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How social expectations affect eighth-grade students' math achievement: An investigation of motivational drivers*[1]

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Abstract

In this study, we aim to discover unique and relative associations among eighth-grade students' motivational constructs (intrinsic and extrinsic motivation and mathematics self-concept), their expectations, social expectations (student perception of teacher treatment, school teacher expectations and parent expectations) and mathematics achievement using Trends in International Mathematics and Science Study 2015 dataset. We analyzed direct and indirect relationships between these constructs using structural equation modeling on the Turkey portion of the dataset (N=6,079; 2,933 female and 3,123 male). We found that intrinsic motivation, mathematics self-concept, student expectation, parent expectations and SES significantly predicted mathematics achievement. Teacher treatment predicted mathematics self-concept and mathematics self-concept predicted student expectation. We also found that student expectation and parent expectations partially mediated the relationship between SES and mathematics achievement and mathematics self-concept fully mediated the relationship between teacher treatment and mathematics achievement. We did not find evidence for achievement gap between female and male students. However, female students are found to be more extrinsically motivated than male students; female expectations are higher; and their mathematics self-concept is less than that of male students. Based on our findings, interventions targeting associations among these cognitive and non-cognitive elements—specifically the mediation role of student motivation and expectation on the relationship between social expectations and mathematics achievement—can contribute to future research toward creating a more feasible and low-cost educational context toward improving mathematics achievement using a more comprehensive approach.

Keywords: Mathematics Achievement, Motivation, Social Expectations, Self-concept, Gender.

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INTRODUCTION

As acknowledged by numerous studies, low mathematics achievement is one of the prominent issues in many countries (OECD, 2010) including Turkey (Kalaycıoğlu, 2015). International research has established that disadvantaged contexts—e.g., ill-equipped schools, schools in poor neighbourhoods and lower tracks—offer students less-challenging curriculum, low instructional quality, low expectations and insufficient educational resources (Brunello & Checchi, 2007; Kelly, 2004) and these factors have been known to have adverse effects on mathematics achievement (e.g., De Boer et al., 2010; Rubie-Davis et al., 2015). Although finding comprehensive solutions to these economical and policy-related barriers may not be viable in the short term within these contexts, cost-effective and feasible interventions targeting non-cognitive factors such as motivation and social expectations have proven to be effective on enhancing mathematics achievement (e.g., Benner & Mistry, 2007; Frank, 2020).

Evidence suggests that student motivation and expectations, and teacher and parent expectations have been found to be significant predictors of mathematics achievement, student prior achievement, and student highest-level mathematics course taken (Areepattamannil, 2014; Froiland & Davison, 2016; Lee & Stankov, 2013; Smith et al., 1999). Noncognitive factors have also been shown to have substantial influence on future schooling decisions, employment, work experience and career decision (Heckman et al., 2006) through their effect on middle school mathematics achievement (Adelman, 2006).

Despite the prominence of non-cognitive factors, studies investigating these factors are scarce (Pitsia et al., 2017) and their results are sometimes contradictory. McInerney (2007) posits that students' learning and classroom behaviors might substantially differ across different cultures and educational settings. For this reason, examining noncognitive constructs and their association with learning outcomes across different cultures is warranted (Arepattamannil et al., 2011). The context of Turkey is examined in this study.

To take a comprehensive approach, we adopted a social cognitive theory (SCT) perspective which acknowledges the complex nature of behaviors and describes learning as the product and processes of triadic relationship between human agency, environment and behavior (Bandura, 1989). The present study, therefore, aims to discover unique and relative associations among eighth-grade student motivational constructs and their expectations (i.e., human agency), the expectations of 'significant others' (i.e., environmental factors) and mathematics achievement (i.e., the behavior) using the Turkey portion of the Trends in International Mathematics and Science Study (TIMSS) 2015 dataset.

BACKGROUND

In this section, theoretical findings that assist in building the structural model of our study is reported.

Motivational Constructs

According to self-determination theory (SDT), intrinsic motivation is the inner energy source that activates the organism to engage with a task (Deci & Ryan, 1985). The majority of research studies found positive effect of intrinsic motivation on mathematics achievement (e.g., Akben-Selcuk, 2017; Areepattamannil, 2014; Areepattamannil et al., 2011; Froiland & Davison, 2016; Zhu & Leung, 2011). According to SDT, the degree of satisfaction of the needs for autonomy, competence and relatedness impacts the magnitude and effects of intrinsic motivation on achievement (Ryan & Deci, 2000). Another motivational construct in SDT is extrinsic motivation which is a form of motivation that activates the organism for attaining contingent outcomes (Deci & Ryan, 1985). Although extrinsic motivation has been shown to have a positive relationship with mathematics achievement (e.g., Lee & Stankov, 2013), some studies found negative or insignificant effect of extrinsic motivation on mathematics achievement (e.g., Akben-Selcuk, 2017; Areepattamannil, 2014; Areepattamannil et al., 2011; Liu & Hou, 2018).

A meta-analysis conducted by Deci et al. (1999) indicates that earlier research mostly found negative effects of extrinsic motivation on intrinsic motivation; however, some recent evidences obtained from large scale samples indicate a positive predictive association between intrinsic motivation and extrinsic motivation (e.g., Liu & Hou, 2018; Zhu & Leung, 2011). In summary, the association between intrinsic and extrinsic motivation and their effect on outcomes may differ based on the structure and functions of particular proximal (e.g., family) or distal (e.g., cultural system) social contexts (Deci & Ryan, 2012). Additionally, whereas intrinsic motivation has been shown to have a positive and significant effect on mathematics achievement, when student self-beliefs, attitudes or other motivational constructs are controlled for, the effect of intrinsic motivation on mathematics achievement becomes weaker or sometimes nonsignificant due to its overlap with other motivational constructs (Lee & Stankov, 2013). Thus, understanding relative and unique association of motivational constructs on mathematics achievement within different contexts will contribute the theory.

Mathematics self-concept refers to students' perception of their competence and ability for learning mathematics and performing well on mathematics tasks (Reyes, 1984). International research studies have consistently shown positive predictive effect of mathematics self-concept on mathematics achievement (Goetz et al., 2010; Jussim & Eccles, 1992; Marsh et al., 2006; Pitsia et al., 2017; Suárez-Álvarez et al., 2014). Pipere and Mierina (2017) found that mathematics self-concept was one of the most significant predictors of mathematics achievement. In terms of causal ordering of self-concept and academic achievement, two models are proposed: self-enhancement model where self-concept is a determinant of achievement and skill-development model where academic achievement subsequently influences mathematics self-concept (Marsh, 1990). Although Marsh and Yeung (1997) reported evidences of a reciprocal effect between mathematics self-concept and mathematics achievement, we are interested in self-enhancement model which aligns with the purpose of the study. Because self-concept has strong evaluative and affective components, evidences underpin its predictive effect on intrinsic motivation (Areepattamannil, 2011). Additionally, studies have revealed that student self-concept can be influenced by positive expectations of teachers and parents (Benner & Mistry, 2007; Lazarides et al., 2016; Lazarides & Watt, 2015) and teacher treatment (Zhu et al., 2018). Therefore, modelling social expectations requires consideration of mathematics self-concept as a potential mediator between these expectations and student mathematics achievement.

Student Expectation

Within our SCT framework, student expectation is defined as a personal factor. Student expectation has been found to predict student mathematics achievement (Bodovski et al., 2014). Moreover, according to ecological theory, parent expectations within the family microsystem and teacher expectations within the classroom microsystem act as proximal processes (Bronfenbrenner & Morris, 1998) and student expectation mediates the effect of these proximal processes on academic achievement (Benner & Mistry, 2007; Froiland & Davison, 2016; Lazarides et al., 2016). Thus, student expectation is presumed to have a direct and mediating effect on mathematics achievement.

Teachers' Expectations

Expectations refer to one's beliefs about attaining desired future achievements. Following the seminal work of Rosenthal & Jacobson (1968), researchers have found that teacher expectations of students significantly impact mathematics achievement (Benner & Mistry, 2007; Smith et al., 1999). Generally, teacher expectations have been found to reflect the accurate portrait of the student potential (Jussim & Eccles, 1992) and the effect of biased teacher expectation on achievement more likely to dissipate over time (Jussim & Harber, 2005). However, some studies found long-term detrimental effect of biased teacher expectation as the effect of such bias was sustained over time (e.g., De Boer et al., 2010; Smith et al., 1999).

Brophy and Good (1970) proposed a mechanism to explain how teacher expectations lead to self-fulfilling prophecy (Merton, 1948). According to their model of the cycle of self-fulfilling prophecy, i) teacher forms different expectations for students; ii) teacher treatment to students differs based on his expectations; iii) the quality and quantity of teacher interaction with students differ; iv) students perceive teacher expectations and their perception alters their motivation, interest and self-concept; v) student achievement improves/decreases; and vi) teacher realizes the change in achievement and feels supported in the judgement of his expectations of students. Therefore, teacher treatment in the classroom can be conceived as teachers' expectancy-confirming behaviors—by creating less or more learning opportunities (De Boer et al., 2010).

There is a scarcity of research related to the association between student perception of teacher treatment and achievement. A study by Friedrich et al. (2015) found the mediating role of self-concept on the relationship of teacher expectations on achievement. Additionally, to our knowledge, no research exists on the effect of differential teacher treatment on student extrinsic motivation. However, studies show that classroom climate predicts extrinsic motivation (Brunel, 1999), and by definition, teachers' verbal feedback and rewards are associated with extrinsic motivation which implies that teacher treatment might predict extrinsic motivation. Moreover, differential teacher expectations have a significant effect on student own expectation (Benner & Mistry, 2007). This indicates a high probability of a strong association between teacher expectations and student expectation. In addition, Jussim and Harber (2005) argued that examination of a single teacher's expectation might overestimate the true effect of teacher expectancy effect since other teachers' expectations would be omitted. Similarly, Friedrich et al. (2015) indicated that most of the research on teacher expectations investigates within-class (e.g., teacher expectation of individual students) effects and very few studies examined between-class (e.g., average teacher expectations of the classroom) effects. They also pointed out a lack of research on the mediation effect of mathematics self-concept on the relationship between teacher expectancies and mathematics achievement. Therefore, examining the student perception of teacher treatment—as a manifest variable of teacher expectation—and school teacher expectations and their connection to student expectation, mathematics self-concept and mathematics achievement will provide more clarity to the phenomena.

Parent Expectations

Many studies have found predictive power of parent expectations on student achievement (Benner & Mistry, 2007; Froiland & Davison, 2016; Thompson et al., 1988). Indeed, parent expectations have been found to have the largest effect on academic achievement among parental involvement variables (Jeynes, 2012). Theoretically, expectancy-value theorists assert that parent expectations exert an effect on student achievement by improving student expectation (Wigfield & Eccles, 2000). Self-determination theorists, on the other hand, assert that parent expectations improve student motivation, which subsequently improves student achievement (Farkas & Grolnick, 2010). Furthermore, Ma et al. (2018) found that parental expectations enhances mathematics achievement indirectly through mathematics self-concept. Thus, the variable parent expectations is considered an essential element in relation to student mathematics achievement.

Covariates: SES and Gender

Since the influence of socioeconomic status (SES) on educational outcomes are well-established, most studies include direct and indirect effects of SES on educational outcomes. A meta-analysis conducted by Hattie (2009) showed that SES is moderately correlated with student achievement. As an indicator, SES accounted for 7% of student achievement variance. Additionally, SES has been found to have significant effects on student expectation (Tomaszewski et al., 2021; Zha & Hall, 2019), parent expectations (Froiland & Davison, 2016; Wang, Deng & Yang, 2016) and teacher expectations (Wang et al., 2018).

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Recent evidences have shown a decline in gender achievement gap (Hattie, 2009). Despite inconsistent findings in the literature, gender generally have been found to be significantly related to achievement motivation, intrinsic motivation and extrinsic motivation (Dinkelmann & Buff, 2016; D'Lima et al., 2014). Mathematics self-concept also differs among boys and girls. In general, evidence indicates that boys have higher mathematics self-concept than girls (Arens et al., 2017; Chmielewski et al., 2013). Similarly, research conducted in various countries have shown different patterns in boys' and girls' competence and values (Wigfield et al., 2012) and perceived social support (Song et al., 2015).

The Present Study

The first objective of the present study is to improve our understanding with respect to the associations between students' motivation and expectations, social expectations, and mathematics achievement. Based on the preceding discussion, much uncertainty still exists about the relationships between these concepts. The second objective of the study is related to Froiland and Davison's (2016) critique of an assertion of the expectancy-value theory which states that parent expectations largely exert some of its effect on student achievement through student expectation (Wigfield & Eccles, 2000). However, the authors used U.S. high school student data and found that parent expectations had a larger influence on student mathematics achievement than the effect of student expectation on their mathematics achievement. Their finding highlights the need for empirical investigation into this disparity in a different context and educational level. Finally, as the purpose of research has shifted from the treatment of the problem to the prevention of the problem (Anderman & Maehr, 1994), we try to determine the predictive utility of the noncognitive factors on each other and on mathematics achievement in a comprehensive manner. As a part of this objective, we sought to find the factors that mediate the relations of SES and social expectations on mathematics achievement.

We analyzed the proposed structural equation model in Figure 1 that links social expectations factors to student motivational and expectation factors to mathematics achievement. We hypothesized direct and indirect links between social expectations, student motivational factors as well as expectation and mathematics achievement. Additionally, we investigated the direct and indirect effect of SES on mathematics achievement and other constructs. Inclusion of multiple motivational constructs (specifically, intrinsic motivation and mathematics self-concept) that are highly correlated might cause multicollinearity. Therefore, we explored the alternative models for determining predictive power of these motivational constructs when either one of the constructs or both constructs are included in the model.

METHOD

Research Design

This study utilized a quantitative research design to investigate the relationships between student mathematics achievement, motivation, their expectations, parent expectations, teacher expectations, SES and gender variables using structural equation modeling. We used eighth-grade cohort data of the Turkish portion of TIMSS 2015 study. TIMSS is a large-scale international standardized assessment of students' academic performance in mathematics and science that is conducted by the International Association for the Evaluation of Educational Assessment (IEA) that employs a stratified two-stage cluster sampling design (for more information about the methodology, see Martin et al., 2016). The questionnaires used for this study were answered by students and their teachers. The context, Turkey, is located at the intersection of Europe, Asia and the Middle East, and displays aspects of each of these cultures. Education system is highly centralized and the Ministry of National Education (MoNE) controls all school-level policies (OECD, 2017). Compulsory education is 12 years (i.e., 4+4+4 years) and is free at public schools.

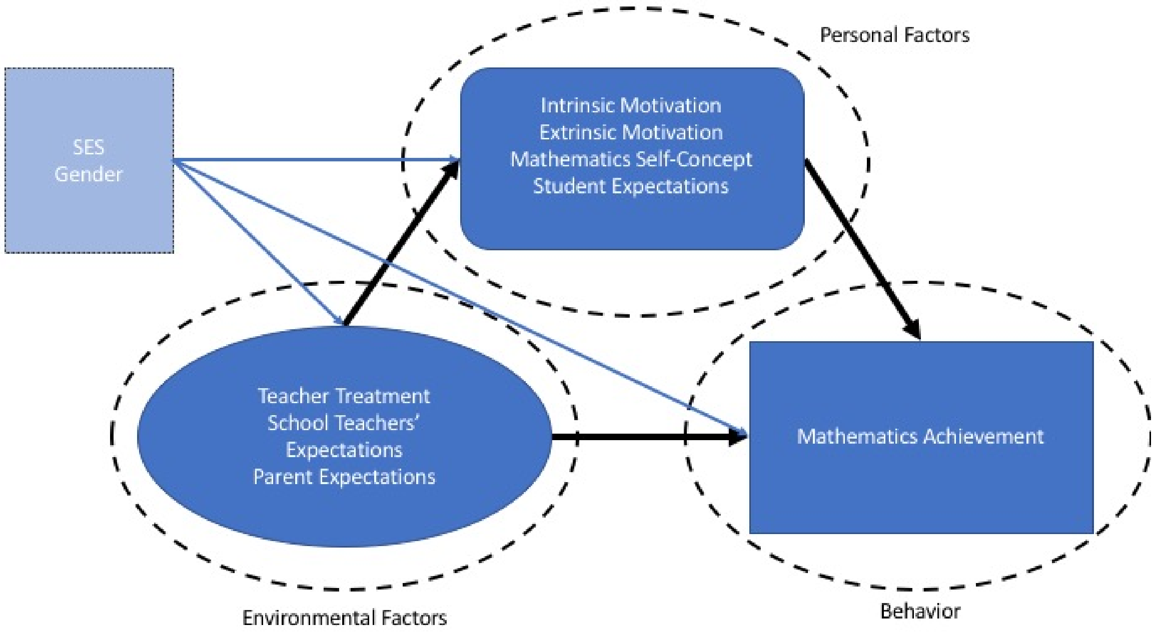

Figure 1. The conceptual model

Participants and Procedure

The TIMSS 2015 study have data for fourth-grade and eighth-grade students. In this study, we used eighth-grade students' data because middle school students are more aware of their beliefs and competencies than elementary school students (Bong et al., 2012) with respect to their cognitive development. Moreover, elementary school students have a tendency to overestimate their abilities and as they grow older this optimism evolve into greater realism which results in the decrease in motivation and competence beliefs (Wigfield et al., 2012). Additionally, middle school has a significant gatekeeping function on selecting high school, post-secondary education and career decisions (Adelman, 2006). Therefore, eighth-grade students' data can provide insights into preventing subsequent low motivation and achievement via appropriate provisions and applications before the end of secondary education.

Our analytical sample included 6079 eighth-grade students (2,933 female, 3,123 male, and 23 unanswered) from 218 schools. The student sample had an average age of 13.93. In terms of mathematics teachers (N=220), 26.6% of teachers had majored in mathematics education, 53.0% of teachers majored in both mathematics or mathematics education, and 17.5% of teachers majored in mathematics but not mathematics education. International average among the participating countries were 13.3%, 35.8%, and 36.0%, respectively. A majority of mathematics teachers were male (53%). In our sample, 12.57% of parents had university education or higher; 5.36% had post-secondary but not university education; 29.9% of parents had upper secondary education; and the rest had lower education levels.

Mathematics Achievement Variables

TIMSS 2015 dataset includes five plausible values of mathematics achievement. These values are aggregated results for the whole assessment. They are obtained via item response theory and imputed using student responses to a subset of assessment items (Martin et al., 2016) to minimize measurement error (Laukaityte & Wiberg, 2017). Using these values individually may cause biased estimates of the relation between student background variables and their proficiency scores. Therefore, to estimate population characteristics—specifically, factor variances and factor correlations—accurately, we treated these values as multiple imputation values (Asparouhov & Muthen, 2010) and conducted our analyses on five imputed datasets (each containing one of plausible values) in Mplus.

Motivational Constructs and Student Expectation

Students responses to 4-point Likert-type items (4='agree a lot' to 1='disagree') were conceptualized to measure latent constructs intrinsic motivation (e.g., 'Enjoy learning mathematics'), extrinsic motivation (e.g., 'Need mathematics to get the job I want') and mathematics self-concept (e.g., 'I usually do well in mathematics'). High scores on these items correspond to the higher level of the corresponding motivational construct. The scale reliability estimates indicated by internal consistency were high with composite reliability values of 0.87 for intrinsic motivation scale, 0.85 for extrinsic motivation scale, and 0.87 for mathematics self-concept scale as shown in Table 1. An item asked students 'How far in education do you expect to go'. The responses ranged from 1 'Finish lower secondary education' to 6 'Finish postgraduate degree' to measure student expectation.

Social Expectation Variables

TIMSS 2015 data does not have a specific item to measure individual teacher expectation. We used Rosenthal's (1974) typology to operationally define teacher behaviors (i.e., differential treatment) as a manifestation of their student-level expectations. Student responses to 4-point Likert-type items (1= 'Agree a lot' to 4='Disagree a lot') were used to measure four factors: climate ('My teacher lets me show what I have learned'), verbal input ('My teacher does a variety of things to help us learn'), verbal output (e.g., 'My teacher tells me how to do better when I make a mistake'), and feedback ('My teacher has clear answers to my questions'). These items were reverse coded. Using these items, we constructed a latent variable representing the student perception of their teacher's treatment as a proxy variable for mathematics teacher expectations. Composite reliability was also high (0.85) for this scale. Additionally, a 5-point Likert-type item ('Teachers' expectations for student achievement') asked mathematics teachers about school teachers' classroom-level expectation of students (1=very high to 5=very low). Responses to this item are general expectations for students through the perception of mathematics teachers. Another item from the mathematics teacher questionnaire measured parent expectation of children (1=very high to 5=very low). Both latter items were reverse coded. After recoding, higher scores on these three items represent higher levels of expectations.

Other Key Variables

In TIMSS 2015, there is no composite SES variable. Therefore, student responses to the following items were used to construct an SES variable: 'Parents' highest education level', 'Number of books in your home', and 'Possession of internet connection at home'. Parents' highest education level was measured with student responses to 6-point Likert-type items (1 = 'University or higher' to 5 = 'Some primary' and 6 = 'Don't know'). This variable was reverse coded so that higher values represent higher level of education. Number of books in student home ranged from one to five, higher scores representing larger number of books. Possession of internet connection at home is a dichotomous variable coded as 1 for 'Yes' and 0 for 'No'. Since these three items have different scale range, we standardized the items and created z scores for each item. These standardized variables were averaged to create a composite SES variable. Last, a dummy variable for gender is created, which is coded 1 for female and 0 for male.

Table 1. Standardized CFA estimates

Latent Factor (Composite Reliability)	Indicator	Factor Loading	Standard Error	Residual Variance
Intrinsic Motivation	BSBM17A	0.80	0.01	0.36
(0.87)	BSBM17E	0.85	0.008	0.28
	BSBM17G	0.83	0.01	0.32
Extrinsic Motivation	BSBM20I	0.70	0.012	0.51
(0.85)	BSBM20B	0.61	0.012	0.62
	BSBM20C	0.65	0.014	0.58
	BSBM20D	0.68	0.013	0.54
	BSBM20F	0.81	0.010	0.34
	BSBM20G	0.75	0.013	0.44
Mathematics Self-Concept	BSBM19A	0.84	0.008	0.30
(0.87)	BSBM19D	0.78	0.009	0.39
	BSBM19F	0.80	0.009	0.36
	BSBM19G	0.75	0.009	0.44
Teacher Treatment	BSBM18E	0.76	0.014	0.43
(0.85)	BSBM18G	0.71	0.013	0.50
	BSBM18I	0.74	0.015	0.45
	BSBM18J	0.76	0.014	0.43
	BSBM18H	0.66	0.019	0.56

Data Analysis

We used Anderson and Gerbing (1988) two-step procedure for structural equation modeling (SEM). First, we conducted confirmatory factor analysis (CFA) to verify the factor structures of latent variables (i.e., intrinsic and extrinsic motivation, mathematics self-concept, and teacher treatment). We tested the fit of a four-factor CFA to our data. Because we use a large and complex dataset, we assigned sampling weights to account for sampling bias (Lei & Wu, 2007). In large and complex datasets, Asparouhov (2005) asserts that non-use of sampling weights can result in 'unequal probability of selection' that may cause bias in parameter estimates. Therefore, we used total student weight (TOTWGT) as the sampling weight. Additionally, since teacher expectation variable is used and students are nested within classrooms, we used a multilevel latent variable approach and accounted for the hierarchical nature of the study by using cluster variable approach in Mplus 8 software (Muthén & Muthén, 2018). This specification eliminates the possibility of the violation of independence of observation assumption. By accounting for the possibility of the homogeneity of the student data within the same classroom and heterogeneity of the data between classrooms, the analyses yield clustered standard errors and adjust fit indices (Stapleton et al., 2016). Prior to data analyses, distribution of the data was examined. Teacher and parent expectations and some indicators of latent variables were slightly negatively skewed. However, mathematics achievement items were normally distributed. Robust maximum likelihood estimation method was adopted i) to account for measurement error since TIMSS 2015 dataset contains sampling weights (Asparouhov, 2005) and ii) to make the analyses results robust to non-normality of observed variables (Muthén & Muthén, 2018). Finally, the problem of missing values is common in large-scale datasets and is a problem when missing values exceeds 5% of the cases (Graham & Hoffer, 2000). To observe how missing values were dispersed into the data, missing values were tabulated. Out of 6079 cases, our observed indicators either did not have missing values or the number of missing values were less than 5% of the cases with no systematic pattern of missing data. We allowed Mplus default procedure to handle missing data via the implementation of the full information maximum likelihood estimator (FIML). To evaluate the model fit, chi square (χ^2) test statistics, root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis Index (TLI) and standardized root mean square residual (SRMR) are used. As a rule of thumb, Kline (2011) recommends RMSEA less than 0.10, CFI and TLI greater than 0.90, and SRMR less than 0.08 as signs of a good fit of the theoretical model to the data.

Threats to ecological validity were minimized by including a large number of variables that are observed within the natural setting. The scales consisting of our manifest variables had high composite reliability (omega coefficients). Thus, following the satisfactory evidences for internal consistency of the scales, we conducted confirmatory factor analyses (CFA) in Mplus to establish evidences for convergent and discriminant validity. Because of the nature of the data (i.e., cross-sectional) and possible method effect due to the same 'stem of the items' (e.g., multiple items starts with the same wording), residual errors were allowed to correlate among the items of the idiosyncratic construct since correlated errors may inflate the parameter estimates (Bong, 2004). In this way, we intended to reflect the constructs realistically due to item content overlap (Byrne, 2012).

In the second stage, we fit an SEM model to estimate hypothesized parameters. We used the same measurement model and added other variables and hypothesized parameters. All grounded in theory, we tested several alternative models by respecifying motivational constructs and their associations with the other variables to avoid confirmation bias and to find the fit of the data to the models. Without changing other variables and their associations, in alternative models the following motivational constructs and their associations were included: in Model 1, all motivational constructs; in Model 2, intrinsic motivation and extrinsic motivation; in Model 3, only mathematics self-concept. Since we tested nested and non-nested models, instead of using chi-square statistics, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) statistics were used to compare models (Mueller & Hancock, 2008). Along with the model fit statistics, total, direct and indirect effects were analyzed. We applied numerical integration—because of the clustered data—and used standard bootstrapping with 1000 replications to estimate robust standard errors of indirect effects. It is important to emphasize that our results do not imply causality due to cross-sectional nature of the data.

Ethical Considerations

This study employed secondary data and it was considered to be in the exempt category. Ethical approval was granted from The Institutional Review Board at the University of Florida (IRB#: IRB201800490).

FINDINGS

In the first analysis, the CFA model fitted the data well. The fit statistics are $\chi^2 = 613.54$ (df=123, p<0.001), RMSEA = 0.026, CFI = 0.986, TLI = 0.982, SRMR = 0.028. The chi-square statistics indicated no exact fit, which was anticipated given the large sample size. Other fit statistics satisfied the cutoff criteria by indicating very good fit to the data. We estimated composite reliability coefficients which is a more advanced measure of reliability than Cronbach's alpha coefficient when test items are not parallel (Padilla & Drivers, 2016). Composite reliability of the scales ranged from 0.85 to 0.87 (see Table 1). Three models were separately analyzed (See Table 2). Goodness of fit statistics as well as AIC and BIC values indicated that although Model 1 and Model 2 fit the data, the best fitting model to the data is Model 3. Standardized regression coefficients of the models are reported in Table 3.

Table 2. Goodness-of-Fit Indices of the Models

Model	χ^2	df	RMSEA	CFI	TLI	SRMR	AIC	BIC
CFA	613.54	123	0.026	0.986	0.982	0.027	231132.47	231575.20
Model 1	1379.74	218	0.030	0.966	0.957	0.035	341096.05	341771.30
Model 2	1425.56	144	0.039	0.945	0.927	0.095	291577.56	292119.09
Model 3	514.05	68	0.033	0.966	0.948	0.033	231068.66	231483.17

Intrinsic and Extrinsic Motivation

The results of Model 1 indicated that the regression coefficient linking intrinsic motivation to mathematics achievement was significant and negative ($\hat{\beta}^s$ = -0.175, $p<0.05$) although a positive correlation exist between these constructs. This negative suppression effects of intrinsic motivation on mathematics achievement might be the result of multicollinearity among intrinsic motivation and mathematics self-concept. Therefore, this relation is not interpretable for this model. Apart from statistical explanation, one possible reason for this suppression effect can be the presence of moderation between intrinsic motivation and mathematics self-concept. In Model 2, where mathematics self-concept is excluded from the model, the path relating intrinsic motivation to mathematics achievement was significant ($\hat{\beta}^s$ = 0.198, $p<0.05$). Extrinsic motivation was negatively associated with mathematics achievement ($\hat{\beta}^s$ = -0.045, $p<0.05$) in Model 1 and nonsignificant in Model 2. In Model 1, mathematics self-concept positively predicted intrinsic motivation with a high degree of effect size ($\hat{\beta}^s$ = 0.836, $p<0.05$). Parent expectations had a negative but small association with intrinsic motivation ($\hat{\beta}^s$ = -0.049, $p<0.05$) in Model 1 but nonsignificant in Model 2. In Model 1, intrinsic motivation and teacher treatment significantly and positively predicted extrinsic motivation with effect sizes ranged from 0.299 to 0.523; however, parent expectations had no significant association with extrinsic motivation in both models.

Mathematics Self-Concept

Compared to all constructs, a substantial positive regression coefficient was found for mathematics self-concept in predicting mathematics achievement in Model 1 ($\hat{\beta}^s$ = 0.505, $p<0.05$) and in Model 3 ($\hat{\beta}^s$ = 0.339, $p<0.05$). As indicated, mathematics self-concept significantly associated with intrinsic motivation with a high degree of effect size. School teachers' and parents' expectations had no significant association with mathematics self-concept. Additionally, the regression coefficient linking mathematics teacher treatment to mathematics self-concept was significant in Model 1 and Model 3 ($\hat{\beta}^s$ = 0.442 and 0.417, respectively).

Student Expectation

The path coefficient linking student expectation to mathematics achievement was significant in all three models ($\hat{\beta}^s$ = 0.193, 0.223 and 0.189, respectively). We also found that mathematics self-concept and SES significantly predicted student expectation in Model 1 ($\hat{\beta}^s$ = 0.206 and 0.201) and Model 3 ($\hat{\beta}^s$ = 0.199 and 0.198). Teacher expectations and parent expectations did not significantly predict student expectation and teacher treatment significantly predicted student expectation in Model 2 ($\hat{\beta}^s$ = 0.116).

School Teacher Expectations and Teacher Treatment

We found that school teachers' expectation did not significantly predict mathematics achievement, mathematics self-concept and student expectation in any models. It had very small and positive effect sizes on these constructs though. However, the regression coefficient linking parent expectations to school teachers' expectations was positive and significant in all models ($\hat{\beta}^s$ = 0.552, 0.551 and 0.552, respectively). On the other hand, teacher treatment had very small but significant negative effect size on mathematics achievement in Model 1 ($\hat{\beta}^s$ = -0.146 and -0.064) and this relation was nonsignificant in Model 2. Specifically, other significant path coefficients of teacher treatment were on extrinsic motivation in Model 1 and 2 ($\hat{\beta}^s$ = 0.299 and 0.327), mathematics self-concept on Model 1 and 3 ($\hat{\beta}^s$ = 0.442 and 0.417) and student expectation in Model 2 ($\hat{\beta}^s$ = 0.116). The regression coefficient linking SES to teacher treatment was nonsignificant in all models.

Parent Expectations

Parent expectations had a significant association with mathematics achievement ($\hat{\beta}^s$ = 0.131, 0.122, and 0.138), school teachers' expectations ($\hat{\beta}^s$ = 0.552, 551, and 0.552) , and SES significantly predicted parent expectations ($\hat{\beta}^s$ = 0.359, 0.358, and 0.358) in all three models. However, the regression coefficient connecting parent expectations to intrinsic motivation in Model 1 was small and negative ($\hat{\beta}^s$ = -0.049.

$p<0.05$). Parent expectations had no significant association with extrinsic motivation, mathematics self-concept, student expectation in all models.

Gender and SES

We included these variables as exogenous variables to observe their associations with other constructs and to control for other associations. We found that gender had no significant association with mathematics achievement, school teachers' expectations and parent expectations. Although its association with intrinsic motivation was small and significant in Model 1, it was nonsignificant in Model 2. Being a female had significant and negative association with mathematics self-concept in comparison with boys. Specifically, it had significant and positive associations with extrinsic motivation, teacher treatment and their own expectation. SES significantly predicted mathematics achievement, student expectation and parent expectations in all models. However, SES was not associated with school teachers' expectations and teacher treatment (see coefficients in Table 3).

Indirect Effects

Next, we obtained results pertaining to possible mediation effects of motivational constructs and student expectation on the relationship between SES, social expectations and mathematics achievement as presented in Table 4. Due to very high correlation between intrinsic motivation and mathematics self-concept, we separately conducted mediation analysis on Model 2 and Model 3.

The results of Model 2 showed a significantly positive indirect relationship between SES and mathematics achievement partially mediated by parent expectations and student expectation ($\hat{\beta}^s$ =0.044 and 0.050, $p<0.05$). Student expectation had significant but small partial indirect effect on the relationship between teacher treatment and mathematics achievement ($\hat{\beta}^s$ =0.000 and 0.026, $p<0.05$). Intrinsic motivation did not mediate the relationship between parent expectations and mathematics achievement. Furthermore, in Model 3, parent expectations and student expectation partially mediated the relationship between SES and mathematics achievement ($\hat{\beta}^s$ =0.050 and 0.038, $p<0.05$). Although mathematics self-concept fully mediated the relationship between students' perception of teacher treatment and mathematics achievement ($\hat{\beta}^s$ =0.141, $p<0.05$), it did not mediate the relationships of school teachers' expectation and parent expectations on mathematics achievement. In Model 3, student expectation had no significant effect on the relationships between social expectations variables and mathematics achievement.

Table 3. Standardized direct path coefficients

	Model 1	Model 2	Model 3
Mathematics Achievement			
Intrinsic motivation	-0.175* (0.036)	0.198* (0.024)	
Extrinsic motivation	-0.045* (0.021)	-0.025 (0.020)	
Math Self-Concept	0.505* (0.039)		0.339* (0.022)
Student Expectation	0.193* (0.017)	0.223* (0.017)	0.189* (0.017)
Teachers' Expectations	0.003 (0.035)	0.016 (0.034)	0.004 (0.035)
Teacher Treatment	-0.046* (0.021)	0.010 (0.020)	-0.064* (0.018)
Parent Expectations	0.131* (0.035)	0.122* (0.034)	0.138* (0.035)
SES	0.336* (0.021)	0.375* (0.020)	0.342* (0.022)
Female	0.019 (0.015)	-0.017 (0.016)	0.010 (0.016)
Intrinsic Motivation			
Math Self-Concept	0.836* (0.010)		
Parent Expectations	-0.049* (0.014)	-0.045 (0.027)	
Female	0.039* (0.012)	0.060 (0.018)	
Extrinsic Motivation			
Intrinsic Motivation	0.498* (0.019)	0.523* (0.019)	
Parent Expectations	0.000 (0.016)	0.000 (0.016)	
Teacher Treatment	0.299* (0.023)	0.327* (0.024)	
Female	0.049* (0.015)	0.048* (0.016)	

Math Self-Concept			
Teachers' Expectations	0.037 (0.023)		0.043 (0.024)
Teacher Treatment	0.442* (0.017)		0.417* (0.017)
Parent Expectations	-0.010 (0.021)		-0.014 (0.022)
Female	-0.090* (0.016)		-0.089* (0.016)
Student Expectation			
Math Self-Concept	0.206* (0.017)		0.199* (0.017)
Teachers' Expectations	0.038 (0.027)	0.046 (0.028)	0.038 (0.027)
Teacher Treatment	0.024 (0.019)	0.116* (0.017)	0.026 (0.019)
Parent Expectations	0.054 (0.030)	0.041 (0.030)	0.056 (0.030)
SES	0.201* (0.019)	0.226* (0.018)	0.198* (0.019)
Female	0.120* (0.017)	0.100* (0.018)	0.119* (0.017)
Teachers' Expectations			
Parent Expectations	0.552* (0.066)	0.551* (0.066)	0.552* (0.066)
SES	-0.018 (0.037)	-0.018 (0.037)	-0.018 (0.037)
Female	-0.004 (0.014)	-0.004 (0.014)	-0.004 (0.014)
Teacher Treatment			
SES	-0.036 (0.026)	-0.045 (0.026)	-0.034 (0.026)
Female	0.109* (0.016)	0.110* (0.016)	0.109* (0.016)
Parent Expectations			
SES	0.359* (0.033)	0.358* (0.033)	0.358* (0.033)
Female	0.03 (0.014)	0.003 (0.014)	0.003 (0.014)

* $p < 0.05$, standard errors are shown in parentheses

DISCUSSION AND CONCLUSION

The findings of this study have unique contribution to the literature since this is the only study that yielded mutually exclusive and comparable relationships of intrinsic motivation and mathematics self-concept on mathematics achievement. Additionally, concurrent investigation of multiple key factors strengthens the ecological validity of the phenomena. This section is organized to subsequently cover the discussion of findings related to motivational constructs, mathematics self-concept, and social expectations.

We found that intrinsic motivation positively predicted mathematics achievement which is in line with the recent studies that mostly reported positive effect of intrinsic motivation on mathematics achievement (e.g., Akben-Selçuk, 2017; Areepattamannil, 2014; Areepattamannil et al., 2011; Froiland & Davison, 2016). Extrinsic motivation had a negative but non-significant association with mathematics achievement. Majority of studies have documented negative effect of extrinsic motivation on mathematics achievement, yet some studies indicated mixed results about the effect of extrinsic motivation on mathematics achievement though (Areepattamannil et al., 2011; Liu & Hou, 2018; Zhu & Leung, 2011). Related to Turkish students, this finding is partially in accord with the study of Akben-Selçuk (2017). Unexpectedly, parent expectations had no significant association with student intrinsic motivation or extrinsic motivation. According to SDT, basic psychological needs (autonomy, competence and relatedness) are important for all cultures; parental support of these psychological needs is critical for cultivating 'optimal growth and adjustment' (Deci & Ryan, 2008); and the nonsignificant associations may signify a possibility of lack thereof. Thus, the moderation effect of parental support of student basic psychological needs on students' motivation needs further examination.

According to SDT research, i) within classroom and home environments, informational support for engagement and rich efficacy feedback via providing greater sense of autonomy in the form of freedom of choice and opportunity for self-direction enhances intrinsic motivation, ii) relatedness to significant others help internalize the external goals, and iii) improving sense of competence via effectance-relevant feedback can help make extrinsic motivation more self-determined, and overall, these approaches improve academic achievement (Ryan & Deci, 2000; Ryan & Deci, 2020). Additionally, the nonsignificant path from extrinsic motivation to mathematics achievement should not be misinterpreted since "(t)he concept of socialization gives recognition to the fact that there are many behaviors, attitudes, and values that are neither natural nor intrinsically motivated, but that are important for effective functioning in the social world." (Deci & Ryan, 1985, pp. 129). Significant and positive prediction of intrinsic motivation on extrinsic motivation implies that student extrinsic motivation level may be improved by emphasizing the high utility of academic activities (Cleary & Chen, 2009) and helping students improve their intrinsic motivation based on SDT research. As a result, improving intrinsic motivation is crucial to help improve average eighth-grade students' mathematics achievement and effective functioning in the society.

Our model provided correlational evidences for self-enhancement model of mathematics self-concept. This finding is in line with the earlier research (e.g., Goetz et al., 2010; Pitsia et al., 2017). Indeed, mathematics self-concept along with SES had the largest effect sizes on mathematics achievement in comparison with other factors. Similarly, Pipere & Mierian (2017) and Suárez-Álvarez et al. (2014) found that mathematics self-concept had the largest effect on mathematics achievement among other constructs. Student self-concept has been found to have stronger effect on school grades than standardized achievement test scores (Marsh et al., 2014). Therefore, our results might have underestimated its effect on mathematics achievement.

We found evidence for significantly positive relationship between teacher treatment and mathematics self-concept. Past research suggested that mathematics self-concept can be improved by teacher and parent expectations (Benner & Mistry, 2007; Lazarides et al., 2016; Lazarides & Watt, 2015). However, in our study, nonsignificant path from parent expectations and school teacher expectations to students' mathematics self-concept implies that i) mathematics teacher treatment (i.e., a proxy for teacher expectations) has more predictive association with student mathematics self-concept than school teachers' expectations, ii) the result might be attributed to a partly collectivist society where the lack of support of basic psychological needs—specifically, autonomy—by parents might diminish predictive effect of parent expectations on student mathematics self-concept; and for similar reasons, iii) students might not internalize parent expectations to form their mathematics self-concept if their parents' expectations do not satisfy or match the affective component of their self-concept.

Aligned with the earlier research (e.g., Bodovski et al., 2014), student expectation had a positive association with mathematics achievement. SES and mathematics self-concept predicted student expectation in Model 2 and 3, and teacher treatment predicted student expectation in Model 2. Related to our second objective and in support of the assertion of expectancy-value theory, student expectation had a larger effect size than that of parent expectations on mathematics achievement which is in contrast with Froiland and Davison's (2016) study on high school students. These results demand further investigation into the role of student educational level in explaining these disparate results. We were expecting to find the mediating role of student expectation on the relationship between social expectations and mathematics achievement as indicated in the earlier research (e.g., Benner & Mistry, 2007; Froiland & Davison, 2016; Lazarides et al., 2016). However, in Model 2, student expectation partially mediated the association between teacher treatment and mathematics achievement, but parent expectations had no mediating role. In Model 3, we did not find a significant indirect path from social expectation to mathematics achievement through student expectation. Therefore, mathematics self-concept appears to have a better mediating role than student expectation.

Overall, our findings show that higher degree of intrinsic motivation, mathematics self-concept and student expectation associated with higher mathematics achievement. Better teacher treatment was found to support mathematics self-concept, extrinsic motivation and student expectation. In addition, when considering no significant path from SES to teacher treatment, more attention needs to be paid to teachers' role in student motivation since mathematics self-concept fully mediated the association between teacher treatment and mathematics achievement. Brophy and Good's (1970) model similarly implied that teacher expectation exerts its effect on mathematics achievement via student motivation, interest and self-concept. Moreover, higher parent expectations and school teachers' expectations were not associated with higher intrinsic motivation, extrinsic motivation, mathematics self-concept and student expectation in this context. Although other types of parental variables might have different association with mathematics achievement, the results indicate the low degree of student internalization of parent expectations. As a cautionary note, we did not include a path from parent expectations to teacher treatment. Parent expectations might influence student achievement through teacher treatment. In agreement with the past research, higher parent expectations corresponded to higher student mathematics achievement (Benner & Mistry, 2007; Froiland & Davison, 2016). School teachers' expectation did not have a significant association with student mathematics achievement and teacher treatment had a small but negative association with mathematics achievement. The findings of this study—pertaining to school teacher expectations and teacher treatment—provide contrary evidence to self-fulfilling theory and the majority of earlier studies. Several interpretations can be made for this finding in this context: i) mathematics teachers generally do not convey their expectations to students effectively, so they do not effectively internalize teacher expectations; ii) school teachers' expectation does not significantly impact eighth-grade student mathematics achievement; or iii) student self-report of their perception of teacher treatment and school teachers' expectations might be biased.

Similar to Friedrich et al. (2015) study, we found that higher teacher treatment is associated with higher student mathematics self-concept but school teachers' expectations were not significantly associated. In summary, the findings imply that higher parent expectations are associated with higher degree of teacher treatment and higher degree of teacher treatment is associated with increased mathematics self-concept that consequently improves eighth-grade student mathematics achievement. These substantial relations should assist future research on developing effective instructional designs.

The Role of Gender and SES on Mathematics Achievement

Similar to earlier research findings (e.g., Hattie, 2009), the regression coefficient linking SES to eighth-grade students' mathematics achievement was substantial. Moreover, SES had positive and significant association with parent expectations which is aligned with the earlier findings (e.g., Froiland & Davison, 2016; Wang et al., 2016). We defined teacher treatment in the classroom as an expectancy-confirming behavior, which is a proxy for teacher expectation. Although Wang et al. (2018) mostly found positive association between SES and teacher expectation based on their systematic review, we found no significant relationship of teacher treatment and school teachers' expectations with SES. This finding implies that mathematics teachers' perception of school teachers' expectations and student perception of teacher treatment were not shaped by students' social class (i.e., SES) and this situation encourages recent endeavors to achieve *equal opportunity to learn*.

In terms of gender, we found no significant difference between male and female students' mathematics achievement. Recent international studies support the decline in achievement gap (Hattie, 2009). Additionally, gender generally have been found to be significantly related to motivation (Dinkelmann & Buff, 2016; D'Lima et al., 2014). We found that female students are more extrinsically motivated than male students, their expectations are higher and their mathematics self-concept is less than that of male students. However, gender was significantly associated with intrinsic motivation only in Model 1. Past studies demonstrate female students' underestimation of their skills and ability in mathematics, and low degree of enjoyment and interest in mathematics (see similar results in Guo et al., 2015) which can be the result of school-wide policies and teachers' conceptualization of females that position girls in disadvantaged ways (Pringle et al., 2012) pertaining to STEM related disciplines. We also found that female students perceived teacher treatment more positively. Therefore, this situation, alternatively, can be related to parents and the society in which they are embedded in. More research is needed to explain psychosocial elements that causes female students' high level of extrinsic motivation and low mathematics self-concept. Additionally, intervention studies that help female students enjoy mathematics and have higher degree of self-concept might contribute to their mathematics achievement.

Limitations and Further Recommendations

Student psychology and educational context are complex entities. As is the case for most research studies within educational research, omitted variables are the biggest threats to the validity of research studies. In this study, the inclusion of multiple variables that are assumed to strongly affect each other as well as mathematics achievement is one of the strengths of the study. However, one of the limitations of the study is related to data constraints. In this study student background variable (specifically, prior achievement) was not included as the control variable because of its absence in TIMSS 2015 dataset. Another limitation of the study is related to causality. Although SEM and regression analyses imply causal directions, to assure causal relationships, longitudinal datasets that are obtained from controlled experiments are needed. We used cross-sectional dataset to analyze the associations between variables. Although the directions of the associations were attained from the literature, the interpretations must be regarded as tentative.

More research is needed i) to examine the conditions in which parent expectations has negative effect on mathematics achievement, ii) to compare the findings of the study in distinct cultural contexts, and iii) to investigate the effect of parental characteristics on student achievement via different research designs (Wang et al., 2016). Furthermore, teacher expectation did not have a significant effect on eighth-grade students' mathematics achievement when other constructs are included in the SEM. A replication of this study in different countries will provide more evidences for making interpretations more confidently.

According to our argument based on Bandura's (1989) social cognitive theory, social expectations are supposed to influence personal factors in our study (i.e., motivational factors). However, we found that parent expectations exert its effect mostly through teacher agency and student expectation. There is a small degree of association between parent expectations and student motivation. Future research needs to investigate why student motivation or some of its subcomponents might be immune to parental expectations.

In conclusion, the advantage of using a large national dataset, the inclusion of multiple variables for obtaining evidences of ecological validity, using data that is obtained from a partly randomized sampling design, and implementation of advanced statistical methods might reduce the threats to validity of the results. Nevertheless, the limitations of this study should guide future educational interventions that account for student, parents and school in a comprehensive manner.

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