School belonging, student bullying, and school disciplinary climate in TIMSS top-performance countries

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Abstract

There is insufficient research on how a student's sense of belonging at school affects their academic performance, particularly in the context of the five East Asian countries that consistently significantly outperform other nations in the Trends in International Mathematics and Science Study (TIMSS). This study examined the relationships between students' sense of school belonging, bullying, school climate, and mathematics achievement in Hong Kong, Japan, Korea, Singapore, and Taiwan. The data analyzed included mathematics test scores and questionnaire responses from 3265, 4446, 3861, 4853, and 4915 eighth graders from 136, 142, 168, 153, and 203 schools in these five countries, respectively. These students participated in TIMSS 2019 and the data was analyzed using path analysis technique. The results showed a significant relationship between a student's sense of belonging and achievement in all countries. However, this significant association disappeared for all countries except Korea and Singapore when factors such as bullying and school disciplinary climate were taken into account. The association was strongest among Singaporean students and weakest among Taiwanese students. The results of this study are consistent with previous research that attributes East Asian students' success to their cultural learning model rather than other factors. A sense of belonging at school is critical to promoting positive academic performance, development and well-being.

Keywords: bullying, East Asian countries, school belonging, school disciplinary climate, TIMSS

Introduction

East Asian countries, particularly Hong Kong, Japan, Korea, Singapore, and Taiwan, are consistently top performers in the Trends in International Mathematics and Science Study (TIMSS) and International Program for Student Assessment (PISA) assessments, which are the

other TIMSS and PISA participating countries or administrative entities by substantial margins in the fourth and eighth grades. Researchers have attributed this success to various factors including self-concept in learning mathematics and science, attitudes toward these two subjects, educational aspirations and family background characteristics, school disciplinary climate, educational programs, teaching methods (Mohammadpour, 2012; 2013; Mohammadpour et al, 2015), the classroom and teaching practices (Stevenson & Stigler, 1992), the planned and implemented curriculum (Stevenson & Baker, 1996), and the centralized nature of the examination system (Stevenson & Baker, 1996). The positive relationship between school membership and academic performance and retention has been documented. However, more research needs to be done to compare the relationships between students' sense of belonging to school and mathematics achievement in the top-performing TIMSS countries and to uncover the association with mathematics achievement. Furthermore, to the standard theory and research findings, a recent study found that school disciplinary climate (SDC) was not significantly associated with the sense of belonging at school (SOBAS) in Singapore, Taiwan, and Japan (Baek, 2023) of the five top-performing countries in the East Asia region. Therefore, this cross-national comparison examines the associations between student SOBAS, student bullying (SB), and school disciplinary climate (SDC) with mathematics achievement. The main question of this study is explicitly: What contribution does SOBAS make to the high achievement of students in Hong Kong, Japan, Korea, Singapore, and Taiwan on TIMSS assessments and what is the relationship between SB SDC, SOBAS, and how is the relationship between SB SDC, SOBAS, and mathematics performance across these countries? Furthermore, contradictory to the standard theory and research findings, a recent study found that school disciplinary climate (SDC) was not significantly associated with the sense of belonging at school (SOBAS) in Singapore, Taiwan, and Japan (Baek, 2023) of the five top-performing countries in the East Asia region. Hence, this cross-national comparison investigates the relationships between students' SOBAS, student bullying (SB), and SDC with mathematics achievement. Explicitly, the central question of this study is: What is the contribution of SOBAS to the high achievement of students in Hong Kong, Japan, Korea, Singapore, and Taiwan in TIMSS assessments, and how is the relationship between SB SDC, SOBAS, and mathematics performance across these countries?

Bullying is a systematic abuse of power and can include physical, verbal, or relational, direct (face-to-face) or indirect (cyberbullying). It is typically viewed as a subset of aggression characterized by repetition and power imbalance (Olweus, 1999). Cyberbullying occurs through digital devices (such as cell phones, computers, and tablets) and through text messaging, texting, and apps or online social media, forums, or games where people can view, participate, or share content (Gün & Akduman, 2022). In the last decade, cyberbullying has emerged through modern communication technologies (Kowalski et al, 2014).

Bullying is studied extensively in Western countries. However, several studies in Asia-Pacific countries suggest that bullying may have different characteristics in other cultural contexts, pointing to cultural and educational aspects of interest in the explanation (Sittichai & Smith, 2015). Many countries included in this study are considered to have more collectivistic

communities than most Western industrialized countries (Triandis & Hofstede, 2010). A more collectivistic culture may entail a greater likelihood of the emergence of concerted whole-group (e.g, whole-class) norms, which can sometimes be aggressive. Therefore, severe class-wide aggression and disrespect for a victim is possible.

Furthermore, some countries (e.g, Japan and Korea) scored high on Gladwin & Hofstede (1980) power distance index. There is more respect for older people, including older students, so abuse of power by older people is seen as legitimate rather than bullying (Gladwin & Hofstede, 1981). There is evidence that conditions of higher density and more pronounced hierarchy in classrooms are associated with a higher risk of persistent bullying (Wolke & Lereya, 2015).

A study with a global sample aged 10 to 17 years in 25 countries, including six Asian countries, examined cyberbullying and reported that 37% of participants reported negative online experiences, including being called names or teased; 58% were aware of online bullying; and 54% reported being very or somewhat concerned about online bullying (Microsoft Corporation, 2013). This study found that teens ages 13 to 17 are at higher risk of being bullied, including online, compared to teens ages eight to 12. They were also more informed and concerned about online bullying than younger people. China, Singapore, and India were the countries where participants reported the highest rates of online bullying at 70%, 58%, and 53%, respectively. This is followed by Malaysia (33%), Pakistan (26%) and Japan (17%). Another study points to remarkable findings on the topic of cyberbullying among young people. In a 2010 survey of 2,981 secondary school students in Hong Kong, 30% reported experiencing cyberbullying in the past year (The Hong Kong Federation of Youth Groups, 2013). In a nationwide survey conducted in Taiwan among 1,539 students ages 10 to 18, 37% said they had witnessed cyberbullying, 18% had bullied others online, 40% were secondary victims of bullying, and 12% were targets or victims of cyberbullying (The Child Welfare League Foundation, 2012). Furthermore, some countries (e.g, Japan and Korea) scored high on Gladwin & Hofstede (1981) power distance index. There is more respect for older people, including older students, so abuse of power by older people is seen as legitimate rather than bullying (Gladwin & Hofstede,1981). There is evidence that conditions of higher density and more pronounced hierarchy in classrooms are associated with a higher risk of persistent bullying (Wolke & Lereya, 2015).

Sense of school belonging

School is an essential developmental framework for children (Longobardi et al, 2019). SOBAS is crucial for promoting more positive academic achievement, development, well-being, and life satisfaction (Korpershoek et al, 2020). According to the self-determination and belonging theories, the need for belonging appears to be inherent to the individual (Allen et al, 2021; Baumeister & Leary, 1995). Belonging is a subjective feeling that individuals are integral to their surrounding systems, including family, friends, school, work environment, community,

cultural groups, and physical places (Hagerty et al, 1992). The need to belong and connect deeply with other people and places is essential for survival (Slavich & Cole, 2013).

In an educational context, SOBAS is critical for understanding the extent to which students feel that other students and teachers accept them, feel physically, emotionally, and culturally safe at school, and that their contributions are welcomed and valued in the classroom. Researchers have found that students who meet their need to belong are more likely to have positive educational experiences, including higher academic achievement, satisfaction, motivation, and persistence, than students whose need to belong is not met (Walton & Cohen, 2011). SOBAS is "the extent to which students feel personally accepted, respected, included, and supported by others in the school social environment" (Goodenow & Grady, 1993). It is widely known that SOBAS predicts students' academic performance and psychosocial success (Wang & Eccles, 2012; Slaten et al, 2016; Loukas et al, 2016; Allen et al, 2018), it shows the quality of school learning to the environment (Cortina et al, 2017).

Over the past three decades, SOBAS has received increasing attention in education due to its many developmental and educational benefits being linked (Petrucci et al, 2022). Researchers (Kitchen et al, 2015; Karaman & Tarim, 2018) reported a positive relationship between students' belonging needs and psychological well-being. Young people who feel they belong to their educational community achieve better academic performance and are more motivated to learn (Korpershoek et al, 2020). A strong SOBAS can reduce the risk of antisocial behavior (Catalano et al, 2004; Rose et al, 2016), absenteeism and school dropout (Korpershoek et al, 2020), and the use of psychoactive substances (Schulenberg et al, 1994). Lack of SOBAS was associated with several adverse developmental outcomes, such as mental health and social and psychological development (Allen & Bowles, 2013). Researchers reported that SOBAS is essential for improving academic performance and reducing internalizing and externalizing symptoms in the face of school bullying (Arslan, 2022). In general, SOBAS is crucial for the health and well-being of adolescents (Vaz et al, 2015). In addition, it is beneficial for teenagers to feel like valuable and indispensable members of their school, accepted and included by their peers. It satisfies their need for connection, promotes their psychological well-being, and develops a positive attitude toward school (Fabris et al, 2023).

Belonging is a social relationship concept. Social relationships and cultural identity are essential to people in research across various disciplines (Cacioppo & Hawkley, 2003). One study found that inadequate social relationships throughout life are linked to depression, poor sleep quality, rapid cognitive decline, cardiovascular difficulties, and reduced immunity (Hawkley & Capitanio, 2015). Specifically, the adverse effects of disaffiliation include increased risk of mental illness, antisocial behavior, reduced immune function, physical illness, and early mortality (Cacioppo et al, 2011; Holt-Lunstad, 2018; Slavich et al, 2010).

Previous studies examined various aspects of the effects of belonging interventions. These include individual characteristics, including personality, social skills, and cognitions (Durlak et al, 2011; Walton & Cohen, 2011); their social relationships (Kanter et al, 2018); the environment in which they live, such as the physical characteristics of the workplace, the sense of space, and opportunities for socializing (Jaitli & Hua, 2013; Trawalter et al, 2020). It has

been argued that SOBAS is neither purely intrapersonal nor exclusively contextual but rather emerges from the interaction of individuals within a particular environment. Therefore, it makes sense to examine SOBAS simultaneously as a measure of individual proximity to school and as an indicator of the quality of the learning environment at the class and school level (Goodenow, 1993). Anderman (2002) reported that most of the variability in the SOBAS measure lies between individuals (interaction of individuals within a given environment) and the remainder, 15%, lies between schools and another 15% between classrooms within schools, indicating that suggests significant context effects (Battistich et al, 1997). Other studies (Allen et al, 2018; Goodenow & Grady, 1993; Hagerty et al, 1992) have examined the benefits of SOBAS. These studies have found various positive effects of a healthy sense of belonging, such as more positive social relationships, academic achievement, career success, and better physical and mental health. In contrast, a lack of belonging has increased the risk of mental and physical health problems (Cacioppo et al, 2015; Sapozhnikov, 2019).

The need for social belonging is widespread, although how it is expressed may vary from culture to culture (Baumeister & Leary, 1995). Belonging has important theoretical aspects for further exploration, as school belonging has an essential cultural component (Cortina et al, 2017). Even in the same school, students from different cultural backgrounds will likely experience school differently (Kumar & Maehr, 2010). East Asian cultures are typically described as communal or collectivist, and people have a more interdependent view of themselves (Cortina et al, 2017), while in individualistic cultures (e.g, Western countries), people tend to think of the relationship rather than the self as a functional unit of conscious reflection (Markus & Kitayama, 1991). Furthermore, in individualistic cultures, people's personal goals are prioritized more than in collectivistic cultures (Triandis, 2001). Collectivistic cultures emphasize social connectedness, interdependence, and intragroup goals, while individualistic cultures emphasize self-reliance, independence, and personal goals (Cortina et al, 2017).

Researchers found that students in more individualistic cultures reported higher SOBAS than students in more collectivistic cultures; the teacher-student relationship strongly connected with a sense of belonging and mediated the association between individualism and SOBAS. Collectivism was not significantly associated with this (Chiu et al, 2016). Results suggest that Asian and Hispanic students report higher levels of school belonging than White and African American students.

Ecological theory (Bronfenbrenner, 1979) indicates that microsystem variables, such as school, have a more immediate influence on the individual than the surrounding macro system variables (e.g, culture), which apply influence mainly through mediating institutions, such as school curricula. Accordingly, while teachers, peers, and parents most directly influence students during their school day, they are also influenced by the political, economic, cultural, and interpersonal macro environment (Eccles & Roeser, 2015). Culture, including the community, school, classroom, and family culture, can influence SOBAS differently. For example, students who grow up in a home where they are accepted, valued, respected, and supported have a higher self-concept level (Gutiérrez et al, 2022). Greater self-confidence can

contribute to students' participation in activities such as completing academic tasks, presenting their views and opinions on issues discussed in class, and taking on social responsibilities in class and school, such as group leadership in teamwork and establishing order and discipline in the school might result in a feeling of belonging more to the school. Students who grew up in a home believing that children should be quiet and passive might struggle with class participation, resulting in less motivation in school belonging.

In contrast, students raised in a community-based culture might need help with independent work. Students in student-based educational settings are more allowed to participate in class activities, while teacher-centered educational settings are less allowed to participate in class activities. As a result, classroom and school activities are not very attractive to him, so his sense of belonging to school weakens.

SOBAS in educational settings can be improved in several ways, such as by encouraging positive relationships with teachers and school staff, creating a positive peer culture of belonging, valuing learning, taking proactive steps toward mental health, and not neglecting parents (Allen et al, 2013; 2017a; 2017b; 2018a; 2018b). Students should be encouraged to have supportive teachers and staff in the school they know and like and to have a safe, mutually respectful, supportive relationship with them, including academic and emotional support. Schools can improve SOBAS by creating an inclusive environment as a place to belong and expecting behaviors that foster a sense of belonging for others, in addition to other school-based behavior expectations. Teaching such behaviors from the day that students start school is essential. Teaching social and emotional skills is also vital in contributing to SOBAS. Students with high academic achievement tend to have a higher sense of belonging; therefore, teachers must help students understand their academic expectations. Developing and reinforcing students' self-concept, efficacy, motivation, and passion toward learning might improve SOBAS. In addition, schools can create and maintain communication with parents, which can boost their children's sense of school belonging.

The school belonging literature shows that researchers (e.g, Slaten et al, 2016; Allen et al, 2018a) have investigated the relationship between SOBAS and students' educational performance. In a recent study, Baek (2023) addressed the issue of predicting students' sense of belonging to the school by mathematics performance along with several student and school-level variables. Baek's (2023) study suggests that SDC was significantly associated with students' sense of school belonging in the U.S. and Canada but not in Singapore, Taiwan, and Japan. Furthermore, he found that students' learning attitudes demonstrated the most substantial relationship with school belongingness in all the countries included in his study, followed by their experiences with bullying.

Conceptual Framework

The reason why some students have more SOBAS than others has been investigated in past studies. Different factors, such as positive SDC (Ma, 2003; OECD, 2017), participation in extracurricular activities (Dotterer et al, 2007; Allen et al, 2016), parents, teachers, and peers support (Allen et al, 2016; Allen et al, 2018a; Crouch et al, 2014; Chiu et al, 2016), perceived

neighborhood safety (Garcia-Reid, 2007), school safety (Allen et al, 2016) and socioeconomic status (OECD, 2017) are identified as positively impacting SOBAS. This study examines the relationship between SOBAS, SB, and SDC with the mathematical performance of students in the five East Asian countries who have consistently performed well in TIMSS assessments. Figure 1 presents how, theoretically, SOBAS is associated with academic achievement and its relationships with SB and SDC.
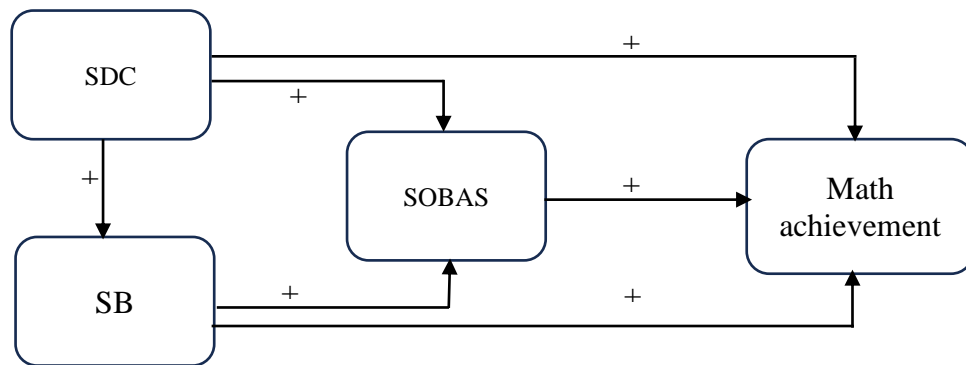
Figure 1. The relationships between SOBAS, SB, and SDC with mathematics achievement

A growing body of research indicates that academic achievement, generally, is influenced by SOBAS (Wang & Eccles, 2012; Slaten et al, 2016; Loukas et al, 2016; Allen et al, 2018b; Korpershoek et al, 2020). Mathematics achievement is also impacted by students' sense of school belonging (Mullis et al, 2020). Hence, the higher the level of students' SOBAS, the better academic achievement, including mathematics as a cornerstone of STEM (Science, Technology, Engineering, and Mathematics) education. Both SDC and SB have a positive relationship with mathematics achievement. SDC has a positive relationship with mathematics achievement; the better the school climate discipline, the higher the mathematics achievement will be achieved. Likewise, students' perception of school safety and lack of bullying is positively and directly associated with mathematics achievement. SDC and SB have a direct and positive relation with SOBAS and an indirect and positive impact on mathematics achievement. Finally, SDC has a positive influence on SB, and then it indirectly affects mathematics achievement.

Students' bullying experience

Bullying is "aggressive, goal-directed behavior that harms another individual within the context of a power imbalance" (Volk et al, 2014). It distresses students, leads to low self-esteem, and makes them feel like they do not belong (Hooper, 2017). Consistent with previous studies (Konishi et al, 2010; Rothon et al, 2011), the results from PIRLS have shown that bullied students tend to have lower reading achievement (Mullis & Martin, 2019). Perceptions of school safety improved when students reported positive relationships with teachers, consistent rules, and a sense of school belonging (Williams et al, 2018). Students who experience bullying exposure are at risk of depression and suicidal behavior (Williams et al, 2017), absenteeism, and school dropout (Bradshaw et al, 2014). Experiencing bullying is a primary factor that

threatens SDC (Yablon & Addington, 2017). Earlier studies have indicated that the stronger SOBAS students have, the lower the level of bullying perpetration occurs (Raskauskas et al, 2010; Goldweber et al, 2013). Hence, the relationship between bullying and SOBAS is investigated among students from the top-performing countries in the TIMSS assessments.

The sense of SDC that comes from having a healthy school environment with few behavioral problems and little or no concern about student or teacher safety is beneficial to student learning (Mullis & Martin, 2019). Physical safety and well-being are closely linked with the quality of individual relationships and the characteristics of the surrounding social world (Hanh, 2017). Ma (2003) found that SOBAS was shaped more by students' mental and physical situations and less by their individual and family characteristics. He further reported that disciplinary climate was more important than school context in shaping students' sense of belonging. The finding shows that schools with clear rules tend to have environments of greater discipline and safety (Cohen et al, 2009). Past research indicates that students in schools with no or little discipline problems had higher reading achievement than those in schools with disciplinary problems (Mullis & Martin, 2019). School effectiveness research using PIRLS/TIMSS 2011 data has shown that SDC is an essential prerequisite for student achievement in many countries (Martin et al, 2011). An orderly, nondisruptive school and classroom can facilitate SOBAS (OECD, 2017). It has been found that SDC is a strong predictor of SOBAS (OECD, 2003; Ovink, 2014; Chiu et al, 2016). Respect for students and teachers, a safe and orderly environment, and constructive interactions among students, parents, teachers, and administrators all contribute to a positive school climate and are related to higher student achievement (Kutsyuruba et al, 2015).

Based on the review of the literature and the conceptual framework discussed above, the hypotheses are made:

1. Sense of belonging at school is significantly associated with the mathematics achievement of students from Hong Kong, Japan, Korea, Singapore, and Taiwan.
2. Sense of belonging at school, experiencing bullying in school, and school disciplinary climate are significantly associated with the mathematics achievement of students from the five countries.
3. Students' bullying and school disciplinary climate are significantly associated with the sense of belonging at school of students in the five countries.
4. School disciplinary climate is significantly associated with experiencing bullying in school students across the five countries.

Methods

The data for the present study was obtained from TIMSS 2019. TIMSS assesses the mathematics and science achievement of fourth and eighth-grade students. This study focuses on eighth-grade students; hence, the data are a nationally representative sample of eighth-grade students in the mainstream school system of the five East Asian countries. A total of 3265, 4446,3861, 4853, and 4915 eighth-grade students from 136, 142, 168, 153, and 203 schools

from Hong Kong, Japan, Korea, Singapore, and Taiwan, respectively, participated in TIMSS 2019.

Measures

As demonstrated in Figure 1, this study investigated the relationships between mathematics achievement, SOBAS, SB, and SDC. The mean of the five plausible values is utilized for mathematics achievement as the predicted factor. For the other three factors, the scales constructed by TIMSS are used. Detailed information on these scales, including label, definition and metrics, items, and Cronbach's alpha reliability, is demonstrated in Appendix A. Descriptive statistics of the scales are presented in Table 1.

Table 1. Descriptive statistics of the scales

	Hong Kong		Japan		Kora		Singapore		Taiwan	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Math Mean	578.107	85.42	593.82	81.20	605.59	93.80	610.32	87.28	610.66	95.82
SOBAS	9.07	1.95	9.23	1.81	9.29	1.73	9.53	1.77	9.24	1.71
SB	9.89	2.11	11.34	1.67	10.98	1.75	9.52	1.74	11.00	1.83
SDC	11.67	1.45	10.98	1.69	10.88	2.15	11.37	1.47	11.72	1.67

The highest mathematics performance belonged to Taiwanese and Singaporean students, jointly followed by Korean, Japanese, and Hong Kong. Singaporean students reported the highest SOBAS, followed by Korean, Taiwanese, Japanese, and Hong Kong; however, variation in the mean scores across the countries is trivial. SB was high in Japan, followed by Taiwan, Korea, Hong Kong, and Singapore. Singaporean students reported less bullying experience compared to other countries. SDC was high in Taiwan, Hong Kong, Singapore, Japan, and Korea.

As presented in Appendix A, SOBAS is a composite factor comprising five items, each measuring an aspect of the SOBAS. Table 2 shows the correlation of each of these items with students' mathematics performance.

Table 2. Correlation between the SOBAS items and mathematics achievement

	Hong Kong	Japan	Korea	Singapore	Taiwan
I like being in school.	-.146**	-.155**	-.148**	.048*	.46
I feel safe when I am at school.	-.032**	-.111**	-.146**	.018	.034
I feel like I belong at this school.	-.144**	-.090**	-.125**	.043	.064*
Teachers at my school are fair to me.	-.128**	-.063**	-.127**	.006	.021
I am proud to go to this school.	-.180**	-.077**	-.089**	.059*	.018

Interestingly, the relationships between every item of SOBAS with mathematics achievement were negatively significant for Hong Kong, Japan, and Korea ($p < .001$). The relationships between "I like being in school" and "I am proud to go to this school" was

positively associated with mathematics achievement for Singaporeans ($p < .05$). The relationship between "feel like I belong at this school" was positively significant for Taiwanese ($p < .05$).

Method of analyses

Path analysis was employed to analyze the data. Four models were estimated. In Model 1, mathematics achievement is considered the predicted factor, and SOBAS was considered as predicted. In Model 2, mathematics achievement is considered the predicted factor, and SOBAS, SB, and SDC are the predictors. In Model 3, SOBAS was considered as predicted, and SB and SDC as predictors. In Model 4, SB was treated as a predicted factor and SDC as a predictor.

Methods should be described with sufficient details to allow others to replicate and build on the published results. This section explains the research design used, the reasons for the design, the research procedures applied, the population and research samples or participants, research instruments, data collection techniques, and data analysis techniques. The description should be in the past tense.

Explaining research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition. The description of the course of research should be supported references, so the explanation can be accepted scientifically, Figures 1-2, and Table 1 are presented center, as shown below, and cited in the manuscript. Figure 2(a) shown math representation ability students and Figure 2(b) reasoning ability students

Results

In Model 1, mathematics achievement is considered the predicted factor, and SOBAS is the predictor. The summary of Model 1 is presented in Table 3.

Table 3. Model 1 summary model

Country	R	R Square	Adjusted R Square	Std. Error of the Estimate
Hong Kong	.146	.021	.021	84.367
Japan	.105	.011	.011	80.754
Kora	.147	.022	.021	92.752
Singapore	.191	.036	.036	85.667
Taiwan	.095	.009	.009	95.353

Table 3 indicates that 2.1%, 1.1%, 2.2%, 3.6%, and 0.9% of the total variance in mathematics scores of students from Hong Kong, Japan, Korea, Singapore, and Taiwan can be predicted from SOBAS.

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The regression coefficients of Model 1 are presented in Table 4.

Table 4. The regression coefficients of Model 1

Country	Model	Coefficients					95% Confidence Interval for B		Collinearity Statistics	
		Unstandardized Coefficients		Standardized Coefficients			Lower Bound	Upper Bound	Tolerance	VIF
		B	Std. Error	Beta	t	Sig				
Hong Kong	Math	520.89	7.052		73.868	.000	507.066	534.718		
	SOBAS	6.362	.760	.146	8.367	.000	4.871	7.853	1.00	1.00
Japan	Math	550.41	6.281		87.634	.000	538.093	562.720		
	SOBAS	4.713	.668	.105	7.056	.000	3.404	6.023	1.00	1.00
Korea	Math	531.32	8.173		65.013	.000	515.301	547.347		
	SOBAS	7.994	.864	.147	9.247	.000	6.299	9.689	1.00	1.00
Singapore	Math	520.68	6.736		77.30	.000	507.47	533.88		
	SOBAS	9.412	.695	.191	13.542	.000	8.049	10.774	1.00	1.00
Taiwan	Math	561.41	7.50		74.815	.000	546.696	576.118		
	SOBAS	5.33	.798	.095	6.671	.000	3.761	6.891	1.00	1.00

The result shows that the relationship between SOBAS and mathematics achievement was positive and statistically significant ($p<.001$) across all the countries. A stronger relationship (13.542) was found for Singaporeans, followed by Korea (9.247), Hong Kong (8.367), Japan (7.056), and Taiwan (6.671).

Model 2, in this model, mathematics achievement is considered the predicted factor, and SOBAS, SB, and SDC are predictors. The summary of Model 2 is presented in Table 5.

Table 5. Model 2 summary model

Country	R	R Square	Adjusted R Square	Std. Error of the Estimate
Hong Kong	.169	.029	.006	57.47
Japan	.284	.080	.060	66.553
Kora	.262	.069	.052	75.110
Singapore	.301	.091	.072	81.450
Taiwan	.112	.012	-.002	90.854

Only 3%, 8%, 7%, 9%, and 1% of the total variance in mathematics scores of students from Hong Kong, Japan, Korea, Singapore, and Taiwan can be predicted from SOBAS, SB, and SDC.

The regression coefficients of Model 2 are presented in Table 6.

Table 6. The regression coefficients of model 2

Model		Coefficients					95% Confidence Interval for B		Collinearity Statistics	
		Unstandardized Coefficients		Standardized Coefficients			Lower Bound	Upper Bound	Tolerance	VIF
		B	Std. Error	Beta	t	Sig				
Hong Kong	Math	538.65	56.20		9.59	.000	427.48	649.83		
	SOBAS	4.21	3.48	.106	1.209	.229	-2.678	11.104	.971	1.030
	SB	3.53	2.84	.107	1.240	.217	-2.100	9.154	.993	1.007
	SDC	-1.98	2.37	-.073	-.836	.405	-6.673	2.709	.967	1.035
Japan	Math	541.34	57.033		9.492	.000	428.569	654.113		
	SOBAS	-5.370	3.320	-.132	-1.618	.108	-11.934	1.194	.998	1.002
	SB	10.493	3.470	.254	3.024	.003	3.632	17.354	.946	1.055
	SDC	.535	3.534	.013	.151	.880	-6.453	7.532	.948	1.055
Korea	Math	621.73	55.153		11.273	.000	512.831	730.643		
	SOBAS	8.848	3.427	.200	2.582	.011	2.082	15.614	.956	1.045
	SB	-9.569	3.448	-.215	-2.775	.006	-16.378	-2.761	.954	1.048
	SDC	.611	2.718	.017	.225	.822	-4.756	5.979	.997	1.003
Singapore	Math	499.50	73.279		6.817	.000	354.706	644.305		
	SOBAS	14.670	3.859	.297	3.801	.000	7.044	22.295	.998	1.002
	SB	1.744	3.954	.035	.441	.660	-6.068	9.557	.998	1.002
	SDC	-2.830	4.506	-.049	-.628	.531	-11.735	6.075	.999	1.001
Taiwan	Math	670.24	62.365		10.747	.000	547.262	793.231		
	SOBAS	2.538	3.965	.046	.640	.523	-5.281	10.357	.969	1.032
	SB	.911	3.338	.019	.269	.788	-5.770	7.592	.985	1.015
	SDC	-5.772	3.863	-.107	-1.494	.137	-13.390	1.846	.979	1.021

The result indicates that the relationship between SOBAS and mathematics achievement was positive across all countries but Japan when SB and SDC were considered. However, the relationship was significant only in Korea and Singapore (p<.001). The relationship between SB and mathematics achievement was positive in Hong Kong, Japan, Singapore, and Taiwan. The relationship was significant only in Japan (p<.001). The relationship between these two factors was negatively significant for Korean (p<.001). The relationship between SDC and mathematics achievement was negative in Hong Kong, Singapore, and Taiwan; however, it was insignificant in any of these countries.

Model 3, in this model, SOBAS is considered as the predicted factor, and SB and SDC as predictors. The summary of Model 3 is presented in Table 7.

Table 7. Model 3 summary model

Country	R	R Square	Adjusted R Square	Std. Error of the Estimate
Hong Kong	.081	.007	-.009	1.756
Japan	.233	.054	.040	1.627
Korea	.209	.044	.032	1.711
Singapore	.042	.002	-.021	1.723
Taiwan	.176	.031	.021	1.624

Only 0.7%, 5.4%, 4.4%, 0.2%, and 3% of the variance in SOBAS students from Hong Kong, Japan, Korea, Singapore, and Taiwan, respectively, can be predicted from the factors of SB and SDC.

The regression coefficients of Model 3 are presented in Table 8.

Table 8. The regression coefficient of Model 3

Country	Model	Coefficients					95% Confidence Interval for B		Collinearity Statistics	
		Unstandardized Coefficients		Standardized Coefficients			Lower Bound	Upper Bound	Tolerance	VIF
		B	Std. Error	Beta	t	Sig				
Hong Kong	SOBAS	8.861	1.537	.106	5.765	.000	5.821	11.902		
	SB	.059	.072	.072	.820	.413	-.084	.203	.972	1.029
	SDC	-.032	.107	-.026	-.298	.766	-2242	.179	.972	1.029
Japan	SOBAS	5.725	1.307		4.381	.000	3.141	8.309		
	SB	.232	.084	.228	2.763	.006	.066	.399	1.000	1.000
	SDC	.042	.081	.043	.517	.606	-.118	.202	1.000	1.000
Korea	SOBAS	7.349	1.118		6.572	.000	5.141	9.557		
	SB	.209	.077	.208	2.721	.007	.057	.361	.997	1.003
	SDC	-.005	.062	-.007	-.088	.930	-.128	.117	.997	1.003
Singapore	SOBAS	9.720	1.332		7.298	.000	7.088	12.352		
	SB	-.039	.084	-.039	-.472	.638	-.205	.126	.999	1.001
	SDC	.020	.095	.017	.210	.834	-.168	.208	.999	1.001
Taiwan	SOBAS	6.729	1.008		6.676	.000	4.741	8.716		
	SB	.094	.060	.109	1.562	.120	-.025	.213	.997	1.003
	SDC	.129	.068	.132	1.884	.061	-.006	.264	.997	1.003

The relationship between SOBAS and SB was significant only for Japan and Korea ($p<.0001$) when SDC was controlled. The relationship between SOBAS and SDC was insignificantly negative for Hong Kong and Korea and insignificantly positive for other countries.

Model 4, in this model, SB is considered as the predicted factor and SDC as the predictor. The summary of Model 4 is presented in Table 9.

Table 9. Model 4 summary model

Country	R	R Square	Adjusted R Square	Std. Error of the Estimate
Hong Kong	.169	.028	.021	2.107
Japan	.014	.000	-.007	1.634
Korea	.062	.004	.002	1.733
Singapore	.029	.001	-.006	1.678
Taiwan	.056	.003	-.002	1.908

The results indicate that 0.7%, 5.4%, 4.4%, 0.2%, and 3% of the total variance in SB scores of students from Hong Kong, Japan, Korea, Singapore, and Taiwan, respectively, can be predicted from the SDC factors.

The regression coefficients of Model 4 are presented in Table 10.

Table 10. The regression coefficients of Model 4

	Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig	95% CI Lower Bound	95% CI Upper Bound	Tolerance	VIF
Hong Kong	SB	12.649	1.479		8.552	.000	9.724	15.757		
	SDC	-.248	.126	-.169	-.974	.050	-.497	.001	1.000	1.000
Japan	SB	11.258	.905		12.441	.000	9.469	13.047		
	SDC	.013	.081	.014	.163	.871	-.148	.174	1.000	1.000
Kora	SB	11.564	.691		16.743	.000	10.200	12.927		
	SDC	-.050	.062	-.062	-.805	.422	-.173	.073	1.000	1.000
Singapore	SB	9.112	1.064		8.567	.000	7.011	11.2014		
	SDC	.033	.093	.029	.351	.726	-.151	.216	1.000	1.000
Taiwan	SB	9.971	.951		10.493	.000	8.100	11.850		
	SDC	.063	.080	.056	.786	.432	-.095	.222	1.000	1.000

Model 4 examined the relationship between SB and SDC. The relationship was negative for students from Hong Kong and Korea; it was statistically significant in Hong Kong ($p<.05$), but it was not significant for Koreans.

Discussion

The present study investigated the relationships between SOBAS, SB, SDC, and mathematics achievement utilizing a nationally representative sample of TIMSS top-performing countries. The results indicate that SOBAS was positively and significantly associated with mathematics achievement across all the five countries included in the study. Hence, the first hypothesis, "SOBAS is significantly associated with mathematics achievement of students from Hong Kong, Japan, Korea, Singapore, and Taiwan," was accepted. This result is aligned, in one sense, with what was found in past studies (e.g, Wang & Eccles, 2012; Slaten et al, 2016; Loukas et al, 2016; Allen et al, 2018a) that reported school belonging is widely known to predict students' academic achievement. However, it is not consistent with what was found in these studies, suggesting students with higher academic achievement also have a stronger sense of belonging at school because the SOBAS index was not that high compared to the participating countries in TIMSS 2019; students in all the five countries included in this study reported a low level of SOBAS (Mullis et al, 2020). This result also confirms those of Jang (2023), who reported that a sense of belonging at school was more vital for South Asian students and weaker for East Asian students.

After controlling for SB and SDC, there was no or weak relationship between SOBAS and mathematics achievement across the five countries included in this study. Hence, this finding partially rejects the second hypothesis that the "SOBAS, SB, and SDC are significantly associated with mathematics achievement of students from the five countries." The relationship was significant for Koreans and Singaporeans, particularly for Singaporeans. This finding could be because SB and SDC are more important for students in Hong Kong, Japan, and Taiwan education systems than SOBAS. Secondly, the relationship between SOBAS and mathematics achievement varies across the five TIMSS top-performing countries. The social aspect of SOBAS is emphasized in previous studies. Assessing students' experiences of being bullied is a way of measuring the social dimension of SOBAS. Students bullied more frequently had a weaker sense of belonging (Baek, 2023). Likewise, the same is true for the SDC measure; students who attend schools with higher discipline and safety problems feel a weaker sense of school belonging. The findings further indicated that SB and SDC were significantly correlated with mathematics achievement only for Japanese and Korean students. Therefore, the third hypothesis, "SB and SDC are significantly associated with SOBAS of students in the five countries," was also partially rejected. This result is consistent with previous findings (OECD, 2003; Ovink, 2014; Chiu et al, 2016) suggesting that SDC was not significantly associated with SOBAS across East Asian countries or administrative entities. Additionally, the results demonstrate that the link between SDC and SB was significant only for students from Hong Kong; thus, the fourth hypothesis, "SDC is significantly associated with SB of students across the five countries," was also partially rejected.

Although the five East Asian countries consistently topped the list of the TIMSS participating countries, students from these countries reported a much lower level of school belonging. Similarly, students from these countries reported a low level of self-concept in learning mathematics and science and an attitude toward these two subjects. They placed less value on mathematics and science than other TIMSS participating countries (Mohammadpour

et al, 2015). A study found that student-level factors explained a much smaller proportion of variance in students' science achievement from Singapore, Hong Kong, and Malaysia (Mohammadpour et al, 2015). A possible interpretation of this finding is that the differences in the students-related factors (e.g, school belonging, self-concept in learning school subjects, attitudes toward school and school subjects) may have an origin in the respective cultural values stemming from historical, sociopolitical, and economic influences (Oettingen & Zosuls, 2006).

The results of this study provide support for the past studies that linked the success of East Asian students more to their learning cultural model (Li, 2004; Wong, 2004), self-concept in learning school subjects (Mohammadpour, 2012; 2013; Mohammadpour et al, 2015), educational aspiration (Schneider & Lee, 1990), motivation for socioeconomic advancement (Salili et al, 2001), the learning activities at home (Stevenson & Stigler, 1992), and relationships with their teachers and peers (Hau & Salili, 1991). A possible interpretation of these findings is that countries in this study share the Confucian philosophy based on which group interests are given more value than individual ones (Liu, 2018). According to the Confucian philosophy, a good education is achieved mainly through hard work (Kumar & Maehr, 2006); examinations are highly competitive, and teaching is teacher-centered (Fry & Bi, 2013); competition for outperforming others linked to decreases in SOBAS (Kumar, 2006). East Asian families emphasize their children's academic achievement, and having high academic achievement is a means to honor one's parents and relatives (Ho, 2009).

Evidence suggests that SOBAS decreases during adolescence, the period of transition and identity formation for students (Allen et al, 2016; Allen et al, 2018b). Hence, it is suggested that the sense of belonging and its impact on achievement examined for eight-grade students from TIMSS 2015, for which the data on this factor is available to TIMSS 2023 to examine the changes in this factor over time due to the ever-increasing use of social media and its pervasiveness in everyday life of adolescents (Fabris et al, 2023). It also suggested examining the sense of school belonging among fourth-grade students in these countries and investigating differences with grade eight.

This study has a few limitations. It is correlational research based on cross-sectional data; thus, the findings do not make up any cause-and-effect inference. Furthermore, except for the mathematics achievements resulting from students' answers to the mathematics test items, TIMSS relies on self-reported data by the students and the school principals based on their respective questionnaires, which might be a potential source of data inaccuracy. Third, students' sense of belonging at school, bullying, and school disciplinary climate are measured as defined in the TIMSS dataset. Investigating other dimensions of these factors not covered in the TIMSS dataset might result in different patterns.

Conclusion

The current study investigated the relationships between SOBAS, SB, and SDC with the mathematics achievement of students from the five East Asian countries included in the study. The analyses indicate that SOBAS was significantly associated with mathematics achievement across the five countries; however, the significant association between SOBAS and achievement disappeared, except for Koreans and Singaporeans, when SB and SDC were considered. SB linked significantly with mathematics achievement for Japanese and Korean

after controlling for SOBAS and SDC. Similarly, there was a significant link between SB and SOBAS for Japanese and Koreans when SDC was considered. SDC was negatively and statistically linked with SB in Hong Kong. The results of this study support the past studies that linked the success of East Asian students more to their learning cultural model. The study also highlights those high achievements are obtained more through hard work and home pressure, and parents emphasize their children's success rather than students' attitudes and innate ability.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript

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Appendixes A. Descriptive information on the scales used in the analysis

A1. The investigated factors

Factors	Label	Definition and metrics
Mathematics achievement		Mean of the five plausible values.
Sense of belonging at school 1(agree a lot) to 4(disagree a lot)	SOBAS	Based on the following items regarding students' feelings toward their school and connectedness with the school community: 1. I like being in school 2. I feel safe when I am at school 3. I feel like I belong at this school 4. Teachers at my school are fair to me 5. I am proud to go to this school
Students bullying 1(at least once a week), 2(once or twice a month), 3(a few times a year), 4(never)	SB	Based on students' responses to the following items, how often they experienced bullying behaviours: 1. Said mean things about my physical appearance (e.g., my hair, my size) 2. Spread lies about me 3. Shared my secrets with others 4. Refused to talk to me 5. Insulted a member of my family 6. Stole something from me 7. Made me do things I didn't want to do 8. Sent me nasty or hurtful messages online 9. Shared nasty or hurtful things about me online 10. Shared embarrassing photos of me online 11. Threatened me 12. Physically hurt me 13. Excluded me from their group (e.g., parties, messaging) 14. Damaged something of mine on purpose
School disciplinary climate 1(not a problem), 2(minor problem), 3(moderate problem), 4(serious problem)	SDC	Based on school principals' responses to the following items concerning potential school problems: 1. Arriving late at school 2. Absenteeism (i.e., unjustified absences) 3. Classroom disturbance 4. Cheating 5. Profanity 6. Vandalism 7. Theft 8. Intimidation or verbal abuse among students (including texting, emailing, etc. 9. Physical injury to other students

10. Intimidation or verbal abuse of teachers or staff (including texting, emailing, etc.
11. Physical injury to teachers or staff

A2. Cronbach's alpha reliability of the scales

	Hong Kong	**Japan**	**Korea**	**Singapore**	**Taiwan**
SOBAS	.86	.85	.84	.81	.80
SB	.92	.79	.82	.89	.84
SDC	.81	.92	.95	.86	.89

Note. The "Made me do things I didn't want to do" (BSBG14G) is omitted for the SB scale from the Korean dataset.

Appendixes B. Correlations matrix among the investigated factors

B1. Hong Kong

		Math achievement	**SOBAS**	**SB**	**SDC**
Math achievement	r	1	.146**	.032	.114
	N	3265	3238	3252	135
SOBAS	r	.146**	1	.067**	-.035
	N	3238	3238	3235	135
SB	r	.032	.067**	1	-.169
	N	3252	3235	3252	135
SDC	r	.114	-.035	-.169	1
	N	135	135	135	135

B2. Japan

		Math achievement	**SOBAS**	**SB**	**SDC**
Math achievement	r	1	.105**	-.019	-.120
	N	4446	4440	4438	142
SOBAS	r	.105**	1	.205**	.046
	N	4440	4440	4435	142
SB	r	-.019	.205**	1	.014
	N	4438	4435	4438	142
SDC	r	-.120	.046	.014	1
	N	142	142	142	142

B3. Korea

		Math achievement	SOBAS	SB	SDC
Math achievement	r	1	.147**	-.077**	.022
	N	3861	3852	3857	168
SOBAS	r	.147**	1	.157**	-.018
	N	3852	3852	3852	167
SB	r	-.077**	.175**	1	-.062
	N	3857	3852	3857	168
SDC	r	.022	-.018	-.062	1
	N	168	167	168	168

B4. Singapore

		Math achievement	SOBAS	SB	SDC
Math achievement	r	1	.191**	.151**	-.096
	N	4853	4850	4850	153
SOBAS	r	.191**	1	.209**	.016
	N	4850	4850	4850	153
SB	r	.151**	.209**	1	.029
	N	4850	4850	4850	153
SDC	r	-.043	.016	.029	1
	N	153	153	153	153

B5. Taiwan

		Math achievement	SOBAS	SB	SDC
Math achievement	r	1	.095**	-.003	-.096
	N	4915	4905	4908	203
SOBAS	r	.095**	1	.159**	.138
	N	4905	4905	4903	202
SB	r	-.003	.159**	1	.056
	N	4908	4903	4908	202
SDC	r	-.096	.138	.056	1
	N	203	202	202	203