Examining perseverance and persistence in relation to students' mathematical wellbeing

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Abstract: Student mathematical wellbeing (MWB) declines as students progress through school. This study investigates the role of perseverance and persistence in supporting students' MWB, focusing on how these qualities manifest in the context of mathematical learning. Based on a survey with 13,381 students across Grades Three to Ten in New Zealand, our findings revealed a decline in students' experiences of perseverance and persistence across grade levels, particularly during transitional periods. Qualitative analysis of student responses highlighted the relationship between perseverance, persistence, and MWB. Students who reflected on perseverance as an enabler of their MWB often associated it with overcoming mathematical challenges, which provided a sense of accomplishment and positive emotions upon successful task completion. The study underscores the importance of fostering perseverance and persistence within a supportive classroom environment to enhance students' mathematical understanding and overall MWB. Our findings contribute to the growing body of research on mathematical affect and provide insights into how educators can cultivate perseverance and persistence to create more positive and engaging mathematical learning experiences to support the MWB for all students.

Keywords: MWB, 'challenging tasks', engagement, emotions, mathematics education.

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1 Introduction

Both internationally and in Aotearoa New Zealand, there has been a strong general focus on wellbeing, including within educational settings. This is because wellbeing is recognised as an enabler of many positive learning outcomes like improved social functioning and academic performance (Waters, 2011). We argue that wellbeing in mathematics classrooms (or mathematical wellbeing, MWB) is also critically important given that we have ongoing research studies (e.g., Barroso et al., 2021; Ingram et al., 2020; Li et al., 2021) that continue to show a relationship between mathematics teaching and learning and students' negative affect. Also, mathematical affect (e.g., attitudes, emotions) declines as students progress from primary to secondary school (Grootenboer & Marshman, 2015).

Within the broader context of mathematical affect, this study focuses specifically on perseverance and persistence and their relationship to students' mathematical wellbeing (MWB). These constructs have received growing attention concerning student wellbeing and mathematics education. Perseverance fits within the wider concept of grit, defined by Duckworth et al. (2007) as the factors needed for long-term goals, including consistency of interest, perseverance of effort and trait-level passion. Research on grit shows that perseverance is recognised as a predictor of success in education (Park & Peterson, 2006; Xu et al., 2023) as well as a key component of successfully learning mathematics with understanding (Buenrostro & Erhenfeld, 2023; DiNapoli, 2023). Persistence is the sustained and steadfast effort to complete a goal or task (Bass & Ball, 2015). Few studies have examined the concept of perseverance and persistence concerning MWB, particularly from the student's perspective. Our focus on perseverance and persistence is motivated by their potential to positively influence students' MWB, particularly in the face of challenging mathematical tasks.

While previous studies have explored perseverance and persistence in mathematics education (e.g., Sullivan et al., 2020; Williams, 2014), there is a notable gap in understanding how these constructs specifically relate to students' MWB, particularly from the students' perspectives. This study aims to fill this gap by examining the relationship between perseverance, persistence, and MWB across a wide range of grade levels in New Zealand. By doing so, we contribute to the international discourse on fostering positive mathematical experiences and provide insights that can inform educational practices globally.

To this end, the following research questions guided this study:

1. To what extent are students experiencing perseverance and persistence during mathematics teaching and learning?
2. In what context do students reference perseverance and persistence when describing their MWB?

The following sections will discuss MWB, perseverance, and persistence before presenting the methodology, findings, and study discussion.

2 Theoretical framework

2.1 Mathematical wellbeing

MWB centres on student wellbeing, specifically in the context of learning mathematics. Drawing from value-fulfilment theory (Tiberius, 2018) MWB is the fulfilment of seven values (i.e., accomplishments, cognition, engagement, meaning, perseverance, positive emotions, and relationships), accompanied by positive feelings and functioning (Hill et al., 2020, 2021). Accomplishments refer to reaching goals and mastering mathematics, while cognition indicates having the necessary knowledge, skills, and understanding to perform well in mathematics. Engagement refers to feeling interested and absorbed in mathematics, while meaning is the feeling that mathematics learning is useful, valuable, and worthwhile. Perseverance (and related persistence) is the effort, grit, and drive required to complete mathematics, while positive emotions refer to finding enjoyment and optimism towards mathematics. Finally, relationships encompass feeling supported, connected to, and respected by others. While all seven values contribute to MWB, this study focuses primarily on perseverance and its related construct, persistence. We argue that perseverance and persistence play a crucial role in supporting students' overall MWB by enabling them to overcome challenges, develop greater resilience, achieve their goals, and develop a sense of accomplishment in mathematics.

2. 2 Perseverance and persistence

2.2.1 The perseverance and persistence constructs

Perseverance or persistence is often used interchangeably with productive struggle, goal-striving, grit, zeal, and work ethic (Howard & Crayne, 2019). In this paper, we acknowledge the overlaps with these constructs. We define perseverance in line with Kern et al.'s (2016) EPOCH (engagement, perseverance, optimism, connectedness, and happiness) adolescent wellbeing framework. That is the "ability to pursue one's goals to completion, even in the face of obstacles" (Kern et al., 2016, p. 587). Drawing on Bass and Ball (2015, p. 4), we define persistence as "a stubborn resistance to or a lack of change" towards completing a goal. While closely related, we distinguish perseverance as overcoming challenges or obstacles, whereas persistence refers to sustained effort over time.

2.2.2 Perseverance and persistence in mathematics education

Recent studies have highlighted the importance of perseverance and persistence in mathematics education. For example, Williams (2014) examined optimism, persistence, and confidence among elementary students during problem-solving activities in a mathematics class. Students who were confident and high-performing but lacked persistence (or perseverance) actively discouraged themselves and their group members from exploring beyond what they had already been taught. In contrast, confident optimistic students were more engaged in problem-solving and gained deeper mathematical understanding through this process.

Bettinger et al. (2018) reported how a virtual growth mindset intervention program improved secondary students' perseverance and performance (i.e., less likely to give up, more likely to seek out challenging mathematics questions) in mathematics. Elementary students' enjoyment of mathematics, often perceived as a positive aspect of learning, was associated with lower perseverance during mathematical reasoning tasks. Thus, some of the negative or uncomfortable emotions (e.g., frustration, bewilderment) may stimulate students' self-regulation and reasoning processes and contribute to greater perseverance in mathematics (Barnes, 2021). Therefore, teachers may need to look past students expressing frustration or looking stuck and not be misled by signs of enjoyment or engagement to determine if students have experienced barriers to their mathematical persistence. In contrast, Russo and Hopkins (2017) purported elementary students embraced struggle and persisted when engaging in lessons that involved challenging tasks. The students also enjoyed the challenging process (Russo & Hopkins, 2017). Likewise, Clarke et al. (2014) highlighted how students enjoyed working on challenging mathematical tasks and gained deeper understanding through the process of struggle, with one student in their study noting that “We do learn more when we’re confused, and we’ve got to work out way out of it” (p. 73). This quote also highlights how a student’s appraisal of negative emotions (e.g., confusion) in mathematics can provide a sense of personal growth and meaning.

In our study, we aim to extend this line of research by explicitly connecting perseverance and persistence to students' MWB. By examining how students experience and describe these constructs in relation to their MWB, we hope to provide insights into how educators can foster perseverance and persistence to enhance students' overall mathematical experiences and outcomes.

3 Methods

3.1 Research context

The New Zealand education system is structured into 13-year levels, with students typically starting at age 5. Primary education covers Years 1-6 (ages 5-11), intermediate education Years 7-8 (ages 11-13), and secondary education Years 9-13 (ages 13-18). The data reported in this paper is from a larger longitudinal study focused on exploring student mathematical disposition, wellbeing, and achievement of Year 3 to Year 10 students across years of a research-based professional learning and development (PLD) initiative called "Developing Mathematical Inquiry Communities" (DMIC). This has been funded by the New Zealand Ministry of Education in disadvantaged and diverse schools. The PLD initiative draws on a foundation of ambitious mathematics pedagogy to raise mathematics achievement (Kazemi et al., 2009) while also connecting to culturally sustaining practice (Paris, 2012) and is delivered over a three-year period.

All teachers involved in the PLD are provided with mathematical task resources which include grade level teaching tasks aligned with the New Zealand curriculum, independent activities, and associated teacher notes. The provision of mathematical task resources and expectation to use mathematical tasks set at the appropriate curriculum level is important given research studies and national monitoring reports (Blackberry & Kearney, 2021; Graham et al., 2010; Royal Society Expert Advisory Panel, 2021) that indicate low teacher expectations for diverse students and slippage with teachers often using mathematical tasks with their students which are one to two years below the curriculum expectations. Activities during the PLD focus on teachers exploring, discussing, and reflecting on pedagogical practices that align with ambitious mathematics pedagogy in a culturally sustaining way. For example, teachers may collaborate to plan how to launch a cognitively challenging task in a way that all students can access the task and make sense of the task context while building on their cultural values and ways of being as a strength.

3.2 Participants

We focus on 13, 381 students (46% males, 51% females, 3% another gender/unspecified) who self-identified as New Zealand European (n = 4922), African (n = 328), North or South American (n = 114), Asian (n = 1022), Indian, Pakistani or Sri

Lankan (*n* = 641), Māori (*n* = 2534), Middle Eastern (*n* = 125), Pacific people (*n* = 3069), or other (*n* = 626). Students attended one of 35 state primary or secondary schools, including students in grades 3 (*n* = 959), grades 4 (n = 2467), grades 5 (n = 2693), grades 6 (*n* = 2825), grades 7 (*n* = 1471), grades 8 (*n* = 1471), grades 9 (*n* = 584), grades 10 (*n* = 567), or an unspecified grade (*n* = 297).

3.3 Data collection

All schools undertaking the DMIC PLD were invited to participate in the study. Data was collected during school time with students responding to an online Qualtrics survey using a digital device (e.g., laptop, tablet). The survey items used in this study were psychometrically validated amongst Australian (Hill et al., 2024) and New Zealand (Hill & Hunter, 2024) students.

Drawing on established wellbeing frameworks, particularly the EPOCH (i.e., engagement, perseverance, optimism, connectedness, happiness) measure of adolescent wellbeing (Kern et al., 2016), we developed survey items that would meaningfully capture students' experiences of perseverance and persistence in mathematics education. The EPOCH framework has been extensively validated for measuring perseverance in young people, making it particularly suitable as a foundation for our study. In this paper, we report on responses from the entire cohort of students (n = 13,383) to three carefully structured Likert-style questions (ranging from 0 = not like me at all, up to 10 = completely like me). These items were intentionally grouped to assess both cognitive and behavioural aspects of perseverance and persistence:

1. In maths I finish what I begin.
2. I work hard at my maths learning.
3. I keep at my maths work until I am done with it.

This grouping of items allows us to examine different facets of perseverance while maintaining construct validity, as supported by previous research in mathematical wellbeing (Hill et al., 2024).

In addition to these structured items, all students were asked an open-ended survey question: **What makes you feel really good and do really good in maths?** This question was designed to probe student conceptions of and the factors supporting their MWB in relation to mathematics teaching and learning. In this paper, we also focus on a subset of 712 students whose open-ended survey responses

indicated that perseverance or persistence was an enabler of their MWB. We present an analysis of the student's responses with a focus on the context in which students referenced perseverance or persistence when describing their MWB.

3.4 Data analysis

The quantitative survey responses were imported into SPSS (Version 29) for statistical analyses. Cronbach's alpha determined a high inter-reliability ($\alpha = .79$) across the three survey items. Overall means, standard deviation and ranges were calculated for the whole group and across grade levels. Levene's tests confirmed variance homogeneity was violated for each survey item ($p < .01$); thus, a series of three Welch tests were conducted to compare the survey items across grade levels. The Welch test is a robust alternative to the ANOVA when the assumption of equal variance is not met. Pairwise comparisons between each Grade level were made using the Games-Howell post hoc tests.

The qualitative data was imported into NVivo (Version 12) and analysed using reflective thematic analysis (Braun & Clarke, 2019). Given our large dataset ($\underline{n}$ = 13 381), we began with a text search of students' responses using NVivo, searching for key terms (e.g., challenge, hard, perseverance, persistence, having-a-go, struggle) and their associated synonyms. This resulted in over 1700 results (words) which were then manually cleaned and coded using an inductive, data-driven approach.

4 Results in discussion

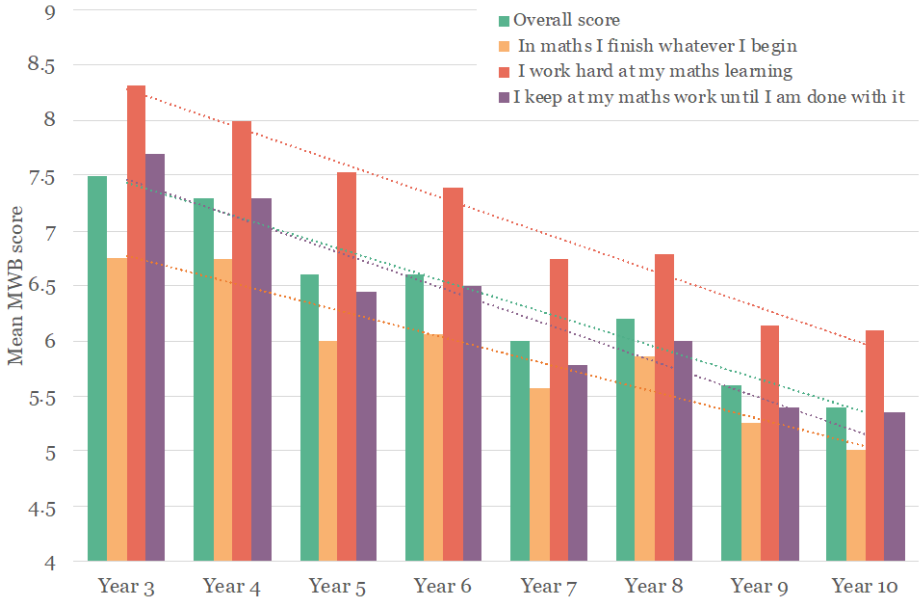
This study highlights the role of perseverance and persistence in supporting diverse students' mathematical wellbeing (MWB). Our findings contribute to the growing body of research on mathematical affect and wellbeing by specifically focusing on how perseverance and persistence relate to students' experiences and perceptions of MWB.

4.1 Students' experiences of perseverance

Our quantitative findings revealed a decline in students' experiences of perseverance and persistence across grade levels, particularly during transitional periods. Figure 1 shows the changes in students' mean experiences of perseverance and persistence across the grade levels, showing a steady decline across all measures from Grades 3 – 8. Welch's test confirmed this decline was statistically significant across all survey

items, including: **Overall perseverance** (composite score) Welch's $F(7, 3888.8) = 95.43$, $p < .01$, $\eta^2 = .05$; **Q1** (*I finish what I begin*) Welch's $F(7, 2793.46) = 43.16$, $p < .01$, $\eta^2 = .02$; **Q2** (*I work hard at my maths*) Welch's $F(7, 4271.13) = 90.14$, $p < .01$, $\eta^2 = .05$; **Q3** (*I keep at my maths work until I am done*) *Welch's F* $(7, 4922.87) = 84.23$, $p < .01$, $\eta^2 = .05$. For the overall perseverance score, the sharpest decreases were often between Years 4 and 5 (*MD* = -.7), Years 6 and 7 (i.e., the primary to secondary school transition, *MD* = -.6), and Years 8 and 9 (*MD* = -.6).

Figure 1. Changes in students' experiences of perseverance and persistence across Grade levels



Note. The bars represent the individual mean scores and an overall composite score across the three survey items.

This decline aligns with earlier studies showing a general decline in students' mathematical affect from primary to secondary school, especially over the middle school period (Grootenboer & Marshman, 2015). However, our study is the first to our knowledge to track cross-sectional changes in perseverance across school grades in mathematics education. This decline suggests a need for targeted interventions to support students' perseverance and persistence, especially during key transition periods.

4.2 The contexts in which students referenced perseverance or persistence

A connection between mathematical challenge and MWB was evident across a large group of student responses (n = 349). These responses indicated that tasks with

mathematical challenge provided a context in which students could both persevere and persist. For example, one student explained: “If the problem is tough to solve it drives me to try harder!” (Student A). These findings connect directly to the theoretical framework of MWB (Hill et al., 2021), particularly the values of accomplishment, perseverance, and positive emotions. By engaging with challenging tasks and persevering through difficulties, students reported experiencing positive feelings and a sense of achievement, both key components of MWB.

While we had anticipated a connection between mathematical challenge and MWB at the outset of our research, given that challenging tasks are obvious triggers for students to persevere, the strength and nature of this connection emerged more clearly from the data analysis. Particularly surprising was the extent to which students expressed a desire for more challenging tasks or for challenging tasks to be introduced more frequently. This unexpected finding highlights the complex relationship between challenge, perseverance, and MWB, suggesting that students may view challenging tasks not just as opportunities to persevere but as integral components of their MWB.

However, while a large group of students indicated their desire for mathematical challenge, a subset within this group (n = 21) also noted the need for an appropriate level of challenge or difficulty. These students referred to tasks needing to be hard but not impossible and appropriately catered to their level of capability. A potential barrier to MWB and engaging with perseverance was evident through student responses as shown below:

> “I really like maths because it challenges me if it is to [sic] challenging then it gets me all worked up and I give up.” (Student B)
>
> “Im [sic] not very good in math but i find it fun when thing [sic] are getting hard but like not to [sic] hard like when it solvable”. (Student C)

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challenging tasks not just as opportunities to persevere but as integral components of their MWB.

These students' responses indicate the need to use challenging tasks in the context of productive struggle and a supportive environment. This relates to the concept of productive struggle in mathematics education (Bass & Ball, 2015) and highlights the delicate balance educators must strike between providing challenging tasks and avoiding excessive frustration. Our results suggest that when this balance is achieved, it can contribute positively to students' MWB by fostering perseverance and persistence.

Within the context of the provision of challenging tasks, analysis of the student responses showed that challenge was coupled by the students (n = 112) with the act of persevering to complete the task. This was described by students in terms of completing, finishing, getting the answer, or solving hard mathematical tasks:

> "Maths make me feel really good when I try something hard and complet [sic] it it makes me feel like ive worked very hard." (Student A)
>
> "Solving a hard problem, being challenged in interesting and non-repetitive ways". (Student B)
>
> "When I figure out a. Really [sic] hard maths question and it feels great once you've worked it out". (Student C)
>
> "Finishing a hard question feels very rewarding and I [personally] think it is the best feeling." (Student D)

As shown in the data, several of the students directly linked the context of mathematical challenge to their behaviour in persevering in the mathematics classroom and the outcome of a positive feeling regarding MWB. They described completing a hard task as the "best feeling" or feeling good or great. These results are similar to those found by Russo and Hopkins (2017), who indicated students embraced struggle and persisted when engaging with challenging tasks.

In a similar way, a number of student responses (n = 80) indicated a connection between perseverance and answering challenging mathematical tasks correctly or accurately. These responses commonly referred to working over an extended period and continuing to engage with the task despite feelings of struggle or perceived difficulty:

> "When I finally get a question right that I've been struggling with for a while, it makes me feel really happy" (Student E)

> "Getting things right so like when im working hard to get things right in maths and actually get it right that makes me feel really good and proud of my self." (Student F)

> "I like getting the questions right but even if i didn't i know i still tried and if i keep on practising i will eventually get the question right". (Student G)

This aligns with Barnes (2021), who indicates that feelings of frustration can be connected with perseverance. Interestingly, other students stated the potential for ill-being when they got a question wrong even after working hard on it:

> "I feel good when I am able to execute a beautiful answer that is correct and I feel bad when I get a question that I've been working so hard on but still get it wrong".

These findings have several implications for mathematics education. In terms of curriculum design, there is a need to incorporate appropriately challenging tasks across all grade levels, with a particular focus on maintaining engagement and perseverance during transitional periods. For teacher professional development, educators should be trained to recognise and foster perseverance and persistence in their students, understanding how these qualities contribute to overall MWB.

Our study also opens up several avenues for future research. Longitudinal studies tracking individual students' perseverance, persistence, and MWB over time could provide deeper insights into how these constructs develop and interact throughout a student's mathematical education. Additionally, intervention studies designed to specifically target perseverance and persistence in mathematics could help identify effective strategies for enhancing these qualities and, by extension, students' overall MWB.

5 Conclusions

Fostering students' perseverance and persistence in mathematics remains a significant challenge in education. When students encounter mathematical difficulties, many view struggle as something to be avoided rather than an opportunity for growth (Sullivan et al., 2020). Our research demonstrates that by fostering perseverance and persistence through appropriately challenging tasks and supportive classroom environments, educators can enhance students' mathematical understanding while contributing to their overall MWB. While students valued mathematical

challenges as opportunities to persevere and derive a sense of accomplishment, they emphasised the importance of appropriately calibrated challenges to avoid frustration. This delicate balance highlights the need to reframe mathematical challenges and productive struggle as valuable components of learning rather than indicators of failure. Creating classroom environments where confusion is normalised and mistakes are viewed as learning opportunities can help students develop resilience and maintain engagement with challenging mathematical tasks (Sullivan et al., 2020).

Looking ahead, the mathematics education community faces the crucial task of developing and implementing practices that cultivate persistence while supporting students' MWB. This requires a multi-faceted approach: providing professional development that helps teachers scaffold productive struggle, designing curriculum materials that incorporate appropriately challenging tasks, and creating assessment practices that value perseverance as much as correct answers. Future research should investigate how different pedagogical approaches influence students' persistence and perseverance, particularly during critical transition periods where our findings indicate a significant decline. This holistic approach to mathematics education, which considers not only achievement but also students' experiences and feelings towards mathematics, has the potential to create more positive and engaging mathematical learning experiences for all students while furthering our understanding of the intricate relationships between perseverance, persistence, and MWB.

6 Research ethics

Author contributions

J.Hill: conceptualisation, designing and validating survey, quantitative data analysis, writing original draft preparation. J. Hunter: conceptualisation, project administration, qualitative data analysis, writing original draft preparation. All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

No artificial intelligence software was used to prepare this manuscript.

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Institutional review board statement

Ethical approval for the study was obtained from the second author's University Ethics Committee.

Informed consent statement

Written informed consent was obtained from all schools involved in the study. Parents and guardians were informed about the research and allowed to withdraw.

Data availability statement

The data supporting this study's findings are available upon reasonable request from the corresponding author (Julia Hill, Julia.hill2@RMIT.edu.au).

Conflicts of Interest

The authors declare no conflicts of interest.

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