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School and Student Factors and Their Influence on Affective Mathematics Engagement

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Abstract: This study examined the student-level (i.e., gender, home language, and immigration status) and school-level (i.e., school economic disadvantage status) variability of the students' affective mathematics engagement. It was hypothesized that there is a school effect that contributes toward explaining differences in affective mathematics engagement besides the student-level differences. For the sake of the nested structure of the data in Trends in International Mathematics and Science Study (TIMSS), we used the Hierarchical Linear Modeling (HLM) methodology. There were 10,221 students from 246 schools in the study. The results of this study explained 5.3% of variance in students' affective mathematics engagement by school-mean economic disadvantage status, where students' demographic factors explained 1.2%. The present study contributed to a better understanding of the opportunity to learn variables at the student- and school-level in students' affective mathematics engagement.
Keywords: affective mathematics engagement, economic disadvantage, gender, immigration, language.

Students' affective mathematics engagement, which is a situational feeling in mathematics learning (Lee et al., 2019a), has attracted the attention of educators and stakeholders in the field of education. In particular, empirical research about affective mathematics engagement and the factors impacting it is expected to illustrate this significant educational topic for both students and educators. Students' affective mathematics engagement is an affective state by a specific situation of a mathematical activity or task (Wang & Degol, 2014). This situational feeling toward mathematics includes individual's comprehensive perspectives such as attitude, emotion, self-acknowledge, and value (Lee et al., 2019a) and promotes students' activity level in mathematical learning situations and comprehensibility of mathematical concepts (Quintero et al., 2022). In turn, affective mathematics engagement impacts students' academic achievement (Dotterer & Lowe, 2011) and encourages them to pursue Science, Technology, Engineering, and Mathematics (STEM)-related majors or careers through the improvement of interest toward mathematics (Grigg et al., 2018). Therefore,

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fostering a positive affective mathematics engagement is one of the biggest factors in students' academic success.

A number of educators in mathematics education have recognized that there was a lack of students' positive affective mathematics engagement in current mathematics classrooms. Many affectively disengaged students felt bored and uninvolved in mathematical learning situations (Goldin et al., 2011). Students' negative feelings of helplessness, tension, and fear during their learning process can be expanded to the long-term damaging effects of mathematical anxiety (Bicer et al., 2020). Eventually, the students who could not feel positive about mathematics and mathematical learning were less likely to develop their mathematical performance (W. Wright, 2015). Therefore, conveying students' short-term and situational status in mathematical learning, which would lead to long-term emotional reactions, is essential.

To investigate students' affective mathematics engagement, previous research on affective mathematics engagement had mainly focused on empirical study, including the impact of instructional methods, such as collaboration, project-based instruction, student-centered instruction, innovative instruction (e.g., Muehlenkamp et al., 2015; Wang et al., 2022). In most studies, demographic variables such as gender, ethnicity, immigration status, language, and socioeconomic status were statistically moderated or did not be considered together. Demographic variables may not be able to suggest educational reform because educational stakeholders cannot manipulate them. However, pedagogical changes are impacted by these variables by (dis)encouraging students' affective mathematics engagement (Lee, 2022).

The role of affective mathematics engagement considering students' backgrounds is inevitable. A myriad of student- and school-level factors are implicated in variability in students' affective mathematics engagement. However, there has been a dearth of research on the relationships between these factors in affective mathematics engagement among students. Owing to a lack of current research findings related to affective mathematics engagement, the field needs more research to understand the relationship between situational factors and students' affective mathematics engagement. Such an exploration will provide a deeper understanding of the relative strengths and weaknesses of educational circumstances and help identify potential ways forward in developing the quality of the educational circumstances. The present study, therefore, aims to examine the student- and school-level factors related to students' affective mathematics engagement. The following research questions address the purpose of this study:

1. What are the effects of student-level factors (gender, home language, and immigration status) and school-level factor (school economic disadvantage status) on students' affective mathematics engagement?
2. Is there any evidence that the effects of student-level factors vary by school-level?

Theoretical Framework

Gender Differences

The issue of gender differences continues to capture much attention within and beyond mathematics education as researchers seek to address the greater number of male students than female students at the highest levels of mathematical performance and interests (Steegh et al., 2018). Female students showed higher levels of mathematics anxiety than male students, which were related to poorer levels of mathematics performance. Gender differences in students' mathematical learning impact gender differences in career paths. According to Lee et al. (2019b), male students were more likely to pursue STEM-related majors or careers compared to female students, and these results were highly influenced by their mathematical learning with demographic backgrounds at K-12 school levels. These gender differences across students' learning and career journeys are related to cultural norms (Lee et al., 2019b). For example, gender stereotypes, which referred that mathematics is for male students, encouraged male students to choose STEM fields for their careers and to engage in mathematics learning situations. On the other hand, female students were discouraged from entering these fields, which also led them to avoid mathematical engagement. They did not see themselves as belonging there. Like this, students' demographic factors directly or indirectly impact their mathematical learning processes. Affective mathematics engagement is a bridge to connect students' backgrounds and their learning because of its impacts on students' mathematical learning and achievement.

Language and Immigration Status

The number of students from many countries, who have diverse backgrounds, has rapidly increased in U.S. schools (Cochran-Smith et al., 2015). Consequently, around 9% of the students who enrolled in public schools were identified as English Language Learners (ELL), and the population of these types of students has been increasing over the past several decades (U.S. Department of Education, 2016). The low level of English-proficient students limited their understanding of mathematical content and situations (Rillero et al., 2017). The roles of the language the students were using in their homes and their immigration status in their mathematical learning process have been documented by many researchers (e.g., Areepattamannil & Freeman, 2008; Martin et al., 2012). Students who spoke the English language more often at home tended to show more positive behavior in mathematics classrooms than students who spoke a foreign language at home (Martin et al., 2012; Mullis et al., 2012). In addition, language issues are related to cultural issues. Most students who were not native English speakers were immigrants or children of immigrants (Cho & Reich, 2008). These individuals have been less exposed to the culture in the U.S. If teachers or peers do not understand a student's cultural background and turn their faces away, the effects of students' mathematical learning would be decreased (Hand, 2012).

School-Mean Economic Disadvantage Status

School-mean economic disadvantage status in this study referred to *how many students in a school came from economically disadvantaged homes*. There has been a growing consensus that school-mean economic disadvantage status is associated with students' mathematical learning. A number of researchers (e.g., Pekrun & Linnenbrink-Garcia, 2012; Skinner & Pitzer, 2012) indicated a strong relationship between economic disadvantage status and students' mathematical performance. The number of students who were from economically disadvantaged homes was considered the main issue in determining school support (Morgan, 2012), which was related to students' academic success. Low income of parents limited students' learning circumstances (McGraw et al., 2006). In addition, the differences between students in terms of economic disadvantage status impacted students' performance during the time they were learning mathematics. For example, economically disadvantaged students also preferred to focus on drill-based or basic computational skills, while economically not disadvantaged students focused on problem-solving and reasoning skills (L. Wright & Slate, 2015). These types of mathematical performance differences between students depending on their economic disadvantage status eventually impacted the differences in their academic achievement (Pekrun & Linnenbrink-Garcia, 2012; Skinner & Pitzer, 2012). The role of schools in minimizing this limitation of students needs to be considered so that students can be supported to overcome the impact of their economic disadvantage on their learning.

Method

The present study used a quantitative analysis of school effects on students' affective mathematics engagement in U.S. public schools. The study aimed to examine student- and school-level variability of students' affective mathematics engagement and hypothesized that the effects of the school contributed toward explaining differences in affective mathematics engagement. Different levels can be explained as salient characteristics of the relationships with other levels of the hierarchy. In education, data are often nested in different levels, such as classrooms, schools, and countries. Ignoring the structure of these nested data was likely to create a biased estimate or let researchers misunderstand the result (Raudenbush & Bryk, 2002). Owing to the nested nature of the data, two-level hierarchical linear modeling (HLM) representing student- and school-level variables were hypothesized for the analysis of this study. Thus, the present study included student- and school-level factors and focused on students' affective mathematics engagement. The student-level factor in the analyses included students' demographic factors (i.e., gender, home language, and immigration status). School economic disadvantage status served as the school-level factor.

Data Sources

Data for the study were drawn from TIMSS 2015 database. TIMSS, administered in participating countries every three years, is an international comparative survey of 4^{th}- and 8^{th}-grade students' academic achievement and affective domains in mathematics and science. It collects comprehensive educational information from students, teachers, and school stakeholders about cognitive and affective domains in mathematics and science, demographic and home contexts, and school characteristics, including policies, curriculum, and instruction. In this study, we used the data from 8^{th}-grade students in the U.S. A total of 10,221 students (female = 5,091 (50.1%), male = 5,071 (49.9%), missing = 59) from 246 schools took part in TIMSS in 2015. The number of students per school in the U.S. sample varied between 3 and 73 (mean (M) = 41.59, standard deviation (SD) = 12.46).

Variables

Reflective indicators were selected from the original TIMSS 2015 questionnaires based on theory and operational definitions used in prior studies. Psychological items in mathematics were selected for exploratory factor analysis (EFA) using Statistical Package for the Social Sciences (SPSS) 25. The principal components analysis (PCA) with Varimax rotation was used to extract affective mathematics engagement factors for the current study. The results of the analysis showed that seven psychological items could be considered as variables of affective mathematics engagement. Following are the specific seven items of affective mathematics engagement used for this study: (1) I enjoy learning mathematics, (2) I like mathematics, (3) I look forward to mathematics class, (4) I usually do well in mathematics, (5) Mathematics is more difficult for me than for many of my classmates, (6) Mathematics is not one of my strengths, and (6) I learn things quickly in mathematics. The Cronbach's α reliability was .894. These items of affective mathematics engagement were well aligned with the items of affective engagement in science by Mo et al. (2013). Mo et al. (2013) demonstrated six items that overlapped with six of the items in this study: The present study included one more item, "I like mathematics." Students were asked to indicate the extent of their agreement with each statement on a four-point Likert-type scale ranging from 1= "Disagree a lot" to 4= "Agree a lot."

The student-level factors included students' affective mathematics engagement and their background characteristics. The student background characteristics included gender

(Question: “Are you a girl or a boy?”, Answer: 1 = “Boy” and 0 = “Girl”), home language (Question: “How often do you speak English at home?”, Answer: 4 = “Always,” 3 = “Almost Always,” 2 = “Sometimes,” and 1 = “Never”), and immigration status (Question: “Were you born in the U.S.?, Answer: 1 = “Yes” and 0 = “No”). The school-level factor included school-mean economic disadvantage status (Question: “Approximately what percentage of students in your school have the following backgrounds? Come from economically disadvantaged homes”, (Reversed) Answer: 4 = “0 to 10%”, 3 = “11 to 25%”, 2 = “26 to 50%” and 1 = “More than 50%”). The school-mean economic disadvantage measured whether most students in the school came from economically disadvantaged homes. Gender and immigration status were dichotomously scaled items (boy/girl or yes/no). Items of home language and school-mean economic disadvantage status were rated on a four-point Likert-type scale. Negatively phrased item (i.e., school-mean economic disadvantage status) was inverted for item response theory (IRT) scaling, and higher values on these indices indicated more positive evaluation. The school-level variable was aggregated because some schools included multiple scores of economic disadvantage by teachers or classes. Thus, school-mean economic disadvantage status became the school-level variable.

Data Analysis

To analyze the data, two-level HLM was conducted using SPSS 25. With the intention to examine the school-level variability of U.S. 8th-grade students’ affective mathematics engagement, the study hypothesized that school effects contributed toward explaining differences of affective mathematics engagement. Because of the nature of students who were nested in hierarchical social structures, they could not be fully independent. The students tend to show similarities different from people who were randomly selected from the population (Hox, 2002). The HLM was a useful analysis technique for dealing with nested data structures (Raudenbush & Bryk, 2002). Therefore, the HLM was built in sequence, using a series of models (McCoach, 2010). First, two-level HLM analyses started with an unconditional model that contained no predictor variables from any level. The unconditional model, which is also called the null or intercept-only model, was run to estimate what portion of the total variance in outcome measures (i.e., students’ affective mathematics engagement) was explained by within-school variance (i.e., variance attributable to student-level factors) and between-school variance (i.e., variance attributable to a school-level factor). This unconditional mixed model is similar to a model of random effects one-way analysis of variance (ANOVA) (Raudenbush & Bryk, 2002). However, only HLM can be used when the data are not completely balanced (i.e., sample size differed from school to school). The estimate of HLM included the mean of the means of affective mathematics engagement for each school instead of the mean of all students in the study. Second, a Level-1 model that included all student-level variables was estimated. Lastly, a full Level-2 model that included both student- and school-level variables was estimated. The random intercepts and fixed slopes models were used for Level-1 and Level-2 models. The indices of model fitness were based on a Wald z value, which is the covariance parameter estimate divided by its standard error provided by SPSS 25.

The use of the hierarchical linear model involved a single cross-section of data with a two-level structure consisting of students (Level 1) nested within schools (Level 2). The Level 1 model added gender, home language, and immigration status as predictors. The Level 2 model included school economic disadvantage status. The HLM mixed model equations are provided below.

- Unconditional model: $(Affective\ Mathematics\ Engagement)_{ij} = \gamma_{00} + u_{oj} + e_{ij}$

- Level-1 model: $(Affective\ Mathematics\ Engagement)_{ij} = \gamma_{00} + \gamma_{10}(Gender)_{ij} + \gamma_{20}(HomeLanguage)_{ij} + \gamma_{30}(ImmigrationStatus)_{ij} + u_{oj} + e_{ij}$
- Full Level-2 model: $(Affective\ Mathematics\ Engagement)_{ij} = \gamma_{00} + \gamma_{01}(SchoolEconomicDisadvantage)_{ij} + \gamma_{10}(gender)_{ij} + \gamma_{20}(HomeLanguage)_{ij} + \gamma_{30}(ImmigrationStatus)_{ij} + u_{oj} + e_{ij}$ (i=student (1≤ $i \leq$ 10,221), j=school (1≤ $j \leq$ 246))

Intraclass correlation coefficient (ICC) was calculated to determine what percentage of the variance in affective mathematics engagement was attributable to school level. The formula for ICC (ρ) is:

$$\rho = \frac{\tau_{00}}{\tau_{00} + \sigma^2}$$

τ_{00} is a variance component at school level, and σ^2 is a variance component at student level.

To obtain information on the HLM models, two auxiliary statistics, variance explained and 2 restricted log likelihood (2LL) were calculated. The variance (r^2) explained by the student-level predictor variables in the outcome variable is:

$$r^2 = \frac{(\sigma^2_{null} - \sigma^2_{random})}{\sigma^2_{null}}$$

σ^2_{null} is a sigma value obtained in the previous step (unconditional model), and σ^2_{random} is a sigma value obtained in the present step (student-level model or school-level model). The result of variance explained revealed how much the variance component at school level (τ_{00}) and the variance component at student level (σ^2) were further explained as more predictors were added (Raudenbush & Bryk, 2002). The 2 restricted log likelihood (2LL) was calculated to select the best-fit model for the collected data by examining whether the variable increased the model fitness.

Results

Unconditional Model

Table 1 presented the detailed results of fixed and random effects of all four models (unconditional, gender, home language, and immigration status). The results of the unconditional model indicated the average mean for students' affective mathematics engagement as 15.779 ($t = 136.195$, $p < .001$). The estimates of the variance components at student level was $\sigma^2 = 29.214$ and at school level, ($\tau_{00} = 2.480$, Wald $z = 68.489$, $p < .001$).

This result indicated that mean affective mathematics engagement score among schools was 15.779 and that there was more variation within schools than among the different schools. These results showed that there was statistical justification for running HLM. In addition, the ICC for this unconditional model is equal to $\rho_{uc} = .078$. The ranges of ICC in educational research with a cross-sectional design are considered between .05 and .20 in general (Kwok et al., 2008; Snijders & Bosker, 1999). The estimated ICC value indicated that 7.8% of the variability in the students' affective mathematics engagement scores was due to the organizational unit (i.e., school-mean economic disadvantage). Because variance existed at both student- and school-levels of the data structure, independent variables were individually added at each level.

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Table 1

Results of Hierarchical Linear Modeling Analyses Predicting Students' Affective Mathematics Engagement

	Unconditional model			Level-1 model			Full level-2 model		
	B	***SE***	***t/Wald z***	***B***	***SE***	***t/Wald z***	***B***	***SE***	***t/Wald z***
Fixed effects									
Intercept, (r_{00})	15.779**	.116	136.195**	13.957**	.374	37.356**	13.112**	.541	24.246**
Level 1									
Gender (r_{10})				.606**	.112	6.232**	.739**	.117	6.324**
Home language (r_{20})				.222*	.093	2.400*	.219*	.098	2.244*
Immigration status (r_{30})				.691*	.255	2.707*	.574*	.270	2.128*
Level 2									
School mean economic disadvantage (r_{01})							.286*	.113	2.540*
Random effects									
Intercept variance (u_{0j} or τ_{00})	2.480		8.311**	2.488		8.305**	2.347		7.814**
Level-1 variance (Students variation, e_{ij} or σ^2)	29.214		68.489**	28.996		68.126**	28.855		64.960**
Intraclass correlation coefficient (ICC) (ρ)	.078			.079			.075		
Variance in affective mathematics engagement between schools explained (%)	N/A			-.3			5.3		
Variance in affective mathematics engagement within schools explained (%)	N/A			.7			1.2		
2 Restricted Log Likelihood (2LL)	60161.554			59497.436			54035.394		

Note. *$p < .05$, **$p < .001$.

Student- and School-Level Factors Predicting Affective Mathematics Engagement

Level-1 Model

For the student-level model, I added three student-level fixed factors: gender, home language, and immigration status. A regression coefficient was estimated, and its significance confirmed the relationship between student-level predictor variables and the outcome variable (affective mathematics engagement). The results of the present analysis supported the relationship between affective mathematics engagement and gender ($r_{10} = .696, p < .001$), home language ($r_{20} = .222, p < .05$), and immigration status ($r_{30} = .691, p < .05$). That is, students' gender, home language, and immigration status were statistically significantly related to their affective mathematics engagement. In particular, male students, students who spoke English at home, and students who were born in the U.S. scored statistically significantly higher on affective mathematics engagement. To calculate a measure of effect size, the variance ($r^2_{within1}$) explained by the student-level predictor variables in the outcome variable was $r^2_{within1} = .007$, and the variance ($r^2_{between1}$) in affective mathematics engagement explained between schools was: $r^2_{between1} = -.003$. This result indicated that gender, home language, and immigration status explained .7 percent of the variance in affective mathematics engagement.

Full Level-2 Model

For the student- and school-level model, I added a school-level fixed factor: the school-mean economic disadvantage status. A regression coefficient was estimated, and its significance confirmed the relationship of student- and school-level predictor variables with the outcome variable (affective mathematics engagement). The results of the present analysis supported that affective mathematics engagement was explained by student-level variables (gender: $r_{10} = .739, p < .001$, home language: $r_{20} = .219, p < .05$, and immigration status: $r_{30} = .574, p < .05$) and the school-level variable (school-mean economic disadvantage status: $r_{01} = .286, p < .05$). That is, gender, home language, and immigration status of students and economic disadvantage status of schools were statistically significantly related to students' affective mathematics engagement. In particular, the slope of student-level variables was positive, meaning that male students, students who spoke English at home, and students who were born in the U.S. scored statistically significantly higher on affective mathematics engagement. When controlling for other variables in the model, male students were associated with scoring .739 points higher than female students; students who were born in the U.S. were associated with scoring .574 points higher than student who were not born in the U.S.; and a unit increase in students who spoke English at home predicted an increase of affective mathematics engagement score of .219 points. In addition, schools that had fewer economically disadvantaged students scored statistically significantly higher on affective mathematics engagement. For every unit decrease and school-mean economic disadvantaged status predicted an increase .286 points in affective mathematics engagement.

The variance ($r^2_{within2}$) in affective mathematics engagement within schools explained is $r^2_{within2} = .012$. This result indicated that gender, home language, and immigration status explained 1.2% of the variance in affective mathematics engagement. The variance ($r^2_{between2}$) in affective mathematics engagement between schools explained is $r^2_{between2} = .053$. This result indicated that school-mean economic disadvantage status explained 5.3% of the variance in affective mathematics engagement. The 2LL value of this full level-2 model was smallest, which indicated the best-fit model.

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Conclusions and Discussions

In the 21st century, the crucial role of investigation and encouragement of students' affective mathematics engagement has been highlighted in mathematics education. The improvement of students' affective mathematics engagement is highly related to their high achievement of academic performance (Organization for Economic Cooperation and Development [OECD], 2010; Perry & McConney, 2010) as well as their future major or career choices in STEM-related fields (Capraro & Slough, 2013; J. Chen & Usher, 2013; Lent et al., 2010). In particular, the U.S. has been emphasizing the preparation of a STEM-proficient workforce and filling positions in the growing STEM-related job market (President's Council of Advisors on Science and Technology [PCAST], 2012). Therefore, the objective of the present study was to examine the relationships of student- and school-level factors to students' affective mathematics engagement among U.S. 8th-grade students. Hierarchical linear modeling (HLM) was used to statistically analyze a data structure where students (level-1) were nested within schools (level-2). Of specific interest was the relationship between students' affective mathematics engagement and both student-level factors (gender, home language, and immigration status) and a school-level factor (school-mean economic disadvantage status). The finding of the study indicated that schools accounted for more of the variability in affective mathematics engagement than did the students within schools. A school-level variable explained about 5.3% of the total variance in affective mathematics engagement, and student-level variables explained 1.2%. All factors of student- and school-level were statistically significantly associated with affective mathematics engagement.

Student-Level Analysis

Gender, home language, and immigration status of students have significant positive effects on their affective mathematics engagement. Consistent with the findings of prior research (e.g., Boedeker et al., 2015; Buck et al., 2008; Bystydzienski & Bird, 2006; Steegh et al., 2019, the results of the present study revealed significant gender differences in affective mathematics engagement. Male students' affective mathematics engagement was more positive than female students. The gender differences in students' perspectives toward mathematics were shaped by socio-cultural factors (Spelke, 2005) and national indicators of gender egalitarianism (Guiso et al., 2008). According to prior research, students' affective mathematics engagement was found to be male-dominated. The cultural stereotype has been considered one of the reasons implicated in male students' superiority in positive affective mathematics engagement (Dowker et al., 2016; Wai et al., 2010). For example, female students who endorsed such stereotypes were less likely to have positive affective mathematics engagement (Schmader et al., 2004). In addition, many female students believed that mathematics did not involve creativity and chose not to pursue STEM-related careers (Bicer et al., 2017; Boedeker et al., 2015, Wai et al., 2010). Moreover, female students tended to show less interest in taking advanced STEM related courses as compared to male students (Boedeker et al., 2015; X. Chen, 2009). There have been a number of educational attempts to encourage female students' affective mathematics engagement and to combat the widening of gender differences over time (Nosek et al., 2009). However, the findings of this study suggested that there is still a need for social and educational efforts to bolster female students' affective mathematics engagement. One possible explanation for the underrepresentation of female students at the high end of affective mathematics engagement could be explained by cultural norms. Despite mounting evidence of gender similarities in mathematical academic achievement (Hyde, 2014), the stereotype threat that female students lack affective mathematics engagement compared to males has persisted. Mathematics-related disciplines and careers have been considered as male-dominated fields (Buck et al., 2008). A number of researchers (e.g., Boedeker et al., 2015; Bystydzienski & Bird, 2006) have shown male students as advantaged in mathematics and the stereotypes about female students in mathematics. Mathematics tended to be viewed as masculine and unexciting for female students (Boedeker et al., 2015). There was much research demonstrating stereotypes - female students being less capable in mathematics (Boedeker et al., 2015; Bystydzienski & Bird, 2006). Another stereotype about female students in mathematics was that female students tend to have a lower mathematical affect (Dowker et al., 2016; Wai et al., 2010). This low mathematical affect of female students manifested itself in female students being less affectively engaged in mathematics learning situations (Watt & Goos, 2017) and interested in taking advanced mathematics-related courses compared to male students (Boedeker et al., 2015).

Speaking English at home was positively linked to students' affective mathematics engagement, a finding consistent with prior findings (e.g., Areepattamannil & Freeman, 2008; Martin et al., 2012; Mullis et al., 2012; Rillero et al., 2017). In the U.S., the population of students who were represented as ELL has been increasing (U.S. Department of Education, 2016). Low-level of English proficiency limited students' understanding of the content and situation in the mathematics classroom (Rillero et al., 2017), mediated affective mathematics engagement. When the content and situation were not conveyed to the students, they could not affectively engage in mathematics classrooms (Lee et al., 2019a; W. Wright, 2015). Given the statistically significant relationship between students' language proficiency and their affective mathematics engagement, instructional interventions aimed at enhancing academic language proficiency may be required for students who fail to develop sufficient proficiency in academic English for their academic success in mathematics learning (Slama, 2012).

Students' immigration status was another factor associated with their affective mathematics engagement. In particular, U.S.-born students had more positive affective mathematics engagement than students who were not born in the U.S. This immigration status brought to the fore the cultural issue. Most students who were not born in the U.S. were either immigrants or children of immigrants, and many of them belonged to ethnic minorities and spoke English as a second language (Cho & Reich, 2008). Similar to the findings of this study, students who speak English as a second language are likely to have low affective mathematics engagement (Maldonado et al., 2018). In addition, students who were not born in the U.S. have been less experience with U.S. culture. For example, the East Asian cultural norm is that students do not question the teacher, therefore, East Asian culture (e.g., Korea, Japan, China) indoctrinated students might be afraid of speaking in front of their peers during the mathematics class (Lee et al., 2022). It is because, in most East Asian countries, students are taught by listening to what others say than by speaking what they want to say. If teachers fail to recognize East Asian cultural differences or for that matter cultural differences of others, then students' mathematical performance would suffer (Lee et al., 2022). In this case, direct instruction encouraging students' verbal participation in mathematics activities might be helpful (Rillero et al., 2017).

School-Level Analysis

School-mean economic disadvantage was linked to students' affective mathematics engagement. This finding concurred with prior research (e.g., McGraw et al., 2006; Perry & McConney, 2010) that students who attended economically advantaged schools tended to do well on standardized measures of affective mathematics engagement compared with their peers who attended economically disadvantaged schools. These results suggested that there may be negative consequences of school economic segregation in terms of students' learning opportunities and atmosphere in mathematics classrooms. Because the school's economic status was highly related to how many economically disadvantaged/advantaged students they had (Perry & McConney, 2010), the students who attended economically advantaged schools were likely to be exposed to greater instructional advantages and more learning opportunities. Greater instructional advantages tend to positively influence students' affective mathematics engagement (Lee et al., 2018; Lee et al., 2019a). In addition, students' economic status was related to the social and emotional atmosphere of mathematics classrooms (Griffiths et al., 2009; Reyes et al., 2012). Students may have exhibited more affective mathematics engagement in socially and emotionally healthy classroom environments that were characterized by a sense of enjoyment, interest, satisfaction, connectedness, and belongingness. Therefore, educational policies targeted at improving education in low-socioeconomic schools that make use of instructional equity can have a positive influence on academic and affective success (OECD, 2010; Perry & McConney, 2010). In addition, reducing the differences in the educational context at the school-level may minimize the school's economic segregation (Palardy, 2013). Students' positive affective mathematics engagement starts from the socially and emotionally healthy learning environment.

Implications

The findings of the study have implications for educators and stakeholders in mathematics education. All levels—student and school factors—contribute to the overall variability of affective mathematics engagement. The reasons for these interactional effects bring to mind the more general critique of U.S. mathematics education and educational atmosphere. Especially the policy-related findings related to the effects of school-level factors. The results explain 5.3% of variance in students' affective mathematics engagement by school-mean economic disadvantage status, where student level explains 1.2%. The large variance between schools indicates that how many students in a school came from economically disadvantaged homes does matter and has a strong effect on students' affective mathematics engagement. This finding suggests further investigation related to the reasons for interactional effects and policy-relevant developments.

The roles of schools and educational administration could have been an important issue (Chiu et al., 2015) when they had a large portion of economically disadvantaged students who needed to have extra administrational and instructional supports (Morgan, 2012). For example, schools provided diverse opportunities to explore mathematics-related disciplines and careers regardless of students' economic disadvantage status. These experiences increased motivational beliefs, including self-efficacy, interest, values, and identity processes, impacting students' career aspirations and choices (e.g., Jacobs et al., 2005; Tomlinson et al., 2014). In addition, schools providing mathematics activities using multimedia, like a computer, broadened students' experience, particularly those who did not have any opportunities to use them in their learning situations. However, schools included a large number of students who often represented that the economic statuses of these schools were also disadvantaged compared to those which had a large number of advantaged students. Providing opportunities for diverse mathematics activities and using technological material for the mathematics classroom was sometimes difficult to implement because of the economic issue (Baroudi, 2019). These economic statuses impacted students' affective mathematics engagement. Students from economically advantaged schools had a positive affective mathematics engagement and greater confidence than did their peers from economically disadvantaged schools (Perry & McConney, 2010). Therefore, we recommend, for one, administrational and instructional supports to assist schools and districts. These supports will help reduce the gaps between students who have diverse backgrounds.

Limitations

The results of this study should be treated with caution for three reasons. First, the result of this study should not be interpreted as causal inferences. Because of the cross-sectional nature of TIMSS data, they were limited by the fact that the reported significant relationships were correlational and they were carried out at a one-time point (Levin, 2006). Therefore, the results can be different in the sequence of events or if another timeframe is chosen. Second, there is a possibility of aggregation bias. School-level variable, which is economic disadvantage, has been aggregated at level-2, therefore, the aggregated means that were used in the imputation also constrained variation. In the aggregate, different characteristics within the school-level defined the characteristic as a unique school that affected each student in the school. In this aggregated model, within-school variation was ignored, and students were treated as homogenous entities (Gill, 2003). However, students who were sampled within a particular school were more similar to each other than to students who were randomly selected from other schools. For example, students in a particular school tend to come from a community that is more homogeneous in terms of educational exposure, physical environment, and even economic status than the students as a whole (Cai, 2008). Further, sharing the experience in the same learning environment may lead to increased homogeneity over time (Cai, 2008; Lauen et al., 2015). Third, the student-level factors, school-level factors, and affective mathematics engagement responses were collected via self-report. Students' self-referent thinking processes may influence on their evaluation (Preckel et al., 2010). Because of the sensitivity of self-reports toward students' internal processes of the task, the self-report has challenged the reliability and validity of measures (Fulmer & Frijters, 2009). However, this perceived challenge of self-report would therefore be of special importance when it comes to the students' perceptions or subsequent behaviors (Bergomi et al., 2013). This makes self-report measures a good or even better than other competing or alternative measures (Fulmer & Frijters, 2009; Krannich et al., 2019).

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