fiji. Research studies illustrate teachers' deficit perceptions in relation to marginalised students' capability in mathematics and others show deficit beliefs are highly resistant to change (e.g., Louie, 2017; Turner et al., 2015). Both deficit teacher perceptions and the ongoing documented challenge of achieving equitable outcomes for Māori and Pacific students (Allen & Trinick, 2021; Hunter & Hunter, 2018) have the potential to influence students' MWB.

When students' values are fulfilled in the mathematics classroom they feel good, are more engaged, and become more resilient to challenge and adversity – that is, they have high MWB. Conversely, because wellbeing is value dependent, cultural mismatches in the mathematics classroom (i.e., teachers or pedagogical values incongruent with students' cultural values) can contribute to anxieties, disengagement, or poor achievement (Stephens et al., 2012; Hill et al., 2021) – all indicators of ill-being. In New Zealand, Māori and Pacific students experience a cultural mismatch between the values of a Eurocentric educational system and their own cultural values

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and often believe mathematical success is possible only when they suspend their own cultural identity and values (Hunter & Hunter, 2018). Milne (2013) describes this as 'white space' - or when marginalised students assume the mindset of the dominant culture. This cultural identity flipping reinforces deficit beliefs; degrades student autonomy, and agency; impacts on students' motivation to learn; and ultimately undermines their wellbeing (Ryan & Deci, 2000). We argue shifting marginalised students' mindsets so they can begin to embody and celebrate their cultural values in the mathematics classroom requires a sustained, dedicated, and long term approach.

Culturally responsive/sustaining mathematics pedagogy (CSMP) is a means of responding to cultural mismatches and addressing challenges in relation to equitable outcomes for marginalised students (Gay, 2010; Paris, 2012). In New Zealand, a three-year professional learning and developmental initiative called *Developing Mathematical Inquiry and Communities* or DMIC (see following section) focuses on CSMP and aims to counteract deficit theorising, support teacher practices for inclusivity and enactment of lessons of higher intellectual quality; and support student MWB through cultural value alignment. This study reports on students' responses to a survey measuring their MWB. Specifically, we investigate the difference in MWB for students attending schools engaged in the first, second or third year of DMIC PLD or those students' attending schools which have completed the PLD and are working to sustain the practices that align with the PLD.

DMIC PROFESSIONAL LEARNING AND DEVELOPMENT INITIATIVE

The DMIC model is a research-based professional development and pedagogical change initiative. A key component is the construction of collaborative learning communities across schools, with groups of teachers, and in individual schools and classrooms. The PLD is set within the central tenets of a culturally sustaining model (Paris, 2012) as well as supporting teachers to create, plan and enact ambitious mathematics pedagogy to raise mathematics achievement (Kazemi et al., 2009). New Zealand schools serving marginalized Pacific communities are prioritised for inclusion in the initiative, which is funded by the New Zealand Ministry of Education. Many of these schools also have significant numbers of students of Indigenous Māori heritage.

The DMIC PLD takes a whole-school approach predominantly working with teachers from primary and middle schools (Year One to Year Eight) with some involvement in lower secondary schools (Year Nine and Year Ten). Over the three-year period it involves two complementary forms of PLD, out-of-class PLD sessions and in-class mentoring. In the third year, a lesson-study process (Hunter & Back, 2011) is introduced to develop sustainability. The out-of-class PLD offers opportunities for exploration, discussion, and reflection on pedagogical practices aligned with CSMP and ambitious pedagogy. This includes identifying and building on student funds of knowledge and cultural values, using challenging tasks, implementing mathematical practices with students, and noticing and responding to students' mathematical thinking. During the in-class mentoring, the mentor and teacher work together to co-

construct mathematics lessons and critically reflect on and shift pedagogical practices. This includes explicitly noticing student strengths and creating a classroom environment for respectful social interactions. A key focus in working with teachers is to support them to engage students in a range of mathematical practices such as explanation, justification, and generalisation while also considering the cultural values and beliefs of the students (Hill et al., 2019; Hunter & Hunter, 2018). Following the third year of the professional development, schools move to independently sustaining the pedagogical practices with support when necessary in the form of out-of-class PLD sessions and in-class mentoring only for new teachers at the school. Aligning the teachers' pedagogical values with students' values underpins DMIC with the aim of promoting positive learning outcomes like enjoyment, interest achievement, and engagement – all components of MWB.

THEORETICAL FRAMEWORK & BACKGROUND

Here we define MWB as feeling good and functioning well (Huppert & So, 2013) accompanied by a positive state of functioning from students' experiences in the classroom aligning with their personal, or cultural values (Tiberius, 2018). We explore MWB according to seven dimensions previously identified in the literature (see review by Hill et al., 2022): accomplishments, cognitions, engagement, meaning, perseverance, positive emotions, and relationships. In this study we also include cultural identity as an eighth dimension because of links to Pacific and Māori wellbeing (Matika et al., 2021). Pacific and Māori people embrace collectivist cultural values like respect, relationships, family, belonging, and inclusion. Studies indicate cultural identity, language, and the ability to live in accordance with values, are closely tied with positive wellbeing for Pacific and Māori people (Matika et al., 2021). Applied to the classroom, Pacific and Māori students who feel a sense of cultural pride, cultural belongingness, connectedness, and have their cultural norms/values embraced (e.g., community, love, reciprocity) would likely experience higher wellbeing. These eight dimensions are interconnected rather than being mutually exclusive, e.g., feeling accomplished is often accompanied by positive feelings.

METHODS

In this study, students self-reported their MWB using an 11-point likert scale with 21 questions covering eight MWB dimensions (Hill et al., 2022). This survey was developed from existing wellbeing surveys (e.g., the PERMA wellbeing profiler with 23 survey questions, Butler & Kern, 2016) however, here we adapted the survey questions to reflect mathematics education. For example, survey questions included: *In my maths class I have friends that support me when I need it* (relationship dimension); *Maths is an important part of my culture* (cultural identity dimension); or *When I am doing maths I feel happy* (positive emotion dimension). Cronbach's alpha showed an acceptable internal consistency across each of the eight wellbeing dimensions ($0.68 < \alpha > 0.93$).

Participants included 4218 students (50% male) across New Zealand, including students from Years 3 to 10 (aged 7 to 15). Students were culturally diverse, self-identifying as Pakeha/European (*n* = 2502), Māori (1014), Pacific (384), Asian (291), or unspecified (27). Students attended schools that were either in their first year (*students n* = 1101; *schools n* = 13), second year (1752; 27), third year (1174; 12), or post PLD (191; 4). Students completed the survey in 2021 at the start of Term 1, thus Year 1 were schools right before they had started the PLD (i.e., a baseline group), Year 2 was after a full year of DMIC (and into the second year) and similarly with Year 3. Post PLD were students from schools who had finished the three-year DMIC PLD and were working on sustaining the pedagogical practices aligned with the PLD.

Survey data were imported into SPSS 28, with univariate ANOVA (using post-hoc Tukey tests) assessing statistically significant main effects in students' ratings of MWB across each year schools had participated in the DMIC initiative. Thus, our Year 1 group (shown in Figure 1) included students from multiple Year levels and schools and likewise with the second, third, and post DMIC PLD groupings.

RESULTS

The mean ratings for overall MWB (dotted line) and for each of the eight dimensions (solid colored lines) are displayed in Figure 1.

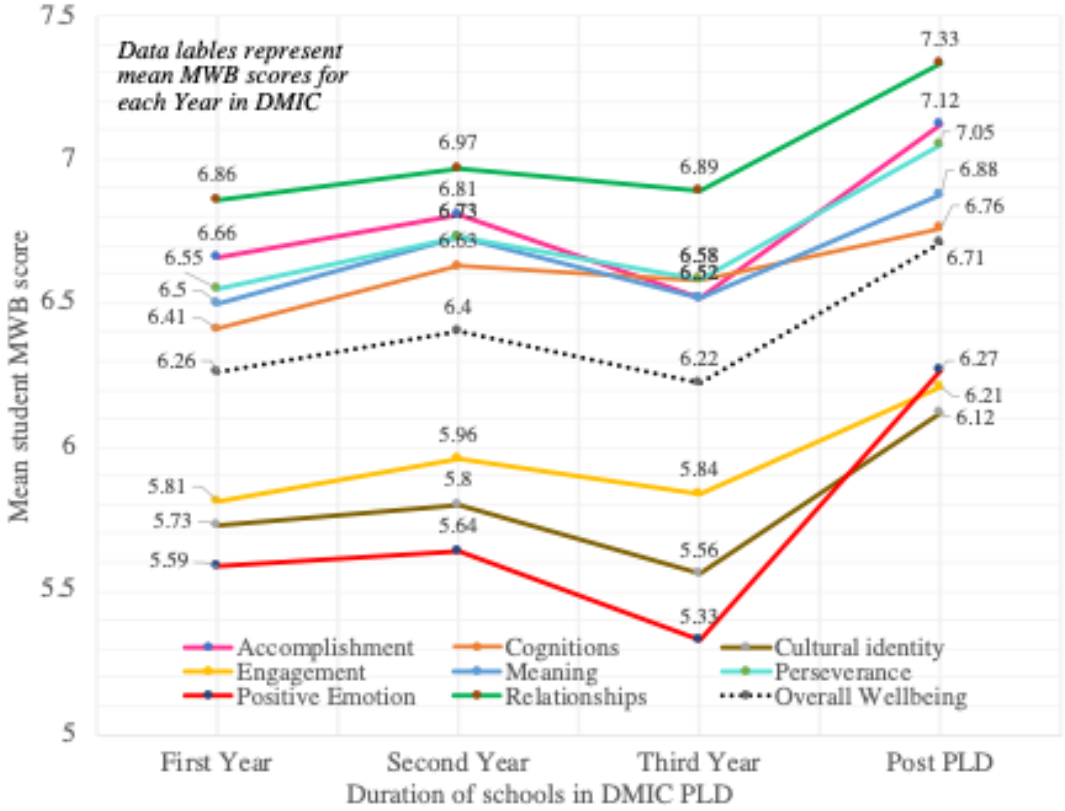

Figure 1: Mean MWB scores across length of time in DMIC PLD.

As shown in Figure 1 students across all years in the DMIC initiative tended to rate relationships (green line) the highest and positive emotions (red line) the lowest, except for the post DMIC period where positive emotions rapidly improved relative to the

other MWB dimensions in the same period. Statistically significant main effects were found for overall student MWB $F(3, 4227) = 5.5$, $p < .001$, attributed to students having significantly higher overall MWB post DMIC (see Figure 1 for all mean values) compared to both the first and third, but not the second years of DMIC. Concerning the eight MWB dimensions, main effects were found for all dimensions except engagement (accomplishment $F(3, 227) = 5$, $p = .017$; cognitions $F(3, 4227) = 2.61$, $p = .05$; culture $F(3, 4203) = 4.12$, $p = .006$; meaning $F(3, 4227) = 3.4$, $p = .017$; perseverance $F(3, 4226) = 3.88$, $p = .009$; positive emotions $F(3, 4226) = 7.39$, $p < .001$; and relationships $F(3, 4227) = 3.36$, $p = .018$). These effects were predominantly because students rated relationships, positive emotions, accomplishment, and perseverance significantly higher in the post DMIC period compared to first and third years of DMIC; positive emotions were rated higher in the post DMIC period compared to all other years; meaning was rated significantly higher only in the second compared to third year; cultural identity higher only in the post DMIC period compared to the third year. Taken together the DMIC PLD programme appears to enhance students MWB broadly and across multiple MWB dimensions from the post PLD period.

DISCUSSION AND CONCLUSION

Our findings demonstrate a positive association between schools participating in the DMIC PLD with higher student MWB, with improvements in students' MWB more likely when they attend schools who have completed the 3-year PLD initiative and are sustaining the pedagogical practices (i.e., the post PLD period). This is an important finding because it demonstrates improvements to student MWB can be sustained even after the PLD has concluded. Key aspects of the DMIC PLD include a focus on CSMP and the introduction of ambitious pedagogy and mathematical practices in ways that align with marginalised students' cultural values. For example, to align with values of respect and collaboration teachers introduce mathematical argumentation as "friendly arguing" and teach students how to disagree with a mathematical idea in a polite way while positioning this both as a respectful action (i.e., it is respectful to show that you have thought deeply about a peer's idea) and an action to collaboratively support others (i.e., through sharing and constructing mathematical ideas). Introducing these high leverage practices in ways that draw on value alignment/fulfillment may in part explain why students' MWB continued to improve post PLD. Additionally, we conjecture that the schools which were working on sustaining the pedagogy post the PLD may have implemented the pedagogical practices with high fidelity (e.g., aligning pedagogical values with students values) over an extended period of time.

Our findings suggest improving students' MWB may not be a quick process, thus a long-term approach to mathematics PLD, to ensure changes in teacher practices and beliefs is required. Earlier research (e.g., Horn, 2010) highlighted the extended time and incremental process for teachers to enact new pedagogies. As teachers see the results of their actions in classrooms impacting student outcomes, the evidence promotes a shift in deficit beliefs and affirms the pedagogical actions, leading to more sustained classroom practices. However, because student outcomes are often delayed

following PLD enactment, as acknowledged in a review of educational PLD (Kennedy, 2016), teachers may doubt the efficacy of their actions resulting in a premature reversion to initial practices. This phenomenon may be contributing to the results shown here in our study where MWB across a range of dimensions decreased slightly (though not significantly) between the second and third year of the DMIC PLD. Alternatively, we conjecture that this may be related to the timeframe in which these schools began the DMIC PLD in 2020. The PLD delivery in 2020 was significantly disrupted due to COVID-19 lockdowns and school closures in the first part of the school year and middle of the year. We will continue to examine this as part of the longitudinal data collection in future to see whether the dip in MWB is consistent in the third year of the PLD.

Our earlier study (Hill et al., 2022) demonstrated a decline in MWB as students progressed through school. Follow-up studies will also investigate how the year level of students interacts with the length of time in the PLD in relation to student MWB. The ultimate effects of PLD on student MWB and other outcomes are likely not completely visible until towards the end of the period of professional learning. Our results support an argument that mathematics PLD evaluation should take a long-term view (Kennedy, 2016) in studying both teacher practices and student outcomes beyond the end of the PLD and as schools themselves sustain the changes in practice.

Notably, our findings point to the positive emotion MWB dimension showing the most change from beginning to post DMIC PLD period (a 0.7 point increase), followed by relationships, and perseverance (both 0.5 point increases). Across many countries, a significant challenge of mathematics education is the negative feelings, dislike, and anxieties students hold towards mathematics, and once developed, these negative feelings often carry through well into adulthood (Grootenboer & Marshman, 2015). Key components of the DMIC PLD focus on elements which potentially improve positive emotions towards mathematics by shifting student perceptions of what it means to do mathematics. For example, a previous qualitative study (Hunter et al., 2019) focused on the changes in Pacific and Māori student perceptions of mathematics after the first year of the DMIC PLD, responses shifted from the majority of students describing learning mathematics as number and calculations at the beginning of the PLD, to students predominantly describing learning mathematics as participatory practices and problem solving.

The DMIC PLD advocates teacher pedagogical practices that align with key collectivist Pacific values such as relationships and collaboration. The strong improvement in students' ratings of the relationship and cultural identity dimensions suggests the PLD is supporting teachers to use practices that fulfill students' cultural values by promoting closer relationships and allowing students to embrace their cultural identity thus counteracting the 'white space' mindset (Milne, 2013). Similarly, the increase in students' ratings of perseverance is encouraging because students who persevere are more likely to recognise their strengths and attempt to persist for a greater

length of time with challenging mathematics tasks. This in turn raises the potential for student achievement and higher accomplishment MWB.

We acknowledge the need for further studies that also draw upon qualitative data to examine and identify both teacher and students' perspectives in relation to the reasons for the shifts in MWB. Additionally, further research should focus on the relationship between teacher actions in the mathematics classroom and student MWB. It would also be beneficial to interrogate longitudinal matched data on student MWB from the same schools to provide a more robust view of the changes in student MWB over time point data. These areas will be the foci of future studies which are currently in progress.

To conclude, we have shown the potential of developing more positive student MWB through the use of PLD which addresses both CSMP and ambitious pedagogy. We note the importance of recognising and building upon cultural values to ensure values alignment and fulfillment. We also illustrate the importance of both a long-term approach to mathematics education PLD and longitudinal data collection related to student outcomes following PLD.

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