Math Ed Res J (2017) 29:219–236
DOI 10.1007/s13394-017-0200-z

ORIGINAL ARTICLE

The impact of within-school autonomy on students' goal orientations and engagement with mathematics

Colin Carmichael[1] · **Tracey Muir**[2] · **Rosemary Callingham**[2]

Received: 6 September 2016 / Revised: 8 February 2017 / Accepted: 16 February 2017 /
Published online: 6 March 2017

Abstract School autonomy has been identified as having an impact on a school's performance, yet less has been reported about the effect this has on students' goal orientations and engagement with mathematics. In a national study conducted in schools across Australia, measures of school autonomy were collected from teachers and school leaders, along with students' perceptions of the mastery and performance goal orientations of their classrooms and personally using surveys. Schools were identified as having high or low levels of autonomy on the basis of school leaders' responses. For the study discussed in this paper, a subset of 14 schools for which matched student and teacher data were available provided students' responses to a variety of variables including goal orientations. The findings suggested students in high-autonomy schools were less likely to hold a personal performance approach and avoidance goals than their peers in low-autonomy schools. Fifty-five case studies conducted in 52 schools provided evidence of some of the practical aspects of these findings, which have implications for systems, schools and teachers.

Keywords Autonomy · NAPLAN · Mathematics · Self-determination theory

✉ Tracey Muir
Tracey.Muir@utas.edu.au

Colin Carmichael
ccarmichael@csu.edu.au

Rosemary Callingham
Rosemary.Callingham@utas.edu.au

[1] Charles Sturt University, Sydney, Australia

[2] University of Tasmania, Launceston, Australia

Introduction

In Australia, concerns have been raised regarding students' disengagement with mathematics, particularly in the middle years, which is likely to contribute to the ongoing decline in numbers of students undertaking senior secondary and tertiary studies in mathematics (McPhan et al. 2008). Several factors have been identified as contributors to student disengagement in mathematics, including inappropriate curricula, insufficiently challenging tasks and ineffective teaching (Luke et al. 2003). Mathematics classroom cultures where students' needs for autonomy, competence and relatedness are not met are also likely to contribute to disengagement from learning (Deci and Ryan 1985). In a synthesis of over 800 meta-analyses relating to achievement, Hattie (2009) identified over 50 factors that provided large effect sizes in enhancing students' learning. In the study addressed in this paper, school and teacher effects, particularly in relation to within-school autonomy, are of particular relevance.

Caldwell (2014) maintains that although no school in a system of public education can be fully autonomous, it is appropriate to refer to schools as having relatively high or low levels of autonomy. In this study, autonomy was addressed as a variable that covered both management aspects of the school such as budgeting and freedom for teachers to make decisions in classrooms about curriculum delivery. Recent research has shown that school autonomy in terms of what to teach, how to teach, organisation of personnel and finances was more likely to result in successful improvement efforts (Reezigt and Creemers 2005). Further, Verschelde et al. (2015) found that greater autonomy in budget allocation at the school level was associated with performance in mathematics even after controlling for school-level factors such as the type of school. Yet, even within two similarly structured schools, management styles could create environments supporting or thwarting autonomous decision-making within the school. Principals and subject coordinators can tightly control what is taught and how it is taught or, on the other hand, allow staff considerable autonomy in making these decisions.

Despite the reported association between school-level autonomy and student-level performance, little research has focused on the impact school autonomy has on students' experiences and attitudes towards learning mathematics. We explore this impact through the lens of self-determination theory (SDT) (Deci and Ryan 1985), arguing that greater autonomy in decision-making at the school level and within the school, and provision of autonomy-supportive environments, influences the types of goals adopted by teachers and that these in turn influence the achievement goals adopted by students themselves. In short, autonomy permits the key players to be more self-determined, thus influencing the 'tone' of the school. This tone, in turn, influences the pedagogical approaches adopted by teachers and experienced by students, which are then enacted in practice through the teaching and learning of mathematics.

Review of the literature

Enhancing mathematics teaching and learning

Research has identified a number of teacher characteristics and practices that contribute to effective mathematics teaching (e.g. Askew et al. 1997; Clarke and Clarke 2002; Muir 2008). In their seminal study involving 90 teachers and over 2000 students,

Askew et al. (1997) found that highly effective teachers could be distinguished from other teachers by a particular set of coherent beliefs and understandings that underpinned their teaching. For example, effective teachers believed that all students are able to become numerate and used teaching approaches that helped students to make connections, be challenged and engaged in purposeful discussion. Muir (2008) identified a number of principles of effective numeracy practices that included making connections, challenging all students, teaching for conceptual understanding, purposeful discussion, focus on mathematics and positive attitudes. These studies are consistent with Yackel and Cobb's (1996, p. 458) view that sociomathematical norms 'enhance students' developing intellectual autonomy in mathematics'.

Teachers can promote classroom autonomy in three different ways: organisational autonomy (classroom rules, for example), procedural autonomy (allowing students to choose ways in which they go about tasks) and cognitive autonomy (allowing students to share and evaluate their own work) (Stephanou et al. 2004). These autonomy-supportive approaches are likely to lead to mathematics classrooms where students are engaged.

According to Attard (2011), engagement in mathematics occurs when students are procedurally engaged during mathematics lessons and beyond; they enjoy learning and doing mathematics, and they view the learning and doing of mathematics as a valuable, worthwhile task, useful within and beyond the classroom. Engagement may be viewed as being multi-faceted and operating at three levels: cognitive, affective and behavioural or operative (Fredricks et al. 2004). Engagement is also linked with motivation, which includes self-efficacy, mastery orientation and the value of schooling (Munns and Martin 2006). 'Motivation for engagement' has been used to describe the degree to which students choose to engage actively in classroom activities because of their affective assessment of mathematics (Williams and Ivey 2001). Positive attitudes to mathematics have been associated with improved achievement in the subject (Ashcraft and Kirk 2001), but students have described school mathematics as being boring and meaningless (Boaler 1994) and in a recent TIMSS report, only 16% of Australian students indicated that they liked learning mathematics (Thomson et al. 2012).

Theoretical framework

SDT is concerned about the quality of motivation in terms of whether behaviours are regulated autonomously or need to be externally controlled. People who undertake tasks for their inherent value or interest seldom require external regulation during the task and act autonomously. These intrinsically motivated individuals typically engage in self-regulation (Lee et al. 2014), display high levels of participation (Watt et al. 2012) and report higher achievement (e.g. Heinze et al. 2005). At the other extreme, some people may require rewards in order to undertake tasks that are of little personal interest. The theory argues that these qualitative differences in motivation occur due to individual differences in the way task completion satisfies the basic psychological needs of autonomy, competence and social relatedness. In the mathematics classroom, for example, students are more likely to engage in tasks set by their teacher if they have some choice in those they complete, believe they are likely to be successful with the tasks and feel connected to the group of learners in the classroom (Sullivan 2011). Such students are likely to become intrinsically motivated, learning mathematics for its

interest. SDT acknowledges, however, that children for whom mathematics has little interest can be motivated instead by the importance of the subject to the extent that they identify with the importance of working hard in mathematics (Ryan and Deci 2000). Although their motivation for engaging in mathematics might be extrinsic, such as getting a good job, the regulation of their behaviour has been internalised. For this reason, SDT differentiates between autonomous motivations (intrinsic and identified) on the one hand and controlled motivations on the other.

Given the positive outcomes associated with autonomous motivation, recent developments in SDT have focussed on strategies for nurturing this motivation. Vansteenkiste et al. (2006), for example, have argued the need for autonomy-supportive environments and intrinsically framed goals. Autonomy-supportive environments are those where individuals have some choice in the activities they undertake or, if choice is limited, they are instead provided with a rationale for the activity. Controlling environments, on the other hand, typically provide limited choice and are associated with negative outcomes such as increased academic dishonesty (Kanat-Maymon et al. 2015), decreased levels of performance (Assor et al. 2009) and increased levels of emotional exhaustion and cynicism (Schultz et al. 2014).

In regard to goal framing, within the SDT framework, theorists differentiate between intrinsic and extrinsic goals (Vansteenkiste et al. 2006). The former, such as achieving personal mastery, are fulfilled in their own right and help lead to the internal satisfaction of the basic psychological needs. The latter, such as performing better than peers, require external measures of worth. Teachers can frame their lesson's goals intrinsically in terms of students mastering the material or extrinsically in terms of students performing well in a test. Similarly, school leaders can frame their teachers' goals intrinsically in terms of teachers mastering their craft or extrinsically in terms of meeting external student performance benchmarks. Interventions have shown that students whose teachers have framed learning goals intrinsically are more likely to display deeper learning strategies and perform better than those whose teachers have framed learning goals externally (Vansteenkiste et al. 2004).

The notion of intrinsic and extrinsic goals overlaps considerably with achievement goal theory (e.g. Wolters 2004), which holds that students' motivation to learn is shaped by their own goals and those promoted in their classrooms. Broadly, these goals are viewed as mastery or performance oriented: an emphasis on mastering the learning material, as opposed to performing well in tests of achievement in comparison to peers. In the SDT framework, mastery goals are viewed as intrinsic and performance goals extrinsic. Consequently, SDT posits that the promotion of mastery goals in an autonomy-supportive environment is likely to lead to the fulfilment of basic needs and thus increase the likelihood of autonomous motivation. As a result, several observational studies report a positive association between autonomy-supportive environments and a mastery goal orientation (e.g. Assor et al. 2009; Standage et al. 2011). Further, a mastery goal orientation is known to be associated with interest (Harackiewicz et al. 2008) and deeper learning (Ikeda et al. 2015).

In a school context, teachers' perceptions of autonomy influence their broad teaching goals, which in turn influence their students' perceptions. Janke et al. (2015) reported that teachers' needs support was strongly associated with their adoption of an achievement goal orientation and although their perceived teaching competence had the greatest impact on this orientation, their perceived autonomy also contributed

significantly. Teachers' goal orientations, in turn, influence the way that they teach, with Patrick et al. (2001) reporting that teachers with a mastery goal orientation were more likely to encourage their students to engage in discussion, display enthusiasm and develop understanding than their peers with a performance orientation. Further, studies also demonstrate an association between students' perceptions of their teachers' autonomy support or suppression and their own achievement goal orientations, with Madjar et al. (2013) reporting a strong positive association between teacher autonomy suppression and students' levels of performance orientation.

Within-school autonomy can relate to several domains, including educational goals (what to teach), educational means (how to teach), organisation and finances (Reezigt and Creemers 2005). While full autonomy in all these domains does not necessarily promote school improvement, an absence of autonomy in all areas has been shown to inevitably lead to failure (Reezigt and Creemers 2005). Leadership and systems can foster within-school autonomy through building professional capacity through staff selection, professional development and appraisal, setting priorities on the basis of data about performance and communication of purpose, process and performance; all these factors have been linked with school autonomy and student achievement (Caldwell 2014). In addition, leadership has been shown to influence school improvement and teacher self-efficacy through promotion of a strong collegial culture of mutual trust and support among teachers and school leaders (Masters 2010).

Informed by the review of the literature and the theoretical framework, the following research questions for this paper are as follows:

1. To what extent is within-school autonomy associated with student goal orientations and engagement?
2. How do school policies and practices provide school leaders and teachers with autonomy?

The present study

The study discussed in this paper draws on data collected from a large-scale study commissioned by the Office of the Chief Scientist (OCS) in 2015. The Best Practice in Mathematics Education (BPME) study involved a large national survey sent to all Australian schools and a set of 52 case study schools that showed superior gain in NAPLAN. The surveys were sent to school leaders, teachers of mathematics and students. Survey responses were received from 89 school leaders, 187 teachers and 1095 students.

Case study schools were selected from schools demonstrating superior gain to cover a variety of school type (primary, secondary, combined); all sectors, all states and territories, diverse locations, school size, socio-economic status as measured by the Index of Community Socio-Educational Advantage (ICSEA) and other features of interest such as selective high schools and single-sex schools. The ICSEA is an index with a median of 1000 and standard deviation of 100 developed by the Australian Curriculum and Reporting Authority (ACARA) (2013). Table 1 shows the distribution of case study schools by state and sector. The purpose of the case studies was to identify schools that had achieved superior gains in NAPLAN numeracy during the time

Table 1 Case study schools by state and sector

State	Government	Independent	Catholic	Total
ACT	5	1	1	7
NSW	6		2	8
NT	2	1		3
QLD	2	2	1	5
SA	3	2	2	7
TAS	3	3		6
VIC	5	4	1	10
WA	2	3	1	6

periods 2011–2013 and 2012–2014 and to examine their practices in mathematics education. Superior gain was defined as achieving growth between years 3 and 5 or between years 7 and 9, more than 1 standard deviation above the mean growth for all schools.

The component of the larger study presented in this paper considered students' survey responses to items relating to personal and classroom-level goal orientations as well as their engagement, in terms of their emotional interest and cognitive interest. The case study data provided additional information about the impact of school autonomy providing nuances that are not possible from surveys alone.

This paper focuses on the identification of school level and teacher practices which have potential to lead to gains in NAPLAN results and includes results from the national surveys and the case studies. Fourteen schools have been analysed for high and low autonomy. There was no attempt to match these schools with those analysed in the case studies, as schools participating in the latter generally chose not to participate in the survey. Specifically, the authors were interested in investigating what autonomous practices principals, school leaders and teachers experienced in their respective schools and whether or not this impacted upon students' learning.

Method

To address the research questions, a mixed methods approach was chosen because the study involved collecting, analysing and mixing both quantitative and qualitative research methods in order to understand the research problem. Within this paradigm, concurrent procedures (Creswell 2008) were used whereby the researchers converged both quantitative and qualitative data that were collected at the same time during the study and then integrated to interpret the overall results. The focus of the study was on the specific contexts, (schools), in which people operated so the research was conducted using a social constructivist perspective (Creswell 2008). The survey data provided the opportunity to build models to address research question 1, and a variety of data sources provided richness and depth to the study of the school cases to address research question 2. Ethical approval from all jurisdictions was granted for the research.

Participants

Participants for the study included 78 school leaders and 491 students from the schools (14) whose leaders provided an autonomy score as explained in the next section. Of these leaders, two thirds worked in government schools, and most (51%) were in a primary school. The school leaders were mainly female (63%) and most (58%) had been leaders in the school for less than 10 years. Just over one quarter of leaders (27%) indicated that mathematics was their major teaching area, and 45% indicated that English and languages was their major focus. Only 21 school leaders were able to be matched to student data. Just over half of this group of leaders taught in government schools and 43% were in primary schools. Almost one half (47%) of them worked in identified superior growth schools. More than three quarters (75%) were female, and 57% indicated that English and languages was their major teaching area.

The student participants ranged in age from 8 to 16 years (M = 10.97, SD = 2.03) and just over half (53%) were girls. They were in year levels ranging from year 3 to year 10, with most (61%) in years 5, 6 or 7. The schools they attended were located in all Australian states, and 78% of the students attended school in the most populous states of Queensland, New South Wales and Victoria. The ICSEA of these schools ranged from 899 to 1202 (M = 1109.83, SD = 72.54).

The participants for the 55 case studies included school leaders, teachers and students from 52 case study schools (some schools operated as two distinct campuses; hence, each site was treated as a different case). The number of participants in each school varied according to the size of the school, type of school and availability. Typically, interviews were conducted in each school with the principal, school leader, two teachers and 1–2 focus groups of students.

Instruments

Surveys

The leader survey constructs most relevant to the study discussed in this paper focused on the extent to which decision-making was divested within the school. A within-school autonomy score was derived from 78 school leaders' responses to 11 items from PISA[1] (Organisation for Economic Cooperation and Development (OECD) 2012) that assessed within-school responsibility for the allocation of resources (e.g. 'Regarding your school, who has considerable responsibility for the following tasks? Selecting teachers for employment') and curriculum and assessment (e.g. 'Choosing which textbooks are used'). Leaders were asked to select one or more applicable categories including state education agency, local education agency, school-level governing board, principal, principal with teacher input and teachers that were coded from 1 to 7, respectively. A leader's autonomy score for a particular item was the highest code if more than one response was selected, with high scores indicative of higher levels of within-school autonomy and thus a culture of divested decision-making.

[1] Technical details on this instrument are available from OECD (2013, p. 284) which reports three indices, with reliabilities of 0.67, 0.65 and 0.63. In the current study, coding was undertaken using Rasch measurement guidelines (Bond and Fox 2007) to enable a single index of within-school autonomy.

Table 2 Within-school autonomy items with difficulty and fit statistics

Item	Difficulty	Infit
Establishing teachers' starting salaries	3.43	0.87
Determining teachers' salary increases	2.96	0.99
Formulating the school budget	0.53	1.00
Hiring and firing teachers	0.45	0.80
Selecting teachers for employment	−0.37	0.72
Deciding on budget allocations within the school	−0.63	0.85
Deciding which courses are offered	−1.03	1.35
Establishing student assessment policies	−1.93	1.23
Choosing which textbooks are used	−3.42	1.33

These leader responses were then tested against a Rasch rating scale model (Andrich 1978). Preliminary analyses suggested that the category structure used was inconsistent with the model, and as per established guidelines (Linacre 1999), the first three categories were thus collapsed post hoc. Moreover, these analyses also revealed that two items, 'approving school admissions' and 'determining course content', were inconsistent with the model because they reported fit statistics outside recommended limits (Bond and Fox 2007). The final school autonomy score, therefore, was based on nine items reported in Table 2. The measure itself explained 67% of the variance in responses and reported a reliability of $\alpha = 0.67$. Within-school autonomy scores ranged from −3.36 to 1.35 ($M = -.67$, $SD = .94$).

In the student surveys, students were asked to report on their interest, both cognitive and emotional, for mathematics and their achievement goal orientations. Three items (e.g. 'I like maths more than my other subjects at school') adapted to the Australian context by Watt (2004)[2] from Eccles and Wigfield (1995) assessed the emotional dimension of interest. Three items (e.g. 'After a maths class, I am curious about what we are going to do in the next lesson') adapted[3] from Frenzel et al. (2012) assessed the cognitive dimension of interest. Seven items (e.g. 'I aim to learn as much maths as I can') assessed a personal mastery goal orientation, three items (e.g. 'I aim to show others that I'm good at maths') a personal performance approach orientation and three (e.g. 'I aim to keep others from thinking I'm not smart in maths') a personal performance avoidance orientation. These goal orientations were adapted to a mathematics context by Conley (2012)[4] from Midgley et al. (2000). All items were reported on a Likert scale ranging from 1 (not at all) to 7 (extremely).

Students also reported their perceptions of their classroom and school environments. Five items (e.g. 'Our teacher really enjoys teaching maths') assessed teacher enthusiasm and were adapted from Kunter et al. (2011) who reported a reliability of 0.86. Three items (e.g. 'Our teacher really wants us to enjoy learning new things') assessed a classroom mastery environment, and three items (e.g. 'Our teacher tells us

[2] Watt (2004) reported a reliability of 0.94 for this subscale.
[3] Frenzel et al. (2012) used six items with a reported reliability of 0.87
[4] Reported reliabilities for mastery, performance approach and performance avoid were 0.86, 0.82 and 0.78, respectively.

how we compare to other students') assessed a classroom performance environment and were adapted from Midgley et al. (2000).[5] All three scales were reported on a Likert scale ranging from 1 (not at all) to 7 (extremely). School caring relationships were assessed using three items (e.g. 'The teachers here respect me') adapted by You et al. (2011) from the Caring Relationships subscale[6] of the widely used Psychological Sense of School Membership scale (Goodenow 1993), which were reported on a Likert scale ranging from 1 (not at all) to 7 (completely true).

Case studies

A detailed protocol was used for the case study data collection, in order to ensure consistency across such a large number of case studies. Interviews with school leaders and teachers began with questions related to school context, followed by questions related to policy, school and class level. Example questions included the following: How is mathematics organised and managed in your school? Who is responsible for teaching mathematics? What role does the individual teacher have for organising and planning curriculum? What characterises an effective mathematics teacher/lesson? Teachers were asked how they organised and planned their mathematics program and to describe a typical mathematics lesson in their classroom. Students in focus groups were asked a variety of questions about their mathematics experiences, including what a typical mathematics lesson looked like, how they felt about mathematics and what they did when they did not know how to work out a mathematics problem. All interviews were audio-taped. Two mathematics lessons were observed and field notes taken using a recording proforma. A reporting template was provided for in-school researchers to provide a consistent reporting focus. The data collection for both surveys and case studies was undertaken concurrently, using the same underpinning framework, to meet study deadlines.

Data analysis

Survey data were analysed to ascertain the influence of within-school autonomy on student factors through comparing means on these factors for participants in schools with above average autonomy scores with means for participants in schools with below average autonomy scores. Given that gender, age and measures of socio-economic status are known to influence some student-level factors (e.g. Carmichael et al. 2013), we compared these means using a series of latent regression models allowing us to assess the impact of high or low school-level autonomy on student goal orientations and engagement factors after controlling for these demographic variables. These models, undertaken using MPlus (Muthén and Muthén 2012), allowed us also to control for measurement error in the response variable. Model fit was assessed using the comparative fit index (CFI) and root mean square error of approximation (RMSEA) as described in Byrne (2012).

Within the project team, three researchers undertook the initial analysis of approximately 20 different case studies each, identifying key themes that related to the

[5] Midgley et al. (2000) used a 5-item subscale for mastery ($\alpha = 0.83$) and 3 items for performance ($\alpha = 0.79$).
[6] You et al. (2011) reported a reliability of 0.74 for this subscale.

framework of the study. Results from these syntheses were then compared and discussed to provide the final set of findings. Due to the tight timeline required for reporting, the interviews were not initially transcribed, but for the purposes of this paper, partial transcription of illustrative case study schools occurred. Illustrative case study schools were those that included direct reference to autonomy or practices that promoted autonomy. As comprehensive data analysis of all the case studies is yet to occur, the authors acknowledge that there may have been examples of schools that did not promote autonomous practices—this however was not evident in the initial data analysis.

Results

Survey results

Descriptive statistics

Summary statistics for identified constructs as well as Pearson correlation coefficients are reported in Table 3. Students who perceived a strong classroom focus on performance were more likely themselves to adopt performance approach goals ($r = .16$) and less likely to adopt mastery approach goals($r = -.11$). Students who perceived a strong classroom focus on mastery were likely to perceive high levels of school care ($r = .56$) and teacher enthusiasm ($r = .80$). Teacher enthusiasm, in turn, was weakly associated with students' emotional ($r = .09$) and cognitive ($r = .11$) interest for mathematics. Further, students who reported a mastery goal orientation were more likely to report higher levels of emotional ($r = .50$) and cognitive interest ($r = .54$).

Modelling within-school autonomy

Of the 14 schools, nine schools with 217 students reported above average autonomy scores and five schools (274 students) reported below average autonomy scores. Of the former schools, four were government primary schools, one a government secondary school and four were independent combined primary/secondary schools. Of the latter, two were government high schools, one a Catholic primary school and one an independent combined primary/secondary school. A dichotomous variable was then created for these 491 students indicating whether or not their school leader had recorded an above or below average autonomy score. As described, each of the identified factors was regressed onto this within-school autonomy score after controlling for ICSEA, gender and age (see Table 4).

Given the number of comparisons that were made and the need to apply the Bonferroni adjustment, only results significant at the 0.5% level are reported. Students in schools with above average autonomy scores were likely to report higher levels of classroom mastery environment ($\beta = 0.16$, $t = 3.16$),teacher enthusiasm ($\beta = 0.19$, $t = 4.10$) and a school caring environment ($\beta = 0.21$, $t = 3.45$) than those in schools with below average autonomy scores. They were also likely to report lower levels of classroom performance environment ($\beta = -0.32$, $t = 5.86$), and a performance avoidance goal orientation ($\beta = -0.20$, $t = 3.61$).

Table 3 Descriptive statistics and Pearson correlations for student constructs

	M	*SD*	α	2	3	4	5	6	7	8	9
1. Emotional interest	4.66	1.83	0.89	0.67**	0.50**	0.19**	0.15**	0.06	−0.01	0.08	0.09*
2. Cognitive interest	4.49	1.58	0.77		0.54**	0.23**	0.19**	0.02	0.01	0.10*	0.11*
3. Mastery approach goals	4.35	0.84	0.85			0.24**	0.26**	0.02	−0.11*	0.04	0.04
4. Performance approach goals	2.60	1.17	0.82				0.48**	−0.03	0.16**	−0.02	0.01
5. Performance avoidance goals	3.19	1.26	0.72					−0.17**	0.06	−0.20**	−0.16**
6. Classroom mastery environment	4.75	1.08	0.75						0.18**	0.56**	0.80**
7. Classroom performance environment	2.60	1.24	0.67							0.04	0.17**
8. School caring environment	4.34	1.18	0.77								0.53**
9. Teacher enthusiasm	4.59	1.16	0.89								

*$p < .05$, **$p < .01$

Table 4 Results of latent regression models, with standardised coefficients shown for each factor tested †

	E.Int	C.Int	CME	CPE	STE	SCE	M.App	P.App	P.Av
Above average autonomy	−0.10*	−0.08	0.16**	−0.32**	0.19**	0.21**	−0.02	−0.12*	−0.20**
Male	0.14**	0.10*	−0.09*	0.06	−0.03	−0.18**	−0.02	0.10	0.16**
ICSEA	−0.04	−0.04	0.02	−0.08	−0.03	0.15**	−0.01	−0.15**	−0.04
Age	−0.26**	−0.33**	0.45**	0.31**	0.37**	0.32**	−0.33**	−0.11*	−0.32**
RMSEA	0.07	0.04	0.06	0.10	0.06	0.02	0.06	0.06	0.06
CFI	0.98	0.99	0.98	0.90	0.98	0.99	0.97	0.98	0.97

*$p < .05$, **$p < .01$

E.Int emotional interest, *C.Int* cognitive interest, *CME* classroom mastery environment, *CPE* classroom performance environment, *STE* student perceived teaching enthusiasm, *SCE* school caring environment, *M.App* mastery approach goal orientation, *P.App* performance approach goal orientation, *P.Av* performance avoid goal orientation

There were no significant differences in levels of emotional and cognitive interest for mathematics between students in these two groups of schools after controlling for age and gender. As shown in the table, model fit indices for each model were within recommended limits in that RMSEA <0.10 and CFI >0.90 (Byrne 2012).

Autonomy in case study schools

This section details how autonomy was enacted within the case study schools. A key finding was that mathematics in case study schools was led by a member of staff who had input at the decision-making or policy level at the school. For example, one principal stated '[the] Head of Maths has a lot of autonomy to put the maths teachers [on classes] … Every time I get something across my desk [about professional learning] it will be on [head of maths] desk to decide' [Principal, P-12 Independent, High ICSEA].

At another independent F-12 school, coordinators for each curriculum area were appointed for each of three separate campuses. Collaborative planning occurred in year group teams. As a result, each year level undertook similar topics of mathematics at the same time, with the provision to extend individual students. The principal and school leaders had the autonomy to keep class sizes reasonably small, with the four year 7 classes, for example, being split into five groups for mathematics. Group sizes were typically larger in the top classes as the lower ability classes required more support and according to the principal 'is another structural consideration that is important.'

Although most schools were guided by the Australian Curriculum: Mathematics, there was flexibility in terms of how this was implemented in each school. A government F-12 school, for example, implemented a whole school approach to teaching mathematics with the staff developing a scope and sequence document including early years (foundation—year 3), middle years (years 4–8) and later years (years 9–10). The document mostly focused on number with other areas still being developed. The numeracy coordinator said:

> Although it [our scope and sequence] is based on the Australian curriculum as teachers we make decisions about where topics fit.

Employment of suitably qualified mathematics teachers was another school-level practice over which many principals had autonomy. In an independent F-12 school, for example, the principal had a deliberate policy of only recruiting suitably qualified teachers in mathematics with some years of experience, and there were no new graduate teachers at the school. In contrast, another F-12 government school also only recruited qualified mathematics teachers but had a strong mentoring program in place, whereby all new teachers were mentored weekly for the first term then informally for the rest of the year and was very willing to employ new graduate teachers.

Within the broad school frameworks established, teachers were autonomous and could usually use resources and pedagogies that suited their particular grade or class group. In one co-educational government secondary school in Victoria, for example, although the school mathematics leader planned the overview for the year, individual teachers had a high level of autonomy to prepare lessons suited to their classes. The mathematics leader stated,

> [you might be working] on the same topic at the same time [but] maybe only within the same staffroom because it's easier. I think probably all the different teachers are doing different things. I wouldn't say they are doing the same topic at the same time.

Schools used a range of groupings and instructional practices to best meet the needs of students. At a government primary school, for example, the year 3 cohort of 81 students was divided into five groups based on learning needs. Three year 3 teachers and two other available teachers were rostered to take allocated groups of students for three half-hour lessons per week. It was the allocated teachers' responsibility to prepare the learning activities for the targeted lessons for their group of students. The school allocated finances to enable the small group teaching with extra teachers. Several schools had access to a numeracy coach or designated a staff position to that role. In one government primary school, the numeracy coach had been at the school for 4 years, during which time the NAPLAN results had shown growth. A whole school approach to mathematics was identified as a need and the numeracy coach introduced the Numeracy Project (a New Zealand program of professional learning).

At a class level, although there was evidence that many schools followed similar lesson approaches, teachers had autonomy within that structure to adapt and use resources accordingly. Furthermore, it appeared as if the teachers who experienced autonomy also encouraged autonomy in their students. For example, one teacher in a high ICSEA, independent high school extended her year 8 class by giving them opportunities to explore different aspects of mathematics. Each student chose a topic and taught this to the rest of the class. The topics were varied and included a way of squaring two-digit numbers mentally, Japanese multiplication, lucky numbers and Keeler's Theorem. This example is similar to the cognitive autonomy described by Stephanou et al. (2004).

An autonomous approach was substantiated and encouraged by school leaders. For example, one principal said:

> Teachers encourage students to have ownership for their learning commencing from preps. If you ask the students why they have been given a particular task to do they will say it is because their teacher knows that is the right challenge for them. [Principal, High ICSEA, F-6 school]

Students in many of the case study schools were autonomous in their approach to mathematics learning. They drew on strategies that they had been taught, not worrying about whether they might be wrong but accepting that they would learn from mistakes. For example, the following comments were made by students when asked what they did when they got stuck on a mathematics problem:

> We don't ask for help. We find it out for ourselves using different stuff like we have a lot of maths charts in our room and maths dictionaries and she tells us to look at these before we ask her. [Primary student, low ICSEA F-12 school]

> I discuss with someone who is also stuck because they might have a bit which I was missing and then we work it out together. [Primary student, high ICSEA primary school]

Interviews with students also showed that they felt teachers cared about them which satisfied their needs for relatedness in particular. The following was typical feedback received in response to an interview question about how the teacher helped them to learn mathematics:

> [He's] always just really positive in class, and he's always saying like I want to help you, like I don't want you to necessarily get As, I just want you to understand it. [He] doesn't care if we get it wrong as long as we understand the process and just keep trying. [Year 9 student, Catholic, average ICSEA, year 6–12 school]

> She'll look in your book and she'll find like the pros and cons and she'll normally just focus on the pros—she won't bother about the cons—until you find out if you need help with them. If half the class are struggling with that thing, she'll make a new lesson out of that. [Primary student, low ICSEA government primary school]

There were also examples of autonomy observed in the classroom lessons. In an observation of a grade 7/8 class in a small rural K-10 government school, the students were following a 'contract' in which they had to complete negotiated tasks over 1 week. The tasks included an algebraic puzzle and designing the net of a cube with drawings on each face that when folded would all face the right way up. During the lesson, the teacher worked with small groups of students on specific concepts to extend their understanding of algebra (substitution). The students appeared comfortable with the autonomy that they had and worked in a focused way on their contract tasks.

Study limitations

The matching of data from students, their teachers and their school leaders proved to be difficult in this study, as many respondents chose not to provide an identifying code. This unavoidable limitation affected the analysis of survey data and precluded the nesting of students with classes and within schools. Further, student-level performance data were not available, preventing us from exploring the relationship between autonomy and student performance.

Discussion

Research question 1: the association of within-school autonomy and students' goal orientations and engagement

The analysis of survey results suggests that the degree of autonomy within a school influenced the perceptions of students but in a nuanced way. Students in schools with above average autonomy scores were more likely to observe a classroom motivational climate with a greater focus on mastery, higher levels of teacher enthusiasm and a greater emphasis on caring in their school than their peers in low-autonomy schools.

There were no significant differences, however, in students' reports of their own goal orientations, other than performance avoidance goals, with students in schools with above average autonomy less likely to adopt these goals. Personal goal orientations appear to be more influenced by the demographic variables of gender, age and socio-economic status than classroom factors, Owens and Barnes (1982) reported similar findings. Recent studies have identified complex relationships between classroom environments and students' goal orientations (Tapola and Niemivirta 2008), suggesting that teachers who adopt learning-focussed goals can influence students' perceptions. The current study indicates that school autonomy plays a role in this process.

There were no significant differences in students' interest, either emotional or cognitive, for mathematics between those attending schools with above average autonomy scores and those attending schools with below average scores. Despite the moderate association between students' levels of interest for mathematics and their adoption of a mastery goal orientation, the latter was not strongly associated with classroom goal orientations and thus within-school autonomy. In terms of the emotional and cognitive components of engagement, therefore, the study did not indicate a link between within-school autonomy and engagement.

We had expected that students in schools reporting higher autonomy would themselves be more likely to adopt mastery goal orientations; however, this was not the case. Instead, students in schools with below average autonomy were more likely to adopt performance avoidance goal orientations, which are known to be positively associated with maladaptive behaviours such as procrastination and negatively associated with adaptive behaviours such as persistence (Wolters 2004).

Research question 2: school policies and practices associated with school autonomy

In all the case study schools visited, there were widespread examples of autonomy-supported environments (Vansteenkiste et al. 2006) where the principals entrusted school leaders to manage the teaching and learning of mathematics. This mathematics leader had a passion for teaching mathematics and led the development process within the school, including mentoring other staff.

Autonomous-supported environments were also manifested through individuals having choice in the activities they undertook (Vansteenkiste et al. 2006). Within the broad school frameworks established, teachers were usually autonomous and could use resources and pedagogies that suited their particular grade or class group. Although many schools used prescribed textbooks and/or adopted similar lesson structures, there was flexibility and choice at an individual class level in how these were used. These findings concur with those of Muir (2008) and Stephanou et al. (2004).

Teachers at these successful schools also encouraged autonomy in their students. Teachers consistently encouraged students to take risks and have ownership over their learning. This approach helped to satisfy students' needs for autonomy, competence and relatedness (Deci and Ryan 1985). Students' comments indicated a mastery rather than performance goal orientation, supporting an association between students' perceptions of their teachers' autonomy support or suppression and their own achievement goal orientations (Madjar et al. 2013). The engagement of students in these classrooms bears out Attard's (2011) findings.

Conclusion

Self-determination theory posits that all humans are motivated to satisfy their need for autonomy, competence and social relatedness. Schools and classrooms are social institutions that assist students to gain competence in, for example, mathematics. Traditionally, they have been tightly controlled, but the theory suggests greater gains can be achieved if schools and classrooms supported autonomy. The case study results show that within-school autonomy in superior gain schools was enacted in a variety of ways, depending on school context, but was typically characterised by devolvement of school leadership and teacher choice, as well as students' independence. This impacted upon the 'tone' of the school which was enacted through shared understandings and common practices of what it meant to teach and learn mathematics effectively. The study has implications for systems, schools and teachers. The results of the case study analysis of superior gain schools clearly reveal that management practices within a school can support autonomy in a wide variety of ways.

Acknowledgements This study was funded by the Office of the Chief Scientist (OCS). The opinions expressed in this article are those of the authors and project team and do not necessarily reflect the view of the OCS. The involvement and contributions of A/Prof. Judy Anderson, Prof. Kim Beswick, A/Prof. Vince Geiger, Prof. Merrilyn Goos, Dr. Derek Hurrel, Dr. Christopher Hurst and Prof. Helen Watt are acknowledged.

References

Andrich, D. (1978). A rating formulation for ordered response categories. *Psychometrika, 43*(4), 561–573.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships between working memory, math anxiety and performance. *Journal of Experimental Psychology, 130*(2), 224–237.

Askew, M., Brown, M., Rhodes, V., Wiliam, D., & Johnson, D. (1997). *Effective teachers of numeracy: report of a study carried out for the teacher training agency*. London: King's College, University of London.

Assor, A., Vansteenkiste, M., & Kaplan, A. (2009). Identified versus introjected approach and introjected avoidance motivations in school and in sports: the limited benefits of self-worth strivings. *Journal of Educational Psychology, 101*(2), 482–497.

Attard, C. (2011). The influence of teachers on student engagement with mathematics during the middle years. In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), *Mathematics: traditions and [new] practices (Proceedings of the AAMT-MERGA Conference, July)*. Alice Springs, NT: AAMT-MERGA.

Australian Curriculum Assessment and Reporting Authority (ACARA). (2013). *Guide to understanding 2013 Index of Community Socio-educational Advantage (ICSEA) values*. Sydney: ACARA Available: http://www.acara.edu.au/verve/_resources/Guide_to_understanding_2013_ICSEA_values.pdf.

Boaler, J. (1994). When girls prefer football to fashion? An analysis of female under achievement in relation to realistic mathematics contexts. *British Educational Research Journal, 20*(5), 551–564.

Bond, T. G., & Fox, C. M. (2007). *Applying the Rasch model: fundamental measurement in the human sciences* (2nd ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Byrne, B. M. (2012). *Structural equation modeling with Mplus*. New York, NY: Routledge.

Caldwell, B. J. (2014). *Impact of school autonomy on student achievement in 21st century education: a review of the evidence*. Melbourne: Educational Transformations Available: http://educationaltransformations.com.au/wp-content/uploads/School-Autonomy-and-Student-Achievement-Evidence.pdf.

Carmichael, C. S., MacDonald, A., & McFarland-Piazza, L. (2013). Predictors of numeracy performance in national testing programs: insights from the longitudinal study of Australian children. *British Educational Research Journal, 40*(4), 637–659.

Clarke, D., & Clarke, B. (2002). Challenging and effective teaching in junior primary mathematics: What does it look like? In M. Goos & T. Spencer (Eds.), *Mathematics making waves proceedings of the 19th biennial conference of the Australian Association of mathematics Teachers* (pp. 309–318). Adelaide, SA: AAMT.

Conley, A. M. (2012). Patterns of motivation beliefs: combining achievement goal and expectancy-value perspectives. *Journal of Educational Psychology, 104*(1), 32–47.

Creswell, J. W. (2008). *Educational research: planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, N.J: Pearson/Merrill Prentice Hall.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: the structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*, 215–225.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109.

Frenzel, A. C., Dicke, A., Pekrun, R., & Goetz, T. (2012). Beyond quantitative decline: conceptual shifts in adolescents' development of interest in mathematics. *Developmental Psychology, 48*(4), 1069–1082.

Goodenow, C. (1993). The psychological sense of school membership among adolescents: scale development and educational correlates. *Psychology in the Schools, 30*(1), 79–90.

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100*(1), 105–122.

Hattie, J. (2009). *Visible learning: a synthesis of over 800 meta-analyses relating to achievement*. Abindon, OXON: Routledge.

Heinze, A., Reiss, K., & Franzizka, R. (2005). Mathematics achievement and interest in mathematics from a differential perspective. *ZDM - The International Journal on Mathematics Education, 37*(3), 212–220.

Ikeda, K., Castel, A.D., Murayama, K. (2015). Mastery-approach goals eliminate retrieval-induced forgetting: the role of achievement goals in memory inhibition. *Personality and Social Psychology Bulletin*, 1–9. doi:10.1177/0146167215575730.

Janke, S., Nitsche, S., & Dickhauser, O. (2015). The role of perceived need satisfaction at work for teachers' work-related learning goal orientation. *Teaching and Teacher Education, 47*(1), 184–194.

Kanat-Maymon, Y., Benjamin, M., Stavsky, A., Shoshani, A., & Roth, G. (2015). The role of basic need fulfillment in academic dishonesty: a self-determination theory perspective. *Contemporary Educational Psychology, 43*(1), 1–9.

Kunter, M., Frenzel, A. C., Nagy, G., Baumert, J., & Pekrun, R. (2011). Teacher enthusiasm: dimensionality and context specificity. *Contemporary Educational Psychology, 36*(1), 298–301.

Lee, W., Lee, M., & Bong, M. (2014). Testing interest and self-efficacy as predictors of self-regulation and achievement. *Contemporary Educational Psychology, 39*(1), 86–99.

Linacre, J. M. (1999). Investigating rating scale category utility. *Journal of Outcome Measurement, 3*(2), 103–122.

Luke, A., Elkins, J., Weir, K., Land, R., Carrington, V., Dole, S., et al. (2003). *Beyond the middle: a report about literacy and numeracy development of target group students in the middle years of schooling*. Canberra: Commonwealth of Australia.

Madjar, N., Nave, A., & Hen, S. (2013). Are teachers' psychological control, autonomy support and autonomy suppression associated with students' goals? *Educational Studies, 39*(1), 45–55.

Masters, G. N. (2010). *Teaching and learning school improvement framework*. Melbourne: Australian Council for Educational Research and Queensland Department of Education and Training Available: http://research.acer.edu.au/cgi/viewcontent.cgi?article=1015&context=monitoring_learning.

McPhan, G., Morony, W., Pegg, J., Cooksey, R., & Lynch, T. (2008). *Maths? Why not?* Canberra: Department of Education, Employment and Workplace Relations.

Midgley, C., Maehr, M. L., Hruda, L. Z., Anderman, E. M., Anderman, L. H., Freeman, K. E., et al. (2000). *Manual for the patterns of adaptive learning scales*. Ann Arbor: University of Michigan.

Muir, T. (2008). Principles of practice and teacher actions: influences on effective teaching of numeracy. *Mathematics Education Research Journal, 20*(3), 78–101.

Munns, G., & Martin, A. J. (2006). It's all about MeE: a motivation and engagement framework. In P. Jeffery (Ed.), *Proceedings of the Annual Conference of the Australian Association for Research in Education (AARE, 2005)*. NSW: UWS Parramatta Campus Available from http://www.aare.edu.au/publications-database.php/4806/its-all-about-mee-a-motivation-and-engagement-framework.

Muthén, L. K., & Muthén, B. (2012). *Mplus user's guide* (Seventh ed.). Los Angeles, CA: Muthen&Muthen.

Organisation for Economic Cooperation and Development (OECD). (2012). *PISA 2009 technical report*. Paris: OECD Publishing.

Organisation for Economic Cooperation and Development (OECD). (2013). *TALIS 2013 technical report*. Paris: OECD Publishing Available from: http://www.oecd.org/edu/school/TALIS-technical-report-2013.pdf.

Owens, L., & Barnes, J. (1982). The relationship between cooperative, competitive, and individualized learning preferences and students' perceptions of classroom learning atmosphere. *American Educational Research Journal, 19*, 182–200.

Patrick, H., Anderman, L. H., Ryan, A. M., Edelin, K. C., & Midgley, C. (2001). Teachers' communication of goal orientations in four fifth-grade classrooms. *The Elementary School Journal, 102*(1), 35–58.

Reezigt, G. J., & Creemers, B. P. M. (2005). A comprehensive framework for effective school improvement. *School Effectiveness and School Improvement, 16*(4), 407–424.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67.

Schultz, P. P., Ryan, R. M., Niemiec, C. P., Legate, N., & Williams, G. C. (2014). Mindfulness, work climate, and psychological need satisfaction in employee well-being. *Mindfulness, 6*, 971–985.

Standage, M., Duda, J. L., & Ntoumanis, N. (2011). Predicting motivational regulations in physical education: the interplay between dispositional goal orientations, motivational climate and perceived competence. *Journal of Sports Sciences, 21*(6), 631–647.

Stephanou, C. R., Perencevich, K. C., Di Cintio, M., & Turner, J. C. (2004). Supporting autonomy in the classroom: ways teachers encourage student decision making and ownership. *Educational Psychologist, 39*(2), 97–110.

Sullivan, P. (2011). *Teaching mathematics using research informed strategies. (Australian educational review, 59.)*. Melbourne: ACER Available from https://research.acer.edu.au/cgi/viewcontent.cgi?article=1022&context=aer.

Tapola, A., & Niemivirta, M. (2008). The role of achievement goal orientations in students' perceptions of and preferences for classroom environment. *British Journal of Educational Psychology, 78*, 291–312.

Thomson, S., Hillman, K., Wernert, N., Schmid, M., Buckley, S., & Munene, A. (2012). *Highlights from TIMSS and PIRLS 2001 from Australia's perspective*. Camberwell, VIC: ACER.

Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. M., & Deci, E. L. (2004). Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of Personality and Social Psychology, 87*(2), 246–260.

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: another look at the quality of academic motivation. *Educational Psychologist, 41*(1), 19–31.

Verschelde, M., Hindriks, J., Rayp, G., & Schoors, K. (2015). School staff autonomy and educational performance: within-school-type evidence. *Fiscal Studies, 36*(2), 127–155.

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values and task perceptions according to gender and domain in 7th through 11th grade Australian students. *Child Development, 75*, 1556–1574.

Watt, H. M. G., Shapka, J. D., Morris, Z. A., Durik, A. M., Keating, D. P., & Eccles, J. S. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: a comparison of samples from Australia, Canada, and the United States. *Developmental Psychology, 48*(6), 1594–1611.

Williams, S. R., & Ivey, K. M. C. (2001). Affective assessment and mathematics classroom engagement: a case study. *Educational Studies in Mathematics, 47*, 75–100.

Wolters, C. A. (2004). Advancing achievement goal theory: using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology, 96*(2), 236–250.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*(4), 458–477.

You, S., Ritchey, K. M., Furlong, M. J., Shochet, I., & Boman, P. (2011). Examination of the latent structure of the Psychological Sense of School Membership scale. *Journal of Psychoeducational Assessment, 29*(3), 225–237.