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Discipline, motivation, and achievement in mathematics learning: An exploration in Shanghai

Bo Ning
Research Institute for International and Comparative Education, Shanghai Normal University, Shanghai, China

Abstract
Utilizing the Programme for International Student Assessment 2012 Shanghai dataset (N = 5,177), this study examined the relationship between school disciplinary climate aggregated from mathematics classrooms and student mathematics learning outcomes, including mathematics achievement and intrinsic and instrumental motivation to learn mathematics, from the perspective of the self-determination theory of academic motivation. The results of the analyses demonstrated challenges supporting students in Shanghai schools to simultaneously perform well in the three mathematics learning outcomes. Meanwhile, an orderly school disciplinary climate might hurt students' instrumental motivation, although it is beneficial to students' mathematics achievement.

Keywords
instrumental motivation to learn mathematics, intrinsic motivation to learn mathematics, mathematics achievement, school disciplinary climate, Shanghai

Introduction

In Confucian culture, cultivating high-performing, motivated, and well-behaved learners now and for life is considered as a conbined duty of schooling.

Corresponding author:
Bo Ning, Guilin Road 100, Building Jiaoyuanlou, Room 1106, Shanghai 200234, China.
Email: nibo2003@163.com

Considerable research has been directed towards examining the relationship between academic motivation and achievement, particularly in Western school contexts (Organisation for Economic Co-operation and Development [OECD], 2013), and the relationship between discipline and achievement, particularly in East Asian school contexts (Ning et al., 2015). However, few studies consider school disciplinary climate as a specific factor influencing students' motivation to learn, particularly in high-performing school systems, such as Shanghai's, relying heavily on an orderly school disciplinary climate to insure students' academic performance (Ning, 2019). In Shanghai, as well as in many Eastern Asian countries and economies, the mastery teaching mechanism, characterized as whole class interactions, small step progress, and teaching with variation, encourages teachers to keep the classroom in a quiet and orderly condition, that is, an orderly disciplinary climate (Boylan et al., 2017). To maintain such a climate, most Shanghai teachers would correct disruptive behaviors at the outset via timely reminding strategies such as standing up during class time and after class talk mechanism such as serious warnings (Ning, 2019). Using data gathered from the Programme for International Student Assessment (PISA) 2012 Shanghai survey, this study examined the relationship between school disciplinary climate and students' motivation to learn mathematics and mathematics achievement, from the perspective of the self-determination theory of academic motivation (see Ryan & Deci, 2017).

The rationale of discipline, motivation, and achievement in mathematics learning

Students' motivation to learn mathematics and their achievement in mathematics are universally important purposes of schooling. Mathematics achievement is strongly related to creativity, problem solving and other high-level cognitive processes, which are in serious need in many societies (OECD, 2013). Motivation to learn mathematics may interact with cognitive effort by modulating the computation and estimation of physical effort costs and rewards and increasing cognitive control, enabling, for example, the patience to focus on work for long periods of time and the efficient allocation of work time (Braver et al., 2014). Traditionally, students' mathematics achievement has been a central focus of school effectiveness research. Nowadays, many leading school systems deem motivation to learn mathematics an important objective. It is extremely important in secondary schooling considering that the level of mathematics interest decreases rapidly during students' transit from primary to secondary school in many countries, and students can avoid mathematics altogether in higher education and career periods (Grootenboer & Marshman, 2016). In PISA 2012, students' motivation to learn mathematics and mathematics achievement are both measured (OECD, 2013).

Students' motivation to learn mathematics and mathematics achievement are developmental and interdependent, and are influenced by the design of educational experience (Middleton, 2013). School context, such as culture, climate, and environment, plays an influential role in determining students' mathematics objective setting and motivation to learn mathematics (Elliot & Murayama, 2008). Students within the same school could be conceptualized as a small social system comprised of individuals diverse in motivation strength and achievement level although within the same school rules and regulations.

The theoretical framework behind this study

From the perspective of the self-determination theory of academic motivation, the distinction between intrinsic and instrumental motivation to learn mathematics relates to the reasons behind students' mathematics learning activities and concerns both the orientation and strength of the motivation (Ryan & Deci, 2017). Instrumental motivation to learn mathematics, known as mathematics utility or extrinsic motivation to learn mathematics, refers to the performance of an activity in order to attain some reward, and thus contrasts with intrinsic motivation to learn mathematics, termed mathematics interest, which refers to doing activities for the inherent satisfaction of the activities themselves (Ryan & Deci, 2000). Both intrinsic and instrumental motivation are extremely important to school success. Intrinsic motivation drives students to approach learning tasks as a challenge, especially in early childhood, which is necessary for success in most cases, and to employ habits that maximize task success (Maclaren et al., 2017). In late childhood and adolescence, instrumental motivators become important drivers of task engagement, since school is the environment in which people acquire most of their experience with organized and intentional learning (Kover & Worrell, 2010).

From the perspective of the self-determination theory of academic motivation, the relationship between students' academic motivation and achievement is not consistently positive across studies (Taylor et al., 2014). Generally, the levels of self-regulation in students' motivation largely determine the effect of motivation on achievement, with intrinsic motivation, characterized by high self-regulation, being more important than instrumental motivation, characterized by low self-regulation (Chowdhury & Shahabuddin, 2007). Particularly, students who are motivated by their intrinsic needs for autonomy, relatedness, and competence are more likely to show greater persistence at learning activities and therefore achieve higher academic scores and psychological wellness (Guiffrida et al., 2013). Educators should cultivate a more self-regulated learning environment, where students perceive that they can make meaningful choices within the learning context (autonomy), feel connected with the teacher, classmates, and learning content (relatedness), and believe in their ability to successfully complete their tasks (competence) (Ryan & Deci, 2017).

In considering the relationship between intrinsic and instrumental motivation, self-determination theory incorporates the idea that the internal and external circumstances, such as the sense of belonging and supportive environments, influence the internalization of instrumental motivation into a sub-theory entitled organismic integration theory (Ryan & Deci, 2000). According to this theory, students could learn mathematics for a reason distinct from mathematics learning itself and still be intrinsically motivated to learn mathematics, with the internalization level of instrumental motivation depending on the circumstances (Kover & Worrell, 2010). Specifically, an instrumentally motivated task will be internalized easily if undertaken in a context supportive of students' experience of autonomy, competence, and relatedness to important others (Kover & Worrell, 2010). The impact of an orderly school disciplinary climate, which restricts student autonomy, supports student competence, and cultivates student peer norms at the school level, needs to be examined in East Asian contexts (Maulana & Opdenakker, 2014).

Research gaps on motivation to learn mathematics and achievement in mathematics

Utilizing the PISA 2012 Shanghai dataset, this study aims to examine the relationship between school disciplinary climate aggregated from mathematics classrooms and student mathematics learning outcomes, including mathematics achievement and intrinsic and instrumental motivation to learn mathematics, from the perspective of the self-determination theory of academic motivation. A brief literature review indicated that the research findings concerning the relationship between intrinsic and instrumental motivation are not always consistent. Several studies concluded that students' instrumental motivation to learn, involving rewards such as admission to prestigious universities or a promising future career, significantly stimulates their intrinsic motivation to learn, in terms of enjoyment of the learning materials, activities, and process (Kover & Worrell, 2010). In contrast, other studies described the joyless and self-injurious behaviors of high-performers who have few personal interests but are eager to be enrolled in prestigious universities, indicating the detrimental effects of instrumental motivation on intrinsic motivation among high-performing students (For further information see Robbins, 2006). An important concern about intrinsic motivation derived from instrumental motivation is its sustainability. Considering the fact that instrumental motivation to learn is focused on outcomes that are extraneous to the learning materials, activities, and process itself, some self-determination theorists of academic motivation have predicted that the encouragement of instrumentally valued learning dampens inherent interest in and enjoyment of academic pursuits (Eccles et al., 1998). These contradictory findings in previous studies led to the development of the hypothesis:

> *Hypothesis 1*. Shanghai students' intrinsic and instrumental motivation to learn mathematics positively predict each other.

A cross-cultural comparison of the findings in this domain indicated that whereas instrumental motivation exerted non-significant or even detrimental effects on students' academic performance in some Western cultures that emphasized individualistic values and student-centered instruction, such as the United States, both intrinsic and instrumental motivation contributed to students' academic performance in some East Asian cultures that emphasized collectivist values and teacher-centered instruction, such as Indonesia and China (Maulana & Opdenakker, 2014; Zhu & Leung, 2011). Furthermore, some previous research found that the impact of intrinsic motivation on academic achievement is much stronger in Western than East Asian cultures (Triandis, 1995). Compared to their peers in the United States, students' experience of autonomy is endorsed less while their experience of competence in frequent exams and relatedness to important others such as teachers and parents are cherished more in Chinese schooling (Tseng, 2004). Specifically, both the interest level and the utility of learning activities and processes for their academic and social-emotional values are important to students in East Asian schools. Based on these findings in previous studies, the following hypotheses were proposed:

Hypothesis 2. Shanghai students' intrinsic motivation to learn mathematics and mathematics achievement positively predict each other.

Hypothesis 3. Shanghai students' instrumental motivation to learn mathematics and mathematics achievement positively predict each other.

Research gaps on the influence of school disciplinary climate

From a neural perspective, an orderly school disciplinary climate is extremely important in the motivation-achievement relationship in adolescence considering that most adolescents' prefrontal cortex, which is in charge of self-control, has not fully matured (Braver et al., 2014). Empricial evidence indicated that teachers' rule clarity and monitoring, indicating an orderly disciplinary climate, enhanced students' intrinsic motivation to learn mathematics (Kunter et al., 2007). Another relevant finding with a sample of Chinese students indicated that students' group level emotion management was positively related to their motivation to engage in collaborative and self-regulated learning, in terms of more conscious motivation monitoring and help-seeking behaviors (Xu et al., 2013). However, findings concerning the effects of discipline on motivation and achievement were inconsistent. Kover and Worrell (2010) confirmed that external events that are controlling in nature have been found to destroy students' sense of self-determination and therefore their intrinsic motivation. In considering the findings and unexamined issues in previous studies, the following hypotheses were proposed:

Hypothesis 4. School disciplinary climate positively predicts Shanghai students' mathematics achievement.

Hypothesis 5. School disciplinary climate positively predicts Shanghai students' intrinsic motivation to learn mathematics.

Hypothesis 6. School disciplinary climate positively predicts Shanghai students' instrumental motivation to learn mathematics.

To examine the hypotheses in this study, a hypothesized structural equation model as suggested in Figure 1 was constructed based on PISA 2012 Shanghai data. Apart from the overall consideration of discipline, motivation, and achievement in mathematics learning, students' background characteristics, including gender, grade level, and economic, social, and cultural status (ESCS), were controlled in the modeling, considering their significant relations to students' academic achievement and motivation.

Method

Measures

PISA is a triennial international survey designed to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students, together with their background non-cognitive characteristics and school context. For each participating country, an international agency, entitled the PISA Consortium, uses a two-stage stratified sampling design to select schools and students successively. In the school sampling stage, the probability of an eligible school being selected is proportional to the number of eligible 15-year-old students enrolled in that school. In the student sampling stage, the student samples are randomly selected for each sampled school with more than 35 eligible students, which is the target cluster size. For each sampled school with 35 or fewer eligible students, all these students are selected (OECD, 2014 b). In the PISA 2012 survey, the skills and knowledge of approximately 510,000 students from 65 countries and economies were measured in five domains: reading, mathematics, science, problem-solving, and financial

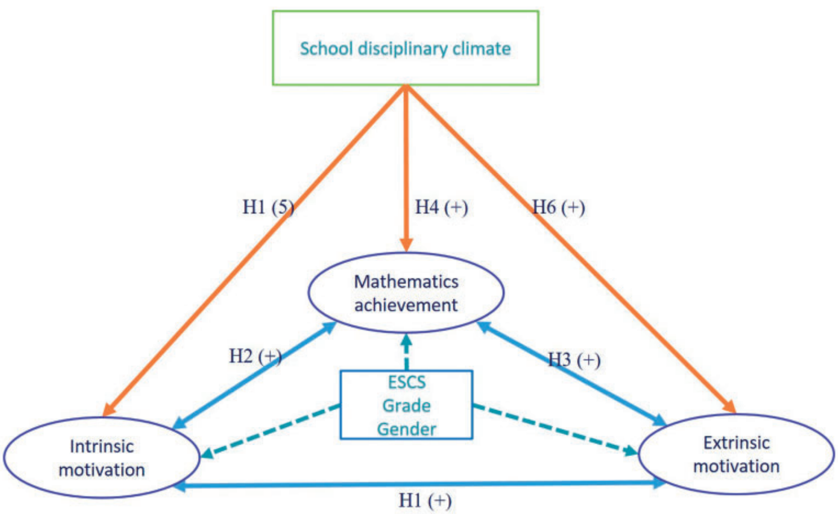


Figure 1. The hypothesized model.

literacy, with a focus on mathematics (OECD, 2014 b). In Shanghai, 5,177 students from 155 schools participated.

Mathematics achievement. In the PISA surveys, mathematics achievement was assessed in terms of the concept of "literacy," which referred to the capacity to formulate, employ, and interpret mathematics in various contexts (for information about the construction of this measure, see OECD, 2014a). Four overarching ideas i.e., quantity, space and shape, change and relationships, and uncertainty and data, were incorporated into the survey to examine students' mathematics literacy (OECD, 2014a). To save time, each sampled student completed only a part of the mathematics assessment scale and context questionnaire in a rotated testing design. Subsequently, the student's mathematics literacy was estimated based on his or her answers, and the answers of similar students for the missing parts. To account for the measurement error that seeps in during the imputation of the missing items, five plausible values for student mathematics literacy were given in the PISA database, enabling us to estimate robust and unbiased population parameters. These plausible values were vertically equated to the results of PISA 2003, in which the results were standardized with an average value of 500 and a standard deviation of 100 for OECD countries. In this study, we used all five plausible values for mathematics achievement in each correlation and structural equation modeling analysis.

Intrinsic motivation to learn mathematics. Intrinsic motivation to learn mathematics was represented by students' reports of their enjoyment of and interest in mathematics learning materials and process, which was listed as the INTMAT index in the PISA 2012 student database. This is a standardized index with an average value of zero and a standard deviation of one for the OECD countries. Technically, the INTMAT index was calculated by averaging students' levels of agreement with four statements in their mathematics lessons, such as "I enjoy reading about mathematics". The response scale ranges from 1 to 4, indicating "strongly agree," "agree," "disagree," and "strongly disagree" respectively. All items were reversed so that a higher number corresponds to a higher level of intrinsic motivation. The scale reliability for INTMAT for our data was 0.91, which indicates an acceptable level of internal consistency.

Instrumental motivation to learn mathematics. Instrumental motivation to learn mathematics was represented by students' ratings of the utility of mathematics to their future study and career, the INSTMOT index in the PISA 2012 student database. This is a standardized index with an average value of zero and a standard deviation of one for the OECD countries. Technically, the INSTMOT index was calculated by averaging students' levels of agreement with four statements regarding their mathematics lessons, such as "I will learn many things in mathematics that will help me get a job." The response scale ranges from 1 to 4, indicating "strongly agree," "agree," "disagree," and "strongly disagree" respectively. All items were reversed so that a higher score corresponds to a higher level of intrinsic motivation. The scale reliability for INSTMOT in Shanghai is 0.88, which indicates an acceptable level of internal consistency.

School disciplinary climate. In research on school climate, students are often used as informants, i.e., multiple observers provide data on one construct, as it is assumed that students' interpretation of the classroom/school climate is more likely to influence their reactions and behaviors compared to objective measures (Ning, 2019). In this study, school disciplinary climate, SCH_DISCLIMA, represented the average level of classroom disciplinary climate in a school, with a higher score indicating a better climate. The authors of this article computed it as a weighted mean of the student level index DISCLIMA, which is available in the PISA 2012 student database. The DISCLIMA index was calculated by averaging students' levels of agreement with five statements in their mathematics lessons, that is, "Students don't listen to what the teacher says," "There is noise and disorder," "The teacher has to wait a long time for the students to quieten down," "Students cannot work well," and "Students don't start working for a long time after the lesson begins." The response scale ranges from 1 to 4, indicating "every lesson", "most lessons", "some lessons", and "never or hardly ever" respectively. All items were reversed so that higher scores correspond to a better disciplinary climate. The scale reliability (Cronbach's raw α) for DISCLIMA in Shanghai is 0.88, which indicates an acceptable level of internal consistency. The effect size of school disciplinary climate on individual students' perceptions of this climate (*ICC*) is .19 in Shanghai, which indicates that a decent proportion of the total variation found in all student ratings can be attributed to the fact that students are nested within schools.

Similar to mathematics assessments, each sampled student completed only a part of the context and non-cognitive questionnaire. Overall, the proportions of the rotated part together with the missing data in the INTMAT, INSTMOT, DISCLIMA were about one-third in each economy. To account for the rotated part and missing data, we used the Markov Chain Monte Carlo (MCMC) method with a single chain to create five imputations for each missing datum in each economy (Enders & Gottschall, 2011). The three student background characteristics, including students' gender (GENDER), grade level (GRADE), and economic, social, and cultural status (ESCS) and the five plausible values for student mathematics literacy, together with the 13 indicators of INTMAT, INSTMOT, DISCLIMA and these indices themselves, were considered in the imputation procedure. Additionally, the hierarchical structure of students in schools was accounted for in the imputation of missing data (Mistler, 2013).

In addition to the aforementioned scales, ESCS, GRADE, GENDER which were listed in PISA 2012 database, were used in the analyses. *GENDER* was coded as a dummy variable with a value of 0 for girls (number of observations = 2,587) and 1 for boys (number of observations = 2,528). *GRADE* represents the grade level of student participants compared to the modal grade in the country or economy, which is grade ten in Shanghai. In Shanghai, the sampled students were distributed across grades seven through twelve. Specifically, there are 54 students in grade seven (coded as −3), 251 students in grade eight (coded as −2), 2,061 students in grade nine (coded as −1), 2,778 students in grade ten (coded as 0), 29 students in grade eleven (coded as 1), and four students in grade twelve (coded as 2). *ESCS* is a standardized index with an average value of zero and a standard deviation of one for the OECD countries. Three indices were used in the construction of the ESCS index, including the highest occupational status of parents (HISEI), the highest educational level of parents in years of education (PARED), and home possessions (HOMEPOS). The scale reliability for ESCS in Shanghai was 0.69. For a detailed discussion of the constructs included in this index, see OECD (2014 b).

For the descriptive statistics for these scales, please see Table 1.

Analysis

Many school effectiveness researchers consider schooling to be a multi-input multi-output production process. A concurrent analysis of several learning outcomes in an outstanding school system could show the benefits and costs of one school improvement strategy simultaneously. In this study, the primary tool of analysis was structural equation modeling (SEM). The authors examined the relationships between school disciplinary climate and student mathematics learning outcomes, including mathematics achievement and intrinsic and instrumental motivation to learn mathematics, controlling for student background characteristics.

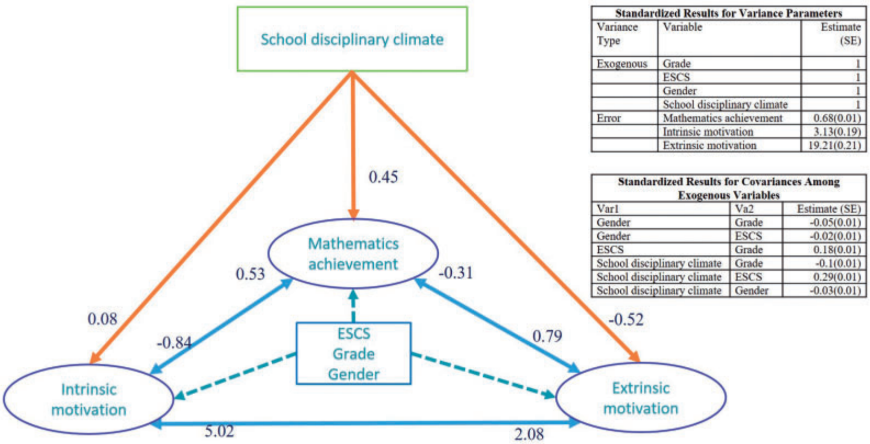
More specifically, we addressed four issues simultaneously, that is, the effects of students' background characteristics on their mathematics learning outcomes, the multilateral relationships among the three student mathematics learning outcomes, and the effects of school disciplinary climate on student mathematics learning outcomes. Covariance structure analyses based on a maximum likelihood estimation method were used in structural equation modeling and an emerging model with an acceptable goodness-of-fit ($\chi^2(21) = 22544.25$, $p < 0.001$; $GFI = 1$; $CFI = 1$; $SRMR = 0$; RMSEA $= 0.062$ [0.055, 0.069], $p < 0.0001$) was fixed as suggested in Figure 2. Considering the necessity to examine the six hypotheses simultaneously, this study fixed the emerging model without further model optimization.

SAS 9.4 was used to impute student level missing data, aggregate school level variables from student level measures, and conduct descriptive analyses and structural equation modeling. An important strength of SAS 9.4 in structural equation modeling is its calculation of multilateral relations between variables simultaneously. Since the sub-sample sizes of students differed across sampling strata, the final student weights (W_FSTUWT) in the PISA 2012 student database were accounted for in the aforementioned data preparation and analyses.

Table 1. Descriptive statistics of the measures in use.

Numerical variables	N	RM	WM	1	2	3	4	5	6	7	8
1 Mathematics achievement	5,177	611.6 (101.44)	612.96 (408.28)	1.00							
2 Intrinsic motivation to learn mathematics	3,436	0.44 (0.93)	0.43 (3.77)	0.19	1						
3 Instrumental motivation to learn mathematics	3,436	0.02 (0.91)	0.01 (3.69)	0.12	0.67	1					
4 Classroom disciplinary climate	3,459	0.58 (0.95)	0.57 (3.86)	0.32	0.14	0.12	1				
5 School disciplinary climate	155		0.57 (1.62)	0.48	0.12	0.09	0.42	1			
6 ESCS	5,167	–0.38 (0.97)	–0.36 (3.91)	0.39	0.07	0.05	0.13	0.27	1		
7 Gender	5,177	0.49 (0.5)	0.49 (2.02)	0.03	0.11	0.02	–0.07	–0.04	–0.02	1	
8 Grade level	5,177	–0.52	–0.51 (2.63)	0.28	–0.04	–0.04	–0.05	–0.14	0.19	–0.07	1

Note: N = number of observed students or schools. RM = raw mean before imputation. WM = weighted mean after imputation. Standard deviations are in parentheses. The weighted standard deviations were calculated as $sd_w = \sqrt{\frac{\sum_{i=1}^{N} W_i (X_i - \overline{X}_W)^2}{\frac{(N'-1)\sum_{i=1}^{N} W_i}{N'}}}$, where W_i is the weight for the ith observation, N' is the number of non-zero weights, and $\overline{X}_W$ is the weighted mean of the observations. All correlation coefficients were calculated based on the imputed data with student weight being counted. The significant levels of these correlation coefficients are .001.



Standardized Results for Variance Parameters		
Variance Type	Variable	Estimate (SE)
Exogenous	Grade	1
	ESCS	1
	Gender	1
	School disciplinary climate	1
Error	Mathematics achievement	0.68(0.01)
	Intrinsic motivation	3.13(0.19)
	Extrinsic motivation	19.21(0.21)

Standardized Results for Covariances Among Exogenous Variables		
Var1	Va2	Estimate (SE)
Gender	Grade	-0.05(0.01)
Gender	ESCS	-0.02(0.01)
ESCS	Grade	0.18(0.01)
School disciplinary climate	Grade	-0.1(0.01)
School disciplinary climate	ESCS	0.29(0.01)
School disciplinary climate	Gender	-0.03(0.01)

Figure 2. The emerging model.

Results

The multi-lateral relations between student mathematics learning outcomes

Students' mathematics achievement and their intrinsic and instrumental motivation to learn mathematics predict one another in different ways. Specifically, students' mathematics achievement negatively predicts their intrinsic motivation to learn mathematics ($b = -0.84$, $p < .001$, 95% CI $[-1.18, -0.5]$) but positively predicts their instrumental motivation to learn mathematics ($b = 0.79$, $p < .001$, 95% CI [0.71, 0.87]). Students' intrinsic motivation to learn mathematics positively predicts their mathematics achievement ($b = 0.53$, $p < .001$, 95% CI [0.49, 0.57]) and instrumental motivation to learn mathematics ($b = 2.08$, $p < .001$, 95% CI [1.92, 2.2]), with the effect size of the former being much smaller than the latter. Students' instrumental motivation to learn mathematics negatively predicts their mathematics achievement ($b = -0.31$, $p < .001$, 95% CI $[-0.35, -0.27]$) but positively predicts their intrinsic motivation to learn mathematics ($b = 5.02$, $p < .001$, 95% CI [4.98, 5.06]). These results are consistent with the prediction of *Hypothesis 1* but inconsistent with the prediction of *Hypothesis 2 and 3*. That is, students' intrinsic and instrumental motivation to learn mathematics positively predict each other but they do not always positively predict mathematics achievement.

The influences of school disciplinary climate on student mathematics learning outcomes

An orderly school disciplinary climate does not benefit all student mathematics learning outcomes. Specifically, a better school disciplinary climate positively predicts students' mathematics achievement ($b = 0.45$, $p < .001$, 95% CI [0.43, 0.47]), non-significantly predicts their intrinsic motivation to learn mathematics ($b = 0.08$, $p < .001$, 95% CI [−0.12, 0.28]), but negatively predicts their instrumental motivation to learn mathematics ($b = -0.52$, $p < .001$, 95% CI [−0.58, −0.46]). These results are consistent with the prediction of *Hypothesis 4* and inconsistent with the prediction of *Hypothesis 5 and 6*.

Conclusion and discussions

Discipline, motivation, and achievement in mathematics learning

Interest-driven students and high-performing students are not necessarily the same group. In Shanghai, interest-driven students tend to perform better in mathematics while high-performing students enjoy mathematics learning to a lesser extent. In contrast, several studies in Western contexts confirmed that subject interest and achievement reciprocally reinforce each other in the long term (Brandenberger et al., 2018; Taylor et al., 2014). For instance, Gottfried et al. (2007) indicated that students' intrinsic motivation to learn mathematics was positively related to their mathematics achievement at both initial and later measurement points, while falling behind in mathematics achievement was a significant contributor to the developmental decline in their intrinsic motivation to learn mathematics from childhood through adolescence. One explanation for the distinct effects of intrinsic motivation to learn mathematics and mathematics achievement on each other in Shanghai is the school quality control mechanism there, specifically the high difficulty level of learning materials, the competitive examination system, and the heavy student workloads necessary to achieve a high score in mathematics, which wipes out high performers' mathematics interest. A similar situation occurred in Korea, where in response the educational administration decided to cut out some difficult contents and increase the interest level of teaching materials in their 2015 National Curriculum Reform to maintain students' mathematics interest (Li & Park, 2018).

Imbalanced associations between mathematics utility and achievement. Apart from high-performing students' low enjoyment of mathematics learning, students appreciating the utility of mathematics tend to perform poorly, that is, the failure of evolutionary utilitarianism in Chinese society. In contrast, the high-performing students tend to appreciate the utility of mathematics in Shanghai. This conclusion is much informative considering that in many countries, there is a serious shortage of mathematically well-educated manpower specifically in scientific and technical fields (Hannula et al., 2014, p. 249). According to the expectancy-value theory of achievement motivation, the development of instrumental motivation to learn mathematics is influenced by at least three factors, the values mathematics students derived from their social context, the importance attached to mathematics by students' culture, and their self-perceptions of mathematics achievement and efficacy (Gaspard et al., 2015).

Consitent prediction of mathematics interest and utility on each other. Personal development in mathematics is best served by combining long-term instrumental aspirations with short-term intrinsic motivation. In Shanghai, students seriously concerned about the utility of mathematics tend to have a high level of intrinsic motivation to learn mathematics, while students seriously concerned about the interestingness of mathematics tend to appreciate the utility of mathematics. These findings confirmed the possibility of inspiring students' mathematics interest via emphasizing the utility of mathematics for future study and work. In addition, these findings suggested the usefulness of reminding interest-driven students of mathematics utility, which might help maintain their intrinsic motivation to learn mathematics. One thing worth mentioning is that although this study indicated positive associations between instrumental motivation and intrinsic motivation to learn mathematics, some studies in other school contexts confirmed that students' instrumental motivation did not significantly affect or even negatively affected their intrinsic motivation (Ryan & Deci, 2000).

Cultivating an orderly school disciplinary climate is not a one-size-fits-all school improvement mechanism. Previous research demonstrated the importance of an orderly school disciplinary climate in Shanghai schooling, as well as in many Eastern Asian school systems, via examining the relationship between school disciplinary climate and student academic achievement (Ning, 2019; Ning et al., 2015). The results in this study, however, confirmed the concern of some educators in China that an orderly disciplinary climate might hurt students' instrumental motivation to learn mathematics, although it is beneficial to students' mathematics achievement. To our knowledge, this study is the first one providing empirical evidence of possible side effects of an orderly disciplinary climate on student mathematics learning outcomes in an East Asian context, which rely a great deal on an orderly school disciplinary climate to insure strong academic performance. Educators should consider its potential harm to students' instrumental motivation in the argument for their academic achievement.

Implications and contributions

Shanghai schooling attracted much attention from the world due to the outstanding academic performance of students in mathematics, science, and reading since PISA 2009. International and local school improvement projects initiated by Shanghai experience have increased rapidly. Among them, the system level school improvement project in the UK, entitled the Sino-England Mathematics Teacher Exchange Project started in 2014, was considered a great success in improving the percentage of pupils achieving the expected standard in mathematics at Key Stage Two (Boylan et. al, 2017). From this study we can see that educational researchers and policy-makers should consider the strong points together with weak ones in their examination of school quality control strategies in Shanghai schooling, featured as teacher-centered whole class teaching and cherishing students' cognitive structure more than their intrinsic and instrumental motivation to learn.

The findings in this study are informative to school managers and psychologists dealing with student misbehaviors. Shanghai schooling experience recommends controlling student misbehaviors at school level, that is, cultivating an orderly disciplinary climate with zero tolerance at the outset in teaching. However, both external school disciplinary climate and internal intrinsic and instrumental motivation are related to student academic success. Behaving only in accordance with mathematics interest, in conflict with maintaining an orderly school disciplinary climate, may decrease students' mathematics achievement, whereas attending to a task only because of school disciplinary climate may undermine additional instrumentality that can come from mathematics learning. These findings are inconsistent partially with the classic descriptions in the self-determination theory of academic motivation, based on some Western education systems in which the importance of self-regulation and intrinsic motivation are emphasized (see Ryan & Deci, 2017).

Limitations and future prospects

Student misbehaviors are lasting challenges to primary and secondary schooling in many countries. To our knowledge, PISA 2012 is the only open access large-scale international resource available for examining the impacts of school disciplinary climate on intrinsic and extrinsic motivation to learn mathematics and mathematics achievement simultaneously. However, readers should keep in mind the limitations of the measures in PISA 2012. For example, there are few statements being used in the measurement of each conceptual construct and the sample responded to these statements in 2012.

This study did not consider the multilevel structure of students in schools in fulfilling the structural equation modeling criteria due to the unsatisfied model fitting. Still, the results from structural equation modeling are quite sensitive due to the multi-lateral interactions among variables being considered. Therefore, the conclusions in this study rely much on the theoretical assumptions that the aforementioned variables are extremely important in Shanghai schooling while the others could be ignored in the relationships between school disciplinary climate and student mathematics learning outcomes.

Moreover, this study did not examine the impact of student mathematics learning outcomes on school disciplinary climate, due to the unsatisfactory model fit, although intrinsic motivation to learn mathematics has been found to play a substantial role in cultivating student self-regulation (Brandenberger et al., 2018). Still, it will be informative if future studies could explore the relationship between school disciplinary climate and students' motivation to learn mathematics at the school level, termed the school mathematics learning atmosphere, considering the finding in a previous study that when group members reciprocally commit to improving the group level emotional atmosphere and motivation jointly, they are more likely to share the regulatory responsibility, bringing it to the "we" level (Järvelä & Hadwin, 2013).

Data availability

Open access data from an international large-scale student survey, entitled the Programme for International Student Assessment 2012, organized by OECD.

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ORCID iD

Bo Ning https://orcid.org/0000-0003-3741-2693

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Author biography

Bo Ning is a Researcher in the Research Institute for International and Comparative Education, Shanghai Normal University, China. His research focuses on cross-country comparison in school, principal, and teacher effectiveness.