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ORIGINAL PAPER

Boys' motivation profiles in mathematics: relations with contextual factors, wellbeing and engagement in a boys-only school

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Abstract
This study examined the extent to which boys fell into clusters comprised of different levels of motivations and costs. In turn, the antecedents of these clusters and associations with engagement and wellbeing outcomes were considered. Based on survey responses from 168 students across Years 5, 7 and 9 from an all-boys' school in Sydney, Australia, three clusters were identified: *Positively Engaged, Disengaged*, and *Struggling Ambitious*. Performance-approach and avoidance achievement goals, mastery classroom goal structure, perceived peer valuing of mathematics and teacher enthusiasm differentially predicted profile membership. Clusters were also found to differ in terms of both wellbeing and engagement, such that students within maladaptive profiles evidenced the most negative outcomes. The study reaffirms prior work, holds implications for addressing student motivation in mathematics, and adds to understanding of the interplay of individual and classroom goal structures in relation to students' mathematics expectancies, values and resultant outcomes.

Keywords Mathematics · Motivation and engagement · Wellbeing · Expectancy-value · Achievement goal · Adolescents

1 Introduction

Mathematics, as an enabler of Science, Technology and Engineering, is crucial to addressing the problem of insufficient numbers of graduates in STEM disciplines to meet demand (Hossain & Robinson, 2012). It is also a key contributor to the problem, with many undergraduates who enrol in STEM-related degrees lacking the mathematics they need to succeed (Holton et al., 2009). The problem can be traced in part to school experiences of learning mathematics that result in many students perceiving the subject as difficult or boring (Moyer et al., 2018), and widely disliking it (e.g. Thomson et al., 2016). Consequently, many students, including those who are mathematically capable, choose to study less demanding mathematics subjects in the senior years of secondary school (Wienk, 2017). This choice limits their options for tertiary study in the STEM disciplines and consequent careers.

Additional to students' interest loss and heightened perceptions of mathematics as difficult through secondary schooling (Beswick et al., 2006; Watt, 2004), their self-concepts and valuing of mathematics as useful are important influences on their subsequent mathematical enrolments and mathematics-related career aspirations (Watt et al., 2012). These also decline through adolescence, although boys rate their self-concepts and interest higher, and difficulty of mathematics lower, despite similar measured achievement (Watt, 2004). More recently, negative 'cost' values have been empirically examined as deterrents to mathematics engagement. For example, in their exploration of prospective primary school teachers' motivation to engage with challenging mathematics tasks, Fielding et al. (2022) considered perceptions of the effort required to complete such activities, and the emotional costs (e.g. worry) of engagement. Cost values were pronounced alongside positive motivation factors in a study (Watt et al., 2019) that identified a motivational profile for mathematics designated "*Struggling Ambitious*". Approximately one in six of the participating 1,172

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Year 10 students were of the *Struggling Ambitious* type who reported high positive motivations *and* costs. These students showed similar achievement background, striving and STEM career aspirations to *Positively Engaged* students, but experienced more performance-oriented classroom environments and poorer wellbeing (Watt et al., 2019). Based on high costs and poor wellbeing, the authors described this profile as 'maladaptive'. Importantly, these students were more likely to be boys. This finding, together with declining undergraduate enrolments in STEM-based disciplines in many countries (Wienk, 2017) for young women *and* men, highlight the importance of understanding and supporting boys' positive engagement with mathematics.

In this article we report on a study grounded in expectancy-value theory (EVT) (Eccles, 2005; Eccles & Wigfield, 2020). Like Watt et al. (2019), we included negative cost factors together with positive motivation factors, to examine profiles among a sample from an all-boys' school. We describe our educed clusters in relation to previous research and consider explanatory associations between clusters and potential antecedents (achievement goals, classroom and teacher factors) and outcomes (school wellbeing and mathematical engagement). Finally, the results of the study are interpreted through perspectives drawn from the educational psychology and mathematics education literatures.

2 Theoretical framework

We structure the theoretical framework according to motivational constructs used to form clusters, potential antecedents to cluster membership, and potential outcomes.

Motivational constructs in education are characterised by a positive or negative valence and varying degrees of stability (Shuckajlow et al., 2017). In mathematics education a range of influences on student motivation has been identified. Van den Huevel-Panhuizen (2005) identified context as an important influence on motivations, indicating that activities are more interesting and meaningful when contextualized. This position contrasts with that of Krawitz and Schukajilow (2018), who argued that a task must provoke intrinsic curiosity in students to be motivating—and that this is not necessarily related to context. Whether related to context or not, motivation is related to individuals' self-beliefs and the value they assign to a task or activity in terms of interest/enjoyment, potential benefit, and the perceived cost of engagement (Eccles & Wigfield, 2020; Fielding et al., 2022).

In his meta-theory of mathematics-related affect, Hannula (2012) noted that motivation can be considered a psychological, social or biological phenomenon. Most mathematics education research on motivation has adopted a psychological stance in which expectancies and values have played an important role (Schukajlow et al., 2017), informed by the "social turn" in mathematics education research (Lerman, 2000). Expectancy-value theory (EVT; Eccles, 2005; Eccles & Wigfield, 2020) is the dominant model in studies aiming to understand how young people's beliefs about their abilities or talents, and the value of a task combine to predict their educational choices and performance. These in turn are shaped by an array of biological, environmental, and social factors. Students' resultant choices relate to achievement striving, course enrolment and career aspirations. In EVT, subjective task values (SVT) include positive values (interest/intrinsic, attainment and utility values) and negative costs (Eccles & Wigfield, 2020). Attainment and utility values have also been combined and termed 'importance value'. A related operationalisation is 'instrumental value', referring explicitly to how mathematics can be useful to the individual's short- or longer-term goals. Costs can include 'Effort cost'—the extent to which the effort needed for the task is considered not worthwhile by the individual; 'Opportunity cost'—the extent to which engaging with a task detracts from one's ability and time for other valued tasks; and 'Emotional cost'—psychological stress due to engaging with a task. Positive values and costs combine to impact overall subjective task value and should be examined together (Wigfield & Eccles, 1992).

Nevertheless, costs have been under-researched compared with positive values (Eccles & Wigfield, 2020). Among studies that have attended to costs is that of Watt et al. (2019), resulting in the identification of student profiles characterised by unique combinations of positive values and negative costs in each of mathematics and science. This study contributes to necessary further investigation, in view of the overrepresentation of boys in the maladaptive *Struggling Ambitious* profile.

2.1 Motivation profiles

Expectancy-value and achievement goal theories have been the main perspectives underpinning person-centred approaches to identify types of students having distinct motivational profiles. Few studies have included costs among clustering variables. In those that have, their value is apparent. For example, three of seven clusters identified as exhibiting "average" mathematics motivation in a study of US Grade 7 students, could be distinguished according to their perceived cost value—the cluster reporting highest cost demonstrated lower mathematical achievement and less positive affect in mathematics (Conley, 2012). Fielding et al. (2022) found prospective teachers' perceptions of costs important to understanding their decisions to engage with challenging mathematics tasks. Multidimensional measures of effort cost, psychological cost, and social cost were included by Watt et al. (2019) alongside the positive expectancy-value constructs of perceived talent (akin to ability beliefs; see Bornholt, et al., 1994; Watt, 2004), intrinsic and utility values for each of mathematics and science. Measured potential antecedents were dimensions of perceived classroom environment; assessed potential outcomes were achievement striving, STEM career aspirations, and psychological wellbeing in terms of depression, anxiety, and stress. Latent profile analysis educed three motivation profiles in each of mathematics and science: *Positively Engaged* (high on positive motivation factors and low on negative costs), *Struggling Ambitious* (high on both positive motivations and negative costs), and *Disengaged* (low on positive motivations and negative costs). For mathematics 55% of students were *Positively Engaged*, 14% *Struggling Ambitious*, and 31% *Disengaged*.

Struggling Ambitious students experienced mathematics classrooms with higher mastery goal structure and lower performance orientation, than either *Positively Engaged* or *Disengaged* students, suggesting potential classroom influences on profile membership. Profiles proved functionally important, differing significantly on the assessed outcomes including dimensions of psychological wellbeing. *Positively Engaged* and *Struggling Ambitious* students reported the greatest effort exertion; *Struggling Ambitious* students concurrently experienced the most depression, anxiety, and stress and contained a concerningly high proportion of boys. An aim of the current study was to explore the extent to which these motivation profiles (Watt et al., 2019) might apply to a sample of only boys.

2.1.1 Gender differences in motivation profiles

EVT was developed initially to explain gender differences in choices about studying mathematics and the reasons why girls are less likely than boys to choose pathways in mathematics and physical sciences, despite similar measured achievements (Eccles & Wigfield, 2020). Questions of gender have remained a strong thread in EVT research (Eccles & Wigfield, 2020). Boys and girls share similar beliefs about the utility and importance of mathematics (Berger et al., 2020), but boys are more likely to report enjoying the subject and finding it interesting (Frenzel et al., 2010), and rate their self-concepts higher than girls (Zander et al., 2020). There is also evidence that teachers' expectations reflect gender-stereotypical views associating success in mathematics with being male (Jaremus et al., 2020). While gender differences have been intensively studied within this framework, *within*-gender associations among self-concepts, values and various costs are less understood. The high proportion of boys found in the *Struggling Ambitious* profile (Watt et al., 2019) represents our point of departure from previous literature as an area requiring further examination.

2.2 Potential antecedents

In EVT, both individual and contextual factors shape students' expectancies and values. Eccles and Wigfield (2020) highlighted the importance of understanding students' expectancies and values as the product of the dynamic interplay between individual characteristics and students' broader social, contextual, and cultural environments. Accordingly, both students' goal orientations and classroom- and teacher-related learning climate factors were included as individual and contextual factors which may be potential antecedents to cluster membership and were considered in the present study.

2.2.1 Achievement goals

Achievement goal orientations can be considered individual attributes that may be antecedent to students' expectancies and values. They fall into two broad categories; those which are mastery-focused—in which individuals are motivated to learn and develop competencies, and those which are performance-focused—in which emphasis is placed on the development of competence relative to others. Within performance-focused goals, there is a distinction between performance-avoidance (to avoid demonstrating worse performance than others) and performance-approach orientations (striving to demonstrate superior performance to others; Elliot, 1999). While mastery goals have been associated with adaptive outcomes such as greater engagement, interest, and enjoyment (Benita et al., 2014), self-efficacy and effort (Headrick et al., 2020), performance avoidance goals have consistently been associated with maladaptive patterns of motivation and engagement such as challenge avoidance, ability failure attribution, and negative affect (Chung et al., 2020).

There appears to be an association between gender and goal orientation, such that boys may be more performance- than mastery-oriented (Dekker et al, 2013; Hutchins, 2009). Males more than females tend to engage in academic tasks to demonstrate competence and reap extrinsic rewards rather than to develop an intrinsic sense of competence (Hutchins, 2009). In EVT, goals are considered broad purposes for learning that students bring to situations (Eccles & Wigfield, 2020). These goals are positioned as antecedent to expectancies and values and subsequent achievement. Although prior work (e.g. Conley, 2012) has examined the interplay of goals and expectancy-value perspectives, few studies have considered associations between goal orientations, and expectancies and values as distinct components of EVT.

2.2.2 Classroom factors

In addition to individual characteristics, classroom contextual factors are recognised predictors of students' expectancies and values (Lazarides et al., 2017). Consistent with achievement goal theory, we consider classroom factors through reference to mastery- or performance-oriented environments, and student-perceived peer valuing of mathematics. Mastery-oriented and performance-oriented classrooms reflect the extent to which classroom environments favour the development of mastery and competence, or students striving to demonstrate success compared to their peers (Carmichael et al, 2017; Tuominen-Soini et al., 2012). As with mastery goals, mastery-oriented learning environments are the most conducive to adaptive outcomes, being associated with greater student intrinsic motivation and task valuing in mathematics (Lazarides et al., 2018) that are more prevalent in younger grades (Carmichael et al., 2017). Watt et al. (2019) found that students in the profile having the most positive motivations and lowest levels of costs, reported more mastery-oriented classroom learning environments. Further person-centred work is required to augment these findings, and to consider mastery and performance climates alongside individuals' own mastery and performance goals to better understand the dual role of individual and contextual goal influences.

Peers are an important influence on adolescents' academic engagement and achievement (Gherasim et al., 2013). Peers' valuing of mathematics is a key classroom influence that can shape students' expectancies and values (Schunk & DiBenedetto, 2020). While support from peers, including friendship with achievement-oriented peers, is related to higher mathematics achievement (Crosnoe et al., 2008), low peer support in the context of competitive classroom environments can reduce engagement and hence achievement (Frenzel et al., 2010).

From the perspective of mathematics education, research has established the value for students' learning, and particularly their conceptual understanding, of mathematics practices aligned with mastery goal structures typically characterised as student-centred (e.g. Ingram et al., 2018; Sullivan, 2011). Mastery classroom goal structures have also been associated with greater student interest in mathematics (Carmichael et al., 2017) but both the likelihood that students experience mastery-oriented classrooms and their interest in mathematics decline with the transition from primary to secondary school (Carmichael et al., 2017). Practices that promote skill development often focus on explicit teacher modelling and considerable practice (Hiebert & Grouws, 2007). Such practices emphasise correct answers and lend themselves to classrooms in which achievement can readily be compared that promote competition as the means to motivate effort, thereby supporting performance goal structures.

2.2.3 Teacher factors

From an EVT perspective, teachers are key socialisers in the lives of students and thus play a significant role in shaping their expectancies and values (Wigfield & Gladstone, 2019). We considered two dimensions of teacher support that may be associated with students' expectancies and values, teacher enthusiasm and the quality of teacher relationships.

Teacher Enthusiasm. Teacher enthusiasm consists of the enjoyment, excitement, and interest displayed by teachers in the classroom. Teacher enthusiasm is considered a support behaviour through which teachers' beliefs may be conveyed to students. That is, when teachers display greater levels of enthusiasm, students tend to report higher levels of motivation. For example, Lazarides et al. (2018) found an association between teacher enthusiasm reported by secondary school students, and greater perceptions of the intrinsic value of mathematics, and lower perceptions of costs associated with mathematical tasks. Teacher enthusiasm has been a relatively recently examined construct found to impact students' engagement in mathematics (e.g. Frenzel et al., 2010; Kunter et al., 2008). Carmichael et al. (2017) reported a strong positive relationship between students' perceptions of their teachers' enthusiasm and their own perceptions of a mastery-oriented classroom environment. Nevertheless, studies of teacher enthusiasm and student motivation remains relatively scant in a person-centred EVT context. Similar concepts to teacher enthusiasm are sometimes conveyed by different words. For example, Beswick (2007) described a teacher whose classroom evidenced enjoyment of his work with students that could be characterised as enthusiasm.

Teacher Relationship. High quality teacher-student relationships are crucial to the development of adaptive motivation among students (Wigfield & Gladstone, 2019). From an EVT perspective, positive teacher-student relationships may foster students' expectancies and values, as teachers are sources of positive social influence. Prior work has found evidence of this relationship. For example, Fan (2011) found a positive association between teacher-student relationships and students' intrinsic value for mathematics. Although studies have shed light on variable-centred associations involving expectancies and values, less is known about the extent to which positive teacher-student relationships may promote combinations of these factors. Adopting a person-centred approach in this investigation advances existing theoretical and empirical understandings.

From a mathematics education perspective, positive teacher-student interactions in the context of a supportive classroom environment were associated with higher levels of student motivation and engagement in a study of middle-school teachers (Durksen et al., 2017). However, the classroom goal structure can dampen the benefits of positive relationships with teachers on student outcomes; classrooms characterised by high levels of performance avoidance goals for students to avoid demonstrating lack of understanding and failure, were found to undermine the benefits of supportive teacher relationships for boys', but not girls', mathematics achievement in a study of students aged 12–15 years (Gherasim et al., 2013).

The extent to which students are likely to experience supportive relationships with their mathematics teachers varies according to their teachers' perception of their ability, whereby students perceived as less mathematically capable are more likely to report negative experiences in mathematics. These students tend to be low attaining and are typically offered impoverished curricula comprised of skills focused tasks (Beswick, 2017; Boaler & Sengupta-Irving, 2016). The teachers in Beswick's (2017) study also associated low mathematics ability with poor behaviour including unwillingness to work (i.e. lack of effort) and disorganisation; connections likely to undermine student–teacher relationships.

Teacher use of representations The use of multiple representations is important to developing understanding of abstract mathematical concepts. Representational tools that teachers use in mathematics teaching include graphs, maps, diagrams and tables, that provide opportunities for students to develop and interrogate their ideas (Hobbs et al., 2018). Within mathematics education, the importance of multiple representations to teaching/learning has been a theme within the literature for at least 20 years, with much of this research focused on the use of technology to promote knowledge and understanding of algebra and calculus (e.g. Ferrara et al., 2006). Students need to make connections between multiple representations of the same idea and be able to change from one representation to another (Even, 1998). This capability is challenging because of the complexity of mathematical structures and the potential multiplicity of its representation (e.g. Pierce et al., 2011). Further, every representation can have advantages and disadvantages for communicating meaning (e.g. Friedlander & Tabach, 2001).

Multiple representations and translation among them have been shown to support concept development including abstraction and generalisation (Glancy & Moore, 2013), although, there is evidence that they are under used. For instance, in a study involving 21 school principals (Hatisaru et al., 2020) and 12 mathematics and science education researchers (Hatisaru et al., 2019) participants' drawings and accompanying written explanations were examined for evidence of multiple representations. Only three principals and four researchers portrayed and/or described contexts that supported the use of multiple representations and provided evidence of at least two different representations, suggesting that their importance was not well understood (Hatisaru et al., 2019, 2020). While it might be expected that teachers are aware of the importance of multiple representations, Dreher and Kuntze (2015) found that both pre- and in-service teachers rated the use of multiple representations as less important to supporting remembering, motivation and interest, than to catering for different learning types. We operationalised representation use in terms of the frequency with which students reported their teachers' use, creation, and translation between common mathematical representations (tables, graphs, diagrams).

2.3 Potential outcomes

2.3.1 Wellbeing

Students are required to study mathematics throughout the compulsory schooling years so their experiences in mathematics classrooms have potential to influence their overall wellbeing in relation to school. There is evidence that this influence is often not positive. Many adults recount negative experiences of learning mathematics (Bekdemir, 2010) including prospective teachers amongst whom mathematics anxiety is common (Bekdemir, 2010; Itter & Meyers, 2017). Among the potential harms of mathematics, school mathematics can leave "some students feeling inhibited, belittled or rejected by mathematical culture and perhaps even rejected by the educational system and society overall" (Ernest, 2018, p. 211). Accordingly, we examined wellbeing by way of school satisfaction, and burnout (i.e. illbeing).

2.3.2 Mathematical engagement

Students' mathematical engagement was examined in the form of effort exertion as a behavioral dimension of engagement. Effort exertion has been examined as an indicator of engagement within the context of EVT (e.g. Putwain et al., 2019; Watt et al., 2019) and is particularly important given its well-established associations with academic achievement (Wang & Eccles, 2012) and self-efficacy (Street et al., 2022). Prior work involving profiles of students (e.g. Watt et al., 2019) found that those displaying adaptive motivation profiles exerted greater effort, while the opposite applied to students having less adaptive patterns of motivation. The present work builds on that study, by focusing specifically on boys and the associations between their motivational profiles and effort exertion.

2.4 Research questions

The present study was guided by the following research questions:

RQ1. Can previously identified clusters be reproduced in a boys-only sample, in terms of their levels of mathematics-related motivations and costs assessed through the lens of EVT?

RQ2. To what extent are students' Year-level, gender, achievement goal orientations and classroom- and teacher-related learning experiences, potential antecedents to cluster membership?

RQ3. To what extent is cluster membership associated with mathematics engagement and wellbeing outcomes?

Based on past findings and the preceding review, associated hypotheses for RQ2 potential antecedents were:

H2.1: We expected declining proportions of *Positively Engaged* in older Year-levels and increasing proportions of *Disengaged*; and that the *Struggling Ambitious* profile may increase with Year-level.

H2.2: Among our boys-only sample, we hypothesised a greater proportion to be *Struggling Ambitious* than among previous mixed-gender samples.

H2.3: We speculated that performance goal orientations may be higher among *Struggling Ambitious*; conversely that mastery goals may be higher among *Positively Engaged*.

H2.4: Performance-oriented classrooms were expected to be most experienced by *Struggling Ambitious* and mastery-oriented classrooms, as well as peer valuing of mathematics, least experienced by *Disengaged* students.

H2.5: We expected *Positively Engaged* to rate teacher enthusiasm and positive relationships higher, and that *Disengaged* students may experience teachers who made less use of representational tools.

For RQ3 engagement and wellbeing outcomes we expected similar findings to previous research, noting that we used different measures of wellbeing in our study. We anticipated lowest effort exertion and school satisfaction among *Disengaged*, and poor wellbeing among *Struggling Ambitious* students.

3 Method

3.1 Sample and procedure

Our sample consisted of 168 students from an all-boys' independent Catholic school in Sydney, Australia, catering for students in Years 5 to 12. The school's Index of Socio-educational Advantage (a measure that accounts for parents' education and occupation, school geographic location, and proportion of Indigenous students) was 1104, placing the school at the 87% percentile of the ICSEA distribution for that year. In Australia, 30% of primary and 40% of secondary students attend non-government schools including Catholic schools (Australian Bureau of Statistics, 2021) and 12% of students are enrolled in single-sex schools (Dix, 2017).

Students were in Year 5 ($n = 44$; $M_{age} = 10.91$ years, $SD = 0.27$), Year 7 ($n = 31$; $M_{age} = 12.55$ years, $SD = 0.72$), and Year 9 ($n = 108$; $M_{age} = 14.51$ years, $SD = 0.70$) at the time of data collection. All data were collected at a single timepoint during Term 3 of 4 school terms in the year. Information about the classes from which the students were drawn was not collected. The data form part of a larger study funded by the Australian Department of Education Science and Employment (Fraser et al., 2021).

3.2 Measures

All measures were included in one online questionnaire. Consistent with the aim of investigating the extent to which clusters existed that were similar to those described by Watt et al. (2019), the scales employed reflected those used in this work. More broadly, these constructs reflect the core expectancies and values described by EVT (Eccles & Wigfield, 1995). Demographic data were collected followed by the substantive constructs: motivations (expectancies, values, costs, and achievement goals), student-perceived classroom and teacher factors, and school wellbeing and mathematical engagement outcomes. Table 1 shows the reliability and descriptive statistics for the core constructs.

3.2.1 Clustering variables

Clusters were formed based on expectancy and value variables, and costs.

3.2.1.1 Expectancies and values Measures of *perceived talent* and *intrinsic value* were derived from Eccles and Wigfield (1995; adapted to the Australian context by Watt, 2002, 2004). *Perceived talent* was examined by 3 items, e.g. "Compared with other students in your Year, how talented are you at maths?". *Intrinsic value* was examined by the single item: "I find maths interesting". Three items from the 2006 PISA survey tapped *instrumental value*, e.g. "I will learn many things in maths that will help me get a job". All items were rated on a 7-point Likert-type scale ranging from 1 (*Not at all*) to 7 (*Extremely*).

3.2.1.2 Costs Perceived costs were examined in terms of *effort cost* (3 items: e.g. "When I think about the hard work needed to get through in mathematics, I am not sure that it is going to be worth it in the end"; Watt et al., 2019); and *perceived difficulty* (3 items: e.g. "To what extent do you consider maths to be a tough subject?"; Watt, 2002). All items were rated from 1 (*Not at all*) to 7 (*Extremely*).

3.2.2 Potential antecedents

3.2.2.1 Achievement goals Students' achievement goals in mathematics were measured for *mastery* (3 items: e.g. "One of my goals in maths is to learn as much as I can"), *performance-approach* (3 items: e.g. "One of my goals is to show others that I am good at maths"), and *performance-*

Table 1 Factor reliabilities and descriptive statistics

	n items	Cronbach's α	*M*	*SD*	Skew	*S.E*	Kurtosis	*S.E*
Clustering variables								
Expectancies and values								
Perceived talent	3	0.81	4.53	1.40	−0.25	0.18	−0.21	0.36
Intrinsic value	1	N/A	4.50	1.69	− 0.21	0.18	− 0.86	0.36
Instrumental value	3	0.85	5.10	1.48	− 0.62	0.18	− 0.16	0.36
Costs								
Effort cost	3	0.62	3.68	1.50	− 0.11	0.19	− 0.52	0.37
Perceived difficulty	3	0.63	4.24	1.20	− 0.32	0.18	0.02	0.37
Potential Antecedents								
Achievement goals								
Mastery^	3	0.87	3.85	0.94	− 0.69	0.19	0.40	0.37
Performance− approach^	3	0.88	3.17	1.11	− 0.16	0.21	− 0.47	0.42
Performance− avoidance^	3	0.78	3.12	1.01	− 0.29	0.21	0.11	0.42
Classroom factors								
Mastery classroom goal structure	3	0.86	5.33	1.48	− 0.84	0.18	0.28	0.36
Performance classroom goal structure	3	0.69	4.33	1.52	− 0.34	0.18	− 0.17	0.36
Peer valuing of mathematics	4	0.79	3.49	1.23	− 0.20	0.18	− 0.50	0.36
Teacher factors								
Teacher enthusiasm	3	0.91	5.39	1.47	− 0.86	0.18	0.31	0.36
Teacher relationship	2	0.93	4.72	1.44	− 0.30	0.18	0.07	0.36
Teacher's use of representational tools	3	0.82	2.43	0.70	0.06	0.18	0.25	0.36
Potential Outcomes								
School satisfaction^	3	0.88	2.75	0.78	0.20	0.19	− 0.80	0.38
Cynicism^	3	0.84	3.22	1.52	0.20	0.19	− 0.93	0.38
Emotional exhaustion^	4	0.88	3.15	1.35	0.38	0.19	− 0.38	0.38
Sense of inadequacy^	2	0.74	3.37	1.45	0.00	0.19	− 0.76	0.38
Effort exerted in mathematics	2	0.87	5.11	1.33	− 0.55	0.19	0.33	0.37

Note. Unless specified, all constructs were measured using a 7-point Likert scale. ^Denotes use of a 5 point-Likert scale

avoidance (3 items: e.g. "It's important that I don't look stupid in maths lessons"). All items were from Midgley et al., (2000) and rated on a 5-point scale from 1 (*Not at all true*) to 5 (*Very true*).

3.2.2.2 Classroom factors Mastery and performance dimensions of classroom goal structure were examined using 3 items each from Midgley et al. (1996), rated on a 7-point scale from 1 (*Not at all*) to 7 (*Extremely*). A *mastery* structure reflects a classroom in which the teacher promotes learning and understanding (e.g. "Our maths teacher really wants us to enjoy learning new things"), whereas a *performance* structure reflects a classroom in which teachers emphasise competition and achievement comparisons between students (e.g. "Our maths teacher tells us how we compare to other students"). Perceived *peer valuing* of mathematics was assessed using 4 items (adapted by Watt, 2002 from Eccles & Wigfield, 1995), for example, "My friends find working on maths…" rated from 1 (*Very boring*) to 7 (*Very interesting*).

3.2.2.3 Teacher factors Three student-perceived teacher factors were assessed. *Teacher enthusiasm* was adapted from Kunter (2013) for students to report their perceptions of their mathematics teacher's enthusiasm (3 items: e.g. "Our maths teacher teaches maths with great enthusiasm"), rated from 1 (*Not at all*) to 7 (*Extremely*). *Teacher relationship* was assessed by 2 items (adapted from Watt, 2002; e.g. "How well do you and your maths teacher relate to each other?), rated from 1 (*Not at all*) to 7 (*Extremely*). In terms of pedagogical practice, 3 items tapped teachers' use of representational tools (derived from Gulek, 1999). These required students to prompts such as "creates tables, graphs and diagrams", each rated from 1 (*Not at all*) to 7 (*Every lesson*), following the stem "How often do you use each of the following?".

3.2.3 Potential outcomes

3.2.3.1 School wellbeing School satisfaction was assessed using 3 items adapted by Barber (see Geagea et al., 2017) from the Multidimensional Students' Life Satisfaction Scale (MSLSS; Huebner, 1994): "school is interesting", "I enjoy school activities" and "I look forward to going to school", rated on a 5-point scale ranging from 1 (*Not at all true for me*) to 5 (*Very true for me*). The 3 factors of the Student Burnout Inventory were also examined (SBI; Salmela-Aro et al., 2009): cynicism (3 items: e.g. "I feel that I am losing interest in my schoolwork"), exhaustion (4 items: e.g. "I feel overwhelmed by my schoolwork") and sense of inadequacy (2 items: e.g. "I used to have higher expectations of my schoolwork than I do now"). All items were rated on 6-point scales, from 1 (*Completely disagree*) to 6 (*Completely agree*).

3.2.3.2 Mathematics engagement Effort exerted in mathematics was measured by 2 items (e.g. "How much effort do you put into mathematics?"; Watt, 2002), rated from 1 (*Not at all*) to 7 (*Extremely*).

3.3 Statistical analyses

3.3.1 Preliminary analyses

All variables appeared normally distributed and adequate reliability was demonstrated by Cronbach's alpha coefficients between 0.62 and 0.93 (see Table 1). Low missing data (7%) were found to be missing completely at random (MCAR) based on the results of Little's (1988) MCAR test (χ^2 ($df = 176$) = 195.668, $p = 0.148$) and therefore handled using listwise deletion.

3.3.2 Phase 1—Cluster analysis

The first analysis phase involved identifying latent expectancy-value-cost clusters of students based on their perceived talent, intrinsic value, instrumental value, effort cost, and perceived difficulty. All variables were standardised to z-scores before conducting hierarchical cluster analysis using Ward's method (and squared Euclidian distance) to explore potential latent clusters. The final cluster solution was selected based empirically on the agglomeration schedule by inspection of the point where error coefficients rose significantly (Yim & Ramdeen, 2015) and changes in the fusion coefficient relative to number of clusters, as well as conceptually in relation to previous research and substantive relevance. MANOVA compared how clusters differed from one another on the 5 clustering variables.

3.3.3 Phase 2—Potential antecedents and outcomes

The second phase of analysis involved 2 MANOVAs, to examine the extent to which cluster membership related to potential antecedents (achievement goals, classroom, and teacher factors) and outcomes (school wellbeing, mathematics engagement).

4 Results

4.1 Phase 1—Cluster analysis

The cluster analysis suggested the existence of 2 to 4 clusters of which the 3-cluster solution was the most parsimonious and conceptually relevant. The 3 distinct clusters resembled those identified by Watt et al. (2019), differing substantively on levels of the cluster variables and qualitatively by shape. This contrasted with the 4-cluster solution in which 2 of the clusters varied only on levels of the variables rather than differing qualitatively in shape, and the 2-cluster solution in which clusters were essentially opposites (i.e. high expectancy-values/low costs and low expectancy-values/high costs) not contributing substantive information.

Table 2 shows the cluster sizes and standardised means for the 3-cluster solution (see also Fig. 1a). Cluster 1 ($n = 60$)

Table 2 Cluster composition descriptive statistics and significant differences

Cluster	n	Perceived talent *M* (SD)	Instrumental value *M* (SD)	Intrinsic value *M* (SD)	Effort cost *M* (SD)	Perceived difficulty *M* (SD)
Standardised scores						
Struggling ambitious	60	0.59^{a} (0.72)	0.46^{a} (0.46)	0.17^{b} (0.76)	0.65^{a} (0.68)	0.65^{a} (0.83)
Positively engaged	50	0.09^{b} (0.88)	0.58^{a} (0.58)	0.88^{a} (0.66)	– 0.92^{c} (0.74)	– 0.36^{b} (0.95)
Disengaged	58	– 0.69^{c} (0.90)	– 0.99^{b} (0.77)	-0.83^{c} (0.75)	0.15^{b} (0.89)	– 0.27^{b} (0.86)
Unstandardised scores						
Struggling ambitious	60	5.36^{a} (1.01)	5.78^{a} (0.98)	4.78^{b} (1.27)	4.66^{a} (1.01)	5.02 ^{a} (0.99)
Positively engaged	50	4.66^{b} (1.22)	5.95^{a} (0.84)	5.98^{a} (1.11)	2.29^{c} (1.10)	3.81^{b} (1.13)
Disengaged	58	3.56^{c} (1.25)	3.64^{b} (1.15)	3.10^{c} (1.26)	3.91^{b} (1.34)	3.92^{b} (1.02)

Note. The superscript values after each mean indicate significant differences between clusters on that variable indicated by Tukey's post hoc tests. ^{a} Represents the highest scores on that variable (i.e. significantly higher than ^{b} and ^{c}). Repeated superscript values indicate no significant difference between the two groups denoted by the same value

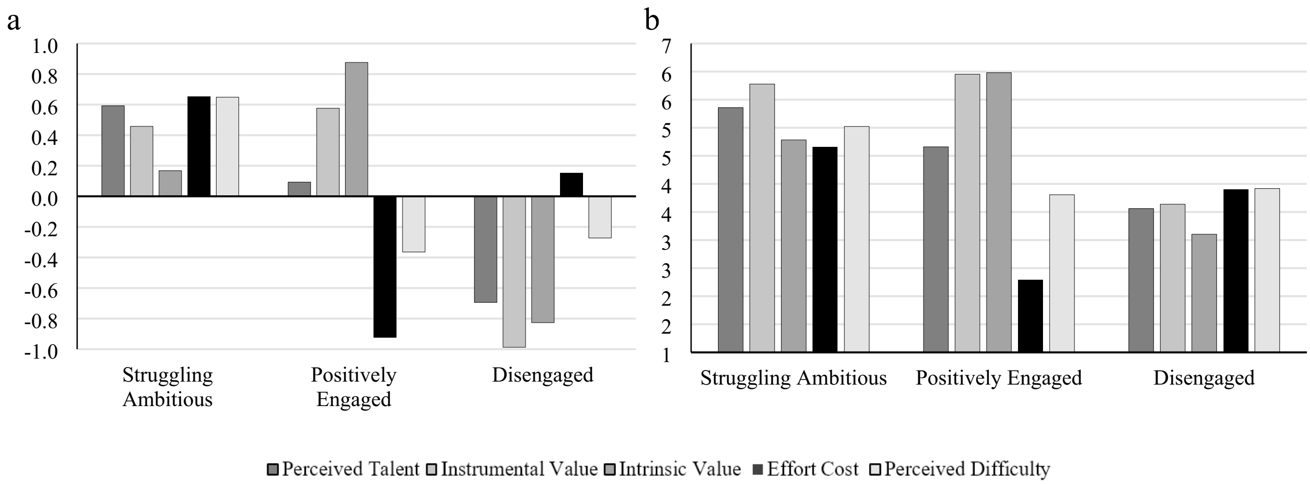

Fig. 1 **a** Standardised cluster solution. **b** Unstandardised cluster solution

represented 36% of the sample. This group displayed above average scores on positive motivations (perceived talent, intrinsic value, instrumental value) and costs (effort cost, perceived difficulty), resembling the *Struggling Ambitious* profile (Watt et al., 2019). In contrast, Cluster 2 ($n = 59$; 29% of the sample) was characterised by relatively low levels of costs, high intrinsic and instrumental values, and above average levels of perceived talent. This cluster was termed *Positively Engaged* based on their generally high expectancies and values and low costs. Cluster 3 *(Disengaged)* contained 35% of the sample who were well below average on the three positive motivational factors, and above average on effort cost. They rated perceived difficulty slightly below average, indicating that while they did not perceive themselves as very talented in mathematics nor value it, they did not find it to be more difficult than students in other clusters.

To identify statistically significant differences in composition between cluster pairs, we compared their standardised means using MANOVA. A significant multivariate effect ($F[10, 322] = 46.422$, $p < 0.001$; Wilk's $\Lambda = 0.168$, $\eta_p^2 = 0.59$) was due to significant univariate effects ($p < 0.001$ in each case) on each of the 5 factors: perceived talent ($F[2, 165] = 35.431$), intrinsic value ($F[2, 165] = 75.303$), instrumental value ($F[2, 165] = 92.298$), effort cost ($F[2, 165] = 57.320$) and perceived difficulty ($F[2, 165] = 23.553$). Tukey post hoc tests revealed significant paired differences for all factors with the exceptions of instrumental value which did not significantly differ between the *Positively Engaged* and *Struggling Ambitious* clusters, and perceived difficulty which did not differ between the *Positively Engaged* and *Disengaged*. To understand cluster scores relative to the original scale metric, we also inspected their unstandardised means (Table 2, Fig. 1b).

There was a significant association between cluster membership and Year-level ($\chi^2(4, N = 168) = 13.38$, $p = 0.01$). As shown in Fig. 2, although there appeared to be a decreasing proportion of *Positively Engaged students* with increasing Year-level, and increasing proportions of *Struggling Ambitious* and *Disengaged* students, significant differences were only found for this latter pattern according to post hoc column comparisons using Bonferroni–corrected *p*-values.

4.2 Phase 2—Potential antecedents and outcomes

The first MANOVA identified a significant multivariate effect of cluster on students' achievement goals and perceived classroom and teacher-related factors ($F[18, 294] = 4.145$, $p < 0.001$; Wilk's $\Lambda = 0.636$, partial $\eta_p^2 = 0.20$). Table 3 displays descriptive statistics and significant univariate differences for performance-approach and avoidance achievement goals, mastery classroom goal structure, perceived peer valuing of mathematics and teacher enthusiasm. Tukey post hoc tests identified significant differences between cluster pairs. Performance-approach goals were highest for the *Struggling Ambitious* cluster than others; performance-avoidance goals were higher for the *Struggling Ambitious* than *Disengaged*, but not significantly different

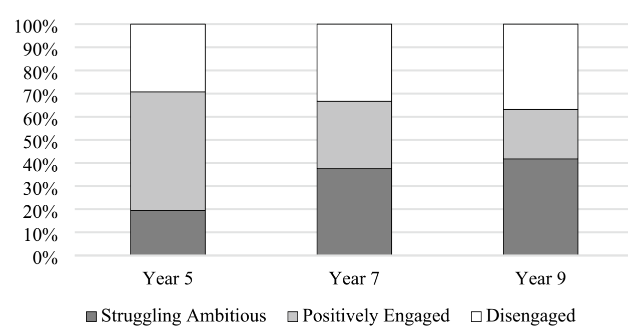

Fig. 2 Cluster membership by year-level

Table 3 Cluster mean differences on potential antecedents and outcomes

	Struggling ambitious *M* (SD)	Positively engaged *M* (SD)	Disengaged *M* (SD)	Between group differences
Potential antecedents				*F*[2, 155], *p*-value
Achievement goals				
Mastery	3.88 (0.77)	3.95 (0.96)	3.63 (1.10)	1.408, 0.214
Performance-approach	3.57 (1.01)[a]	3.06 (1.20)[b]	2.73 (0.95)[c]	9.721, 0.001
Performance-avoidance	3.45 (0.93)[a]	3.06 (0.96)	2.83 (0.99)[b]	5.188, 0.004
Classroom Factors				
Mastery classroom goal structure	5.67 (1.21)[a]	5.76 (1.44)[a]	4.62 (1.54)[b]	20.579, 0.001
Performance classroom goal structure	4.51 (1.50)	4.48 (1.42)	4.03 (1.42)	3.868, 0.199
Peer valuing of mathematics	3.69 (1.15)[a]	4.10 (1.15)[a]	2.80 (1.06)[b]	23.956, 0.001
Teacher Factors				
Teacher enthusiasm	5.82 (1.12)[a]	5.69 (1.40)[a]	4.74 (1.56)[b]	18.296, 0.001
Teacher relationship	4.80 (1.40)	4.70 (1.47)	4.62 (1.46)	0.442, 0.812
Teacher's use of representational tools	2.37 (0.55)	2.34 (0.67)	2.63 (0.81)	1.292, 0.079
Potential Outcomes: *School Wellbeing & Mathematics Engagement*				*F*[2, 149], *p*-value
School satisfaction	2.88 (0.69)[b]	3.10 (0.73)[b]	2.25 (0.66)[a]	19.56, 0.001
Cynicism	3.50 (1.45) [a]	2.17 (1.16)[b]	3.92 (1.34) [a]	22.74, 0.001
Emotional exhaustion	3.37 (1.35)[a]	2.53 (1.17)[b]	3.48 (1.29)[a]	8.11, 0.001
Sense of inadequacy	3.64 (1.46)[a]	2.69 (1.33)[b]	3.81 (1.24)[a]	9.65, 0.001
Effort exerted	5.51 (1.04)[a]	5.79 (1.07)[a]	4.20 (1.28)[b]	27.62, 0.001

Note. The superscript values after each mean indicate significant cluster differences on that variable indicated by Tukey post hoc tests ($p<0.05$); repeated superscript values indicate no significant difference between the two groups denoted by the same value. ^There was no significant difference between the Positively Engaged and Disengaged clusters

from the *Positively Engaged* cluster. Mastery classroom goal structure, and perceived peer values and teacher enthusiasm were significantly higher for *Struggling Ambitious* and *Positively Engaged* clusters versus the *Disengaged*; there was no significant difference between *Struggling Ambitious* and *Positively Engaged* on any classroom or teacher-related factor.

A second MANOVA compared clusters on school wellbeing and mathematics engagement, showing a significant multivariate effect of cluster ($F[12, 288]=8.901$, $p<0.001$; Wilk's $\Lambda=0.585$, $\eta_p^2=0.24$). The *Struggling Ambitious* and *Disengaged* clusters reported similarly greater cynicism, emotional exhaustion, and sense of inadequacy than the *Positively Engaged* cluster. The *Disengaged* cluster reported lower levels of school satisfaction and mathematics engagement in terms of effort exertion, than both Struggling *Ambitious* and *Positively Engaged* clusters.

Potential Year-level effects were explored in 2 further MANOVAs, for each of potential antecedents and outcomes. The first MANOVA showed there was no significant multivariate or univariate effects of Year-level on students' achievement goals, perceived classroom, or teacher factors. The second MANOVA found a significant multivariate effect of Year-level on school wellbeing and mathematics engagement ($F[10, 298])=3.277$, $p<0.001$; Wilk's $\Lambda=0.812$, $\eta_p^2=0.09$), due to older students (Year 9) reporting significantly higher cynicism and sense of inadequacy and lower school wellbeing than Years 5 and 7 students, and higher emotional exhaustion than Year 5 students (Table 4).

5 Discussion

We examined the extent to which previously identified motivational profiles (Watt et al., 2019) were evident among a sample of boys from Years 5, 7 and 9 in one school when similar value and cost variables were examined. Because of the small sample, cluster analysis rather than latent profile analysis was employed, followed by MANOVAs to discern differences between clusters.

5.1 RQ1 Could previously identified motivational profiles be reproduced in our sample?

Our findings suggest that the three profiles identified by Watt et al. (2019) were present in our boys-only sample and are quite robust. Of the three clusters identified the largest included 36% of students and resembled the previously identified *Struggling Ambitious* type (Watt et al., 2019). These students had relatively high scores for positive motivations (perceived talent, intrinsic value, instrumental value) but also for costs (effort cost and perceived difficulty). A

Table 4 Year-level mean differences on potential antecedents and outcomes

	Year 5 *M* (SD)	Year 7 *M* (SD)	Year 9 *M* (SD)	Between group differences
Potential Antecedents				$F[2, 158]$, p-value
Achievement Goals				
Mastery	3.78 (0.94)	4.04 (0.88)	3.81 (0.98)	0.625, 0.535
Performance-approach	2.90 (1.05)	3.25 (1.01)	3.21 (1.14)	1.265, 0.285
Performance-avoidance	3.10 (0.89)	3.16 (0.69)	3.12 (1.08)	0.031, 0.970
Classroom Factors				
Mastery classroom goal structure	5.44 (1.43)	5.62 (1.15)	5.29 (1.55)	0.058, 0.573
Performance classroom goal structure	4.34 (1.42)	3.99 (1.90)	4.44 (1.50)	0.820, 0.442
Peer valuing of mathematics	3.64 (1.21)	3.82 (1.50)	3.42 (1.16)	1.176, 0.311
Teacher factors				
Teacher enthusiasm	5.36 (1.38)	5.62 (1.10)	5.42 (1.54)	0.254, 0.776
Teacher relationship	4.88 (1.33)	4.66 (1.29)	4.66 (1.53)	0.325, 0.723
Teacher's use of representational tools	2.62 (0.71)	2.54 (0.40)	2.36 (0.76)	2.169, 0.118
School wellbeing & mathematics engagement				$F[2, 153]$, p-value
Cynicism	2.54 (1.33) [b]	2.51 (1.23)[b]	3.70 (1.45) [a]	14.33, 0.001
Emotional exhaustion	2.72 (1.24) [b]	2.60 (1.08)^	3.45 (1.36)[a]	6.700, 0.002
Sense of inadequacy	3.07 (1.28)[b]	2.66 (1.39)[b]	3.70 (1.43)[a]	6.022, 0.003
School satisfaction	3.04 (0.78)[a]	3.01 (0.69)[a]	2.56 (0.74)[b]	7.726, 0.001
Effort exerted	5.50 (1.28)	5.65 (1.01)	4.95 (1.34)	4.158, 0.017

Note. The superscript values indicate significant differences between clusters on that variable indicated by Tukey post hoc tests ($p < 0.05$); repeated superscript values indicate no significant difference between the two groups denoted by the same value. ^There was no significant difference between Years 7 and 9 on emotional exhaustion

further 29% (Cluster 2) scored high on intrinsic and instrumental values, above average for perceived talent, and low on costs, resembling *Positively Engaged* (Watt et al., 2019). Cluster 3 included 35% of students and, like the *Disengaged* profile of Watt et al., scored below average on the positive motivational factors and above average on effort costs. The proportions of students falling into each cluster differed from those identified earlier (Watt et al., 2019) in which 14% of students were *Struggling Ambitious*, 55% *Positively Engaged* and 31% *Disengaged.*

5.2 RQ2 Potential antecedents of cluster membership

The proportion of students in the *Disengaged* cluster increased with older Year-levels from Year 5, through Year 7, to Year 9, thus confirming H2.1 in relation to this cluster. Contrary to H2.1, however, we did not find increasing proportions of *Struggling Ambitious* or decreasing proportions of *Positively Engaged* with Year-level. Given the increase with year level of *Disengaged* students, attention to the antecedents of cluster membership from at least Year 5 seems warranted. Pedagogies aimed at supporting all students to develop and maintain expectancies and values characteristic of the *Positively Engaged* such as reducing competition to avoid negative comparisons of ability with peers (perceived talent), recognising the importance of mathematics for future employment (instrumental value), maintaining students' interest in the subject (intrinsic value), and supporting students to see mathematics as a challenging subject in which they can achieve (perceived difficulty) with reasonable effort (effort cost) would benefit all students (e.g. Fielding et al., 2022; Gaspard et al., 2017). Teaching aligned with these aims is strongly supported by research in mathematics education and is consistent with establishing mastery-oriented classrooms in which the teacher demonstrates enthusiasm and support for students (e.g. Carmichael et al., 2017; Sullivan, 2011).

Our *Struggling Ambitious* cluster accounted for 36% of the sample compared with 14% in Watt et al.'s (2019) study, confirming H2.2. Watt et al. (2019) noted the over-representation of boys in their *Struggling Ambitious* profile and speculated that gender stereotypes portraying boys should be good at and interested in mathematics was a contributing factor. It could be that in boys-only settings these stereotypes are more keenly felt, which might also explain their significantly higher scores on performance-approach goal orientations compared to both *Positively Engaged* and *Disengaged* students (consistent with H2.3). The *Struggling Ambitious* cluster was also higher than the *Disengaged* cluster for performance avoidance. The converse proposition in H2.3 was not confirmed; there were no differences between clusters in relation to students' mastery goal orientation.

Consistent with H2.4, classroom goal structures were more likely to be experienced as mastery-oriented by the *Positively Engaged*, in contrast to the *Disengaged* cluster. Contrary to H2.4, the *Struggling Ambitious* were as likely as the *Positively Engaged* to experience mastery-oriented classrooms. This finding contrasts with the more performance-focused classrooms experienced by the *Struggling Ambitious* in Watt et al. (2019). Again consistent with H2.4, *Disengaged* students reported less teacher enthusiasm, but, there were no other differences on teacher factors between any of the clusters. Further exploration of the reasons behind cluster membership than their higher performance-approach goals is needed, including the possible influence of boys-only settings. *Struggling Ambitious* and *Positively Engaged* students also experienced similar and higher mastery-oriented classroom environments, higher peer valuing of mathematics (consistent with H2.4), and teacher support, than the *Disengaged* cluster. Contrary to H2.5, we found no differences between clusters in relation to teachers' use of representational tools.

In summary, our findings suggest potential antecedents of cluster membership were boys' achievement goal orientations (specifically performance-approach and -avoidance), together with a mastery-oriented classroom, peer valuing of mathematics, and teacher enthusiasm. No classroom or teacher factors distinguished the *Positively Engaged* and *Struggling Ambitious* clusters.

5.3 RQ3 Associations of cluster membership with engagement and wellbeing

Motivational clusters appeared important for mathematics engagement (effort), and positive and negative aspects of wellbeing. As hypothesised, *Disengaged* students exhibited least effort exertion in mathematics and poorest wellbeing in terms of school satisfaction; *Struggling Ambitious* and *Positively Engaged* reported similarly higher effort and school satisfaction. Both *Struggling Ambitious* and *Disengaged* students reported greater illbeing on all burnout dimensions (cynicism, emotional exhaustion, sense of inadequacy). In the case of the *Positively Engaged* this finding is consistent with those of several studies in mathematics education that connect engagement to motivation (including mitigation via anxiety) via the valuing of a task/activity (e.g. Stoehr, 2017; Sullivan et al., 2013, 2016). The finding of similarly low illbeing among *Disengaged* students is difficult to explain. It could be that their disengagement is such that they are no longer concerned with studying mathematics, or school in general, in contrast with the *Struggling Ambitious* who remain to perform well and exert effort similar to *Positively Engaged* students while experiencing greater illbeing than students in other clusters.

Students in our *Disengaged* cluster, saw little value in mathematics, did not regard themselves as talented, and tended to believe the effort required was too high, but held slightly lower than average perceptions of mathematics difficulty. Their perception of difficulty could be a consequence of a lack of challenge resulting in boredom, or their level of engagement. Behaviours indicative of boredom (e.g. inattentiveness) could be interpreted by teachers as evidence of limited ability resulting in a further reduction of challenge (Beswick, 2017) and teacher support (Durksen et al., 2017). Such a reduction in challenge stands in contrast to the findings of studies that indicate cognitive activation and motivation are related to the positioning of mathematical challenge as central to classroom culture (e.g.Beswick, 2017; Makar et al., 2015; Schukajlow et al., 2015). Their response could also be interpreted as a defensive stance whereby they safeguard their ability by attributing their lack of achievement to lack of effort rather than to finding the subject too hard (Ryckman & Peckham, 1987).

Both *Struggling Ambitious* and *Disengaged* students reported similarly high burnout (cynicism, emotional exhaustion and sense of inadequacy) than the *Positively Engaged*. This resonates with Ernest's (2018) description of the rejection by mathematics, school and even society in general felt by many students as a result of negative experiences of learning mathematics, and that can last into adulthood (Itter & Meyers, 2017). The larger proportions of our sample in these clusters evidencing poor wellbeing suggests that these issues may be more acute for boys in general or more pronounced in boys-only settings. Further research to tease out the impacts of gender and single-sex settings, including girls'-only schools, is needed.

5.4 Limitations and conclusion

The findings reported here needed to be read cognisant of the limited sample size drawn from an unknown number of classes at a single independent boys' school in Australia. Nevertheless, substantial numbers of Australian students learn in independent schools with approximately 1 in 8 in single sex settings. Our findings support the existence of the previously identified *Positively Engaged*, *Struggling Ambitious* and *Disengaged* mathematics types (Watt et al., 2019) in this setting, and extend participants' age composition beyond Year 10, to include Years 5, 7 and 9. Further research using cost measures alongside positive motivations with larger samples at various Year-levels and in a diversity of settings including girls'-only schools could further explore such profiles and their composition. The high proportions of boys in the maladaptive clusters is concerning. The extent to which these might be attributed to our sample being from a boys'-only school warrants further investigation especially since classroom and teacher factors seemed not to play a role in distinguishing the *Struggling Ambitious* from the *Positively Engaged* cluster. In addition to students from different profiles requiring differing interventions it may be that the gendered status of the setting demands further nuance. The increase in *Disengaged* students, and other possible changes in cluster profiles with year-level, requires investigation via longitudinal studies rather than cross-sectional studies such as ours. A further limitation is that since we were unable to collect data linking students to their classes, we are unable to consider differences between classrooms.

From the perspective of mathematics education the findings lend weight to longstanding calls for classrooms that support students' focus on learning mathematics rather than on performance relative to peers (i.e. mastery goal structures), and in which teachers demonstrate enthusiasm for mathematics teaching and establish positive and supportive relationships with all students (Carmichael et al., 2017). Terminology such as student-centred teaching or simply effective teaching (e.g. Ingram et al., 2018; Sullivan, 2011) often describes such practices. Educational psychologists and mathematics educators alike have noted the decline in students' engagement with mathematics as they progress through the years of schooling (Beswick et al., 2006; Watt et al., 2004). Our findings have identified clusters of students with differing mathematical engagement, along with the antecedents of cluster membership, suggesting specific factors that require attention from primary school onwards to maintain engagement.

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