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Predicting Science Engagement with Motivation and Teacher Characteristics: a Multilevel Investigation

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Abstract The purpose of this study was to investigate the student and teacher-level predictors of Turkish middle school students' engagement in science classes. Students' engagement was examined in terms of agentic, behavioral, cognitive, and emotional engagement. The participants of the study were 134 Turkish science teachers and their 3394 grade 7 students. Separate multilevel models were specified for each dimension of students' science engagement. Results of the HLM analyses indicated that dimensions of students' science engagement were significantly predicted mostly by the student-level variables including science self-efficacy, mastery approach and avoidance goals, and performance approach goals. Teacher-level variables were influential only on the cognitive and emotional engagement. There were also cross-level interactions in predicting science engagement. Results were discussed in the light of related literature.

Keywords Engagement · Instructional goals · Science education · Self-efficacy · Teacher motivation

Introduction

Engagement is critical for all students in that it is related to academic achievement, social-emotional well-being, and it influences future work success in the long run

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(Christenson, Reschly, & Wylie, 2012). However, student engagement research has a relatively short history spanning from the beginning of 1980s to present day (Appleton, Christenson, & Furlong, 2008). As one of the important student outcomes, engagement recently received attention with the reconceptualization of four-dimensional structure, namely agentic, behavioral, cognitive, and emotional engagement (Reeve & Tseng, 2011). Engagement, as a general construct, was defined simply by Natriello (1984) as taking part in the educational activities organized by schools. In time, examination of engagement has gained attention because it yields positive school-related outcomes both in and out of school (Fredricks, Blumenfeld, & Paris, 2004; Heddy & Sinatra, 2013; Tytler & Osborne, 2012). However, a consensus upon the definition and measurement remained inconsistent (Fredricks et al., 2004; Furlong et al., 2003; Jimerson, Campos, & Greif, 2003; Sinatra, Heddy, & Lombardi, 2015). Although there is still definitional disagreement, engagement is considered as the holy grail of education (Sinatra et al., 2015). A widely accepted contention is that engagement is a metaconstruct comprising of various subcomponents such as behavioral, cognitive, and emotional (Christenson et al., 2012; Fredricks et al., 2004). Recently, a fourth dimension of engagement was put forward by Reeve and Tseng (2011). The researchers have presented empirical evidence for agentic engagement that it is positively related to behavioral, cognitive, and emotional engagement and predicts student achievement independent of those three (Reeve & Tseng, 2011). Regarding its subcomponents, agentic engagement is expressing personal preferences and commenting on the flow of the course. It necessitates an active participation by stating ideas and personal preferences without hesitation (Reeve & Tseng, 2011). Behavioral engagement refers to one's active participation in own learning and academic tasks in an effortful, persistent, and attentive manner both in and out of school activities. Behavioral engagement also includes positive conduct such as obeying pre-defined classroom and school rules and not skipping school (Appleton et al., 2008; Reeve, 2013). Cognitive engagement refers to the students' own investment psychologically on learning (mastering) and being self-regulated in terms of using deep-level cognitive strategies and setting challenging goals to go beyond the requirements of the learning task (Fredricks et al., 2004). An example of cognitive engagement could be described as exerting cognitive effort for understanding the learning task, striving for being in advance of the activity steps, and choosing tasks which are challenging such as activities slightly over students' competence (Sinatra et al., 2015). Lastly, emotional engagement refers to the positive or negative feelings towards school, classes, and teachers, etc. (Fredricks et al., 2004). These positive and negative feelings include interest, value, boredom, happiness, sadness, anxiety (Skinner & Belmont, 1993) enjoyment, relief (Sinatra et al., 2015), and identification as belonging (Voelkl, 1997).

Dimensions of student engagement have been found to be associated with other student outcomes such as motivation (Connell, Spencer, & Aber, 1994; Greene, Miller, Crowson, Duke, & Akey, 2004). In an early study, for example, Pintrich and DeGroot (1990) found that self-efficacy and intrinsic value correlated positively with cognitive engagement (measured as strategy use). For the newly proposed dimension, agentic engagement was also found to be correlated positively with student motivation (Reeve & Tseng, 2011).

Engagement in Relation to Student Motivation

In student motivation, the main constructs widely studied include achievement goals and self-efficacy (Schunk, Meece, & Pintrich, 2014). Achievement goals refer to the purposes students have for completing academic tasks or engaging in achievement situations (Ames, 1992; Elliot, 1999). Firstly, two types of achievement goals were proposed by achievement goal theorists which were mastery and performance goals (Ames, 1992). While mastery goals refer to mastering the task, learning the material, understanding deeply, and improving oneself intellectually, performance goals refer to surpassing others, getting the highest grades in normative standards in grading, and showing one's performance to others that one is able (Ames, 1992; Meece, Anderman, & Anderman, 2006; Schunk et al., 2014). Afterwards, Elliot (1999) suggested to divide these two goals into "approach" and "avoidance" dimensions. Thus, a two-by-two frame for achievement goals was espoused in the achievement motivation field. Accordingly, mastery approach goals referred to understanding, mastering, and learning the material. Mastery avoidance goals emphasized avoiding not mastering and not learning completely. On the other hand, performance approach goals represented getting the highest grades and showing the ability to others and performance avoidance goals represented the desire to avoid looking incompetent and dumb in normative comparisons. This two-by-two conceptualization for achievement goals was investigated by educational psychologist in relation with student outcomes in a number of studies. For example, academic achievement (Chen & Wong, 2014), academic self-efficacy, and self-regulation variables such as metacognitive strategy use and effort regulation (Anderman & Midgley, 1997; Kıran, & Sungur, 2012; Pajares, Britner, & Valiante, 2000), and different aspects of engagement (agentic, behavioral, emotional, and cognitive) (Dweck & Leggett, 1988; Hıdıroğlu, 2014; Midgley & Urdan, 1995) were investigated in relation to students' achievement goals. As a general trend, mastery approach goals correlated positively with adaptive outcomes but performance approach goals generated mixed results. For avoidance tendencies, while literature generally yielded negative or no correlation, studies conducted in Turkey demonstrated positive relationships with adaptive patterns of behavior and academic achievement (Kıran, 2010; Midgley & Urdan, 1995). Under these circumstances, it is expected that, in the present study, achievement goals would yield results similar to the studies conducted in Turkey. More specifically, mastery approach-avoidance and performance approach-avoidance goals are expected to have positive associations with students' engagement in science.

According to social cognitive theory, self-efficacy beliefs are one of the most influential and pervasive agents in human decisions on performing certain behaviors. Such a distinctive belief, self-efficacy, is defined by Bandura (1997) as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3)." Choices of activities people make, courses of actions they follow, effort expenditure, and persistence are the most prominent ones that are influenced by self-efficacy beliefs (Pajares, 2002; Schunk et al., 2014). Self-efficacy beliefs are influential in motivation, personal attainments, and welfare of people. That is the main reason which locates self-efficacy beliefs at the center of social cognitive theory (Pajares, 2002). Self-efficacy beliefs are widely documented in the literature that they are effective and lead to personal achievement in many contexts such as business administration, education, sport, work, and health (Pajares, 1996; Schunk, 1995). Considering educational settings, self-efficacy beliefs are associated with students' academic achievement, motivation, cognition, and actual performance (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996; Pajares, 1996; Pintrich & DeGroot, 1990). Students possessing high levels of self-efficacy beliefs are eager to involve in accomplishing a task; those holding low self-efficacy are inclined to avoid it (Schunk et al., 2014). Additionally, students with high self-efficacy were reported to set goals that are slightly higher than their actual ability, select challenging tasks, persist in the face of difficulties, exert greater effort to overcome obstacles in completing academic tasks, and use various learning strategies (Bandura, 1986; Pajares, 2006). Thus, it is expected that self-efficacy is positively linked to student engagement.

Student Engagement in Relation to Teacher Motivation and Job Satisfaction

According to the related literature, engagement appears to be associated with teacher motivation and job satisfaction (Goddard & Goddard, 2001; Urdan, 2004). Considering the relevant studies, the key teacher motivation variables examined in the current study in relation to student engagement include teachers' personal self-efficacy, teachers' collective efficacy, and teachers' approaches to instruction. Uden et al. (van Uden, Ritzen, & Pieters, 2014) reported that teachers' personal self-efficacy was positively associated with students' behavioral, cognitive, and emotional engagement. Concerning the relationship between teachers' collective efficacy and student outcomes, literature, on the other hand, is limited to student achievement. Ross et al. (Ross, Hogaboam-Gray, & Gray, 2004) stated that collective teacher efficacy is a strong predictor of student achievement. In general, it is argued that collective teacher efficacy affects student achievement indirectly by creating school norms and sanctions that enhances intent on persistence on academic tasks (Goddard & Goddard, 2001). Thus, although there are no studies in the literature explicitly examining the student engagement in relation to teacher collective efficacy, it is sensible to expect that higher levels of collective efficacy may lead to creation of learning environments conducive to student engagement. Accordingly, in the current study, positive links were expected between teachers' personal and collective self-efficacy and students' engagement dimensions.

As part of teacher motivation, teachers' approaches to instruction (i.e. mastery and performance approaches) have been investigated in relation with various student outcomes including engagement (Anderman & Patrick, 2012; Midgley & Urdan, 2001; Urdan, 2004). The studies examining the relationship between teachers' instructional goals and engagement demonstrated positive engagement patterns for mastery instructional goals and negative engagement patterns for performance instructional goals (Kaplan, Gheen, & Midgley, 2002; Urdan, 2004). Accordingly, in this study, it is expected that teachers' mastery instructional goals associate positively with student engagement and teachers' performance instructional goals associate negatively or have no association with student engagement.

The relationships between teachers' job satisfaction and student outcomes have not been investigated deeply to date (Michaelowa & Wittmann, 2008). Research on job satisfaction revealed that job satisfaction associated positively with performance at work (Ololube, 2006), undertaking extra-roles towards students and in school organizations (Somech & Drach-Zahavy, 2000), and life satisfaction (Ho & Au, 2006). Moreover, Demirtas (2010) stated that when teachers have high job satisfaction, they are expected to produce qualified instruction and enhance students' educational outcomes. Although literature lacks studies investigating relationships between teachers' job satisfaction and student outcomes, expecting positive relationships is not surprising based on abovementioned assertions. Therefore, positive associations are expected between job satisfaction and student engagement in the current study. Figure 1 summarizes the proposed relations among variables.

The current study focused on science domain considering the fact that, recently, the foremost goal of science education includes development of scientifically literate individuals who grasp scientific knowledge, ideas, and explanations deeply, engage in science activities behaviorally, cognitively, and emotionally, and have positive motivation towards science (MoNE, 2017a, 2017b). Indeed, National Research Council's Committee on a Conceptual Framework for New K-12 Science Education Standards (2012) reported that such habits of minds should be fostered in K-12 education to support the workforce in science, technology, engineering, and mathematics. However, international student assessment results such as PISA (2003, 2006, 2009, 2012) (Program for International Student Assessment) and TIMMS (1999, 2007, 2011) (Trends in International Mathematics and Science Study) indicated that science achievement of Turkish students is below the average of the participating countries' score. Thus, as an important component of scientific literacy, results of international exams suggest that Turkish students do not possess a good understanding of scientific concepts and ideas. Accordingly, there is a need for investigating the factors related to students' achievement in science as well as their motivation and engagement. Although there is common literature suggested relations among teacher variables including their motivation and job satisfaction and such student outcomes, empirical studies examining

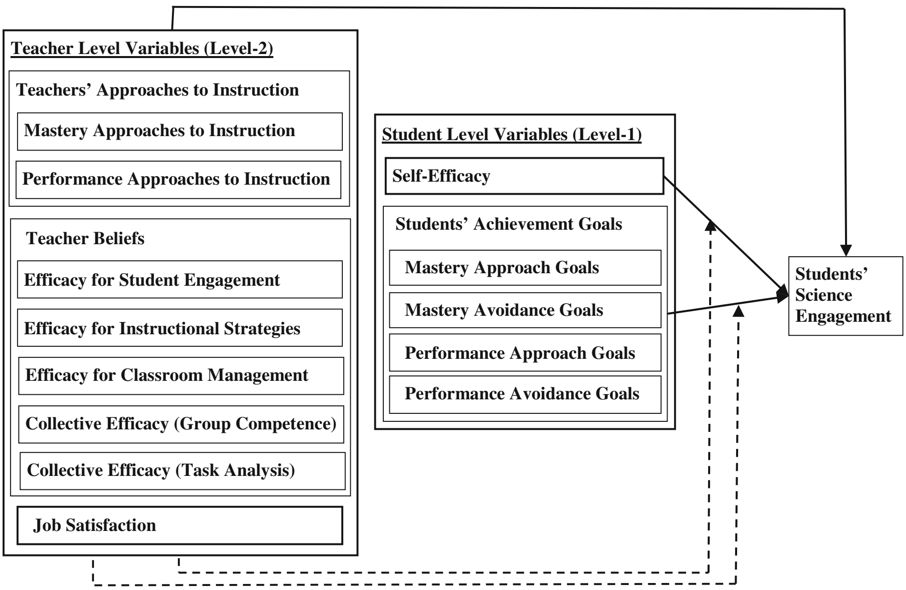

Fig. 1 Hypothetical model representing the interrelationships among teacher (level 2) and student variables (level 1) and students' science engagement

these relations are limited in number and scope. The researcher came across with only two studies (i.e. Pamuk, Sungur, & Oztekin, 2017; Yerdelen, 2013) conducted in Turkey that investigated the relationships between teacher variables and student outcomes in science. In these studies, researchers have used a nested data structure and HLM analysis. More specifically, in Turkey, previous research has examined the relationships between teacher self-efficacy and student outcomes (Pamuk et al., 2017) and teacher job satisfaction and student outcomes (Yerdelen, 2013) but there were limited studies examining the relationship between student outcomes and teachers' collective efficacy and instructional goal orientations. Indeed, review of the relevant literature indicated that while teachers' collective efficacy were reported to be associated with student achievement, the relationship between teachers' collective efficacy and student motivation and engagement was ignored. In this study, the influence of teacher collective efficacy was examined in relation to students' motivation, engagement, and science achievement using HLM analysis. Another gap in the literature was that the influence of teachers' approaches to instruction on student outcomes was generally investigated from the perspective of students' perception of classroom goals that are made salient by the teacher. For instructional goals, while previous studies have assessed teachers' instructional approaches from students' perspective, this study measured this construct from teachers' perspective. Thus, in the present study, how teachers approached to instruction in the classroom and the influence of this approach on student outcomes were investigated without aggregating student-level data to produce a class-level data. Use of HLM analysis enabled keeping important variance between students and classes. Accordingly, current study adopted a more comprehensive approach and conceptualized teacher motivation in terms of teachers' self-efficacy, collective efficacy, and teachers' instructional goals. In addition, job satisfaction, which emerged as an important variable in student outcomes, was investigated.

Method

Participants

The present study included both teacher and student participants in the sample. In teachers' part of the sample, there were 134 science teachers from the public schools of two districts of Ankara, Turkey. The participating science teachers' age ranged from 24 to 59 (M = 38.13, SD = 10.00) and they had teaching experience of 1 to 40 years (M = 14.38, SD = 9.74). These teachers had 20 to 45 students in class (M = 31.44, SD = 4.87) and had weekly 16 to 30 h of class (M = 23.51, SD = 3.93). Of the participating science teachers, 75% were graduates of college of education and 81.3% of them held bachelor degrees.

In the students' part of the sample, there were 3394 seventh grade students from 60 public middle schools. The mean age of the students was 13.31 (SD = 2.60). The mean previous semester science grade was 3.31 (SD = .81) out of 5.

Instruments

The data for the present study were collected by teacher and student instruments.

Teacher Instruments

Teachers' Approach to Instruction Scale (TAIS) It is a 5-point Likert-type scale ranging from 1 = "Strongly disagree" to 3 = "Somewhat agree" to 5 = "Strongly agree". It was developed by Midgley et al. (2000) to assess teachers' instructional approaches in two sub-scales namely mastery approaches to instruction (e.g. during class, I often provide several different activities so that students can choose among them, four items) and performance approaches to instruction (e.g. I display the work of the highest achieving students as an example, five items). In the present study, the reliability coefficients for the mastery instructional approach and performance instructional approach were found to be .71 and .73, respectively.

Teachers' Sense of Efficacy Scale (TSES) The short form of the instrument developed by Tschannen-Moran and Woolfolk-Hoy (Tschannen-Moran & Hoy, 2001) was used to assess science teachers' teaching efficacy beliefs. It is a 9-point Likert-type instrument ranging from "1 = nothing" to "9 = a great deal". It consists of 12 items in three subscales namely efficacy for student engagement (e.g. How much can you do to help your students' value learning?, four items), efficacy for instructional strategies (e.g. How well can you implement alternative strategies in your classroom?, four items), and efficacy for classroom management (e.g. How well can you establish a classroom management system with each group of students?, four items). In the present study, the alpha coefficient for the subscales was found as .79 for student engagement, .80 for instructional strategies, and .87 for classroom management.

Teachers' Collective Efficacy Scale (TCES) It was developed by Goddard et al. (Goddard, Hoy, & Hoy, 2000) on a Likert-type scale ranging from "1 = strongly disagree" to "6 = strongly agree" to assess teachers' collective efficacy beliefs. It consisted of 21 items in a single-factor structure. However, further studies demonstrated that a two-factor structure is also possible. A two-factor structure was observed in this study as well; analysis of teaching task (e.g. the students here come in with so many advantages they are bound to learn, eight items) and group competence (e.g. Teachers here are well-prepared to teach the subjects they are assigned to teach, 13 items). The reliability coefficients for group competence and task analysis were .87 and .80, respectively.

Teachers' Job Satisfaction Scale (TJSS) Science teachers' job satisfaction was measured by a four-item scale, which was developed by Skaalvik and Skaalvik (2011) on a 6-point Likert-type scale ranging from "completely disagree" (1) to "completely agree" (6). An example item is "I enjoy working as a teacher". In the current study, the reliability coefficient for the job satisfaction was .80.

Student Instruments

Student Engagement Questionnaire It was used to assess 7th grade students agentic, behavioral, cognitive, and emotional engagement in science classes. The SEQ was developed by Reeve and Tseng (2011) as 7-point Likert-type scale ranging from "1 = strongly disagree" to "7 = strongly agree" with the anchor "4 = agree and disagree equally". The Student Engagement Questionnaire (SEQ) includes 22 items in four subscales, namely agentic engagement (e.g. During science class, I express my preferences and opinions, five items), behavioral engagement (e.g. I work hard when we start something new in science class, five items), cognitive engagement (e.g. When doing schoolwork, I try to relate what I'm learning to what I already know, eight items), and emotional engagement (e.g. When we work on something in science class, I feel interested, four items). Reliability coefficients for the subscales were .78 for agentic engagement, .83 for behavioral engagement, .82 for emotional engagement, and .76 for cognitive engagement in the present study.

Achievement Goal Questionnaire It was used to assess seventh grade students' goal orientations in science classes. The Achievement Goal Questionnaire (AGQ) was developed by Elliot and McGregor (2001) on a 5-point Likert-type scale ranging from "1 = strongly disagree" to "5 = strongly agree". The AGQ includes 15 items in four subscales that are mastery approach goals (e.g. It is important for me to understand the content of this course as thoroughly as possible, three items), mastery avoidance goals (e.g. I am often concerned that I may not learn all that there is to learn in science class, three items), performance approach goals, (e.g. It is important for me to do well compared to others in this class, three items), and performance avoidance goals (e.g. I just want to avoid doing poorly in this class, six items). In the present study, all of the reliability coefficients of the subscales were in acceptable ranges; .74 for mastery approach goals, .77 for mastery avoidance goals, .77 for performance approach goals, and .77 for performance avoidance goals.

Motivated Strategies for Learning Questionnaire (MSLQ) It is a self-report instrument on a 7-point Likert-type scale (1 = not at all true of me to 7 = very true of me) developed by Pintrich et al. (Pintrich et al., 1993). Within the scope of the present study, only one of the sub-scales, namely, self-efficacy for learning and performance (8 items), was used to collect data concerning students' science self-efficacy. An example item for self-efficacy scale is "I believe I will receive an excellent grade in science class". The alpha reliability coefficient of the scale is quite high ($\alpha = .88$).

Context

Compulsory education lasts 12 years in Turkey (age 6 to 18). Students take integrated science classes from grade 3 to grade 8. Throughout these years, they have 4 h of science classes weekly. Science teachers in elementary and middle schools receive their training in 4-year programs in faculty of education. During their last year, they visit public or private schools once a week as a requirement of their teaching practice course to experience real classroom settings. They also have the opportunity to teach during this practicum experience.

Results

Descriptive Statistics

Descriptive statistics for teacher self-efficacy showed that participant teachers had high self-efficacy for teaching science in all three dimensions (see Table 1). Regarding participant science teachers' approaches to instruction, the subscale mean scores suggested that teachers tend to adopt mastery and performance approaches at high and similar levels. According to the mean subscale scores for collective efficacy, participant teachers appeared to have a strong belief in their group capability. On the other hand, their mean task analysis score was below the scale midpoint of 3. For job satisfaction, the subscale mean score implied that participating science teachers mostly agreed that they were pleasant from being in the teaching profession.

With regard to students' variables, descriptive statistics of engagement scale indicated that the highest subscale mean belonged to the behavioral engagement subscale and the lowest subscale mean belonged to agentic engagement. For achievement goals in the present study, the highest subscale mean was found for mastery approach goals and the lowest was found for mastery avoidance goals. In general, seventh grade Turkish students favored approach goals than avoidance goals. Lastly, concerning students' self-efficacy in science classes descriptive statistics showed that scale mean

Table 1 Descriptive statistics for teacher and student variables

Student variables (level 1)			M	SD	Scale
Student engagement		Agentic engagement	2.90	.64	1–7
		Behavioral engagement	3.37	.52	
		Cognitive engagement	3.16	.53	
		Emotional engagement	3.34	.57	
Student motivation		Achievement goals			
		Mastery approach goals	4.50	.58	1–5
		Mastery avoidance goals	3.51	1.08	1–5
		Performance approach goals	4.30	.81	1–5
		Performance avoidance goals	3.83	.87	1–5
		Self-efficacy	5.46	1.29	1–7
Teacher variables (level 2)					
Teacher motivation	Job satisfaction	Teacher job satisfaction	4.81	1.05	1–6
	Goals	Mastery approaches to instruction	3.97	.67	1–5
		Performance approaches to instruction	3.87	.79	
	Self-efficacy	Teacher self-efficacy—student engagement	6.69	1.11	1–9
		Teacher self-efficacy—instructional strategy	7.34	.99	
		Teacher self-efficacy—classroom management	7.06	1.12	
	Collective efficacy	Teacher collective efficacy—group competence	4.74	.80	1–6
		Teacher collective efficacy—task analysis	2.63	1.11	1–6

was well above the scale midpoint. It means that participating seventh graders feel themselves efficacious in science classes.

Predicting Science Engagement with Teacher Variables and Student Motivation

In this study, teacher and student data constitute a two-level data structure (students are nested in classes taught by a science teacher). Data were gathered from teachers and their students. Each teacher represents a class of students that he or she teaches. Therefore, a link between a teacher and classroom is established to demonstrate how student-level variables vary across classrooms, how teacher and student variables are interrelated, how all together these variables influence students' science engagement. Due to these reasons, HLM analysis was selected for this study as the analysis technique. Hierarchical Linear Modeling generates a different regression model for each and every student group. The structural relations and residual variability enable researchers to observe the interrelatedness between the two data levels. HLM also makes possible to examine the relationships among level one variables and how level two variables moderate these relationships.

A two-level HLM (Hierarchical Linear Model) was designed to reveal the relationships among students' engagement, motivation, and teacher variables. All continuous variables were standardized prior to the analyses by using *z* scores (M = 0, SD = 1) for ease of interpretability and comparison of the regression coefficients of variables using different scale intervals. In the current study, coefficients must be interpreted as standard deviation units which resemble to the interpretations of beta coefficients in ordinary least squares regression analysis. Predictor variables were created by taking the means of the items that constitute related variable. Thus, variables were all treated as continuous variables. Level 1 variables were grand mean centered due to the fact that student questionnaires assessed personal beliefs rather than learning environment (Trautwein & Lüdtke, 2009). Moreover, recommendations of Raudenbush and Bryk (2002) were followed while constructing the models to be tested. The results of the one-way random effects ANOVA suggested that maximum likelihood estimations of variance components at class level (τ_{00}) for four dimensions of engagement were statistically significant. It means that the variances of class means were varying from class to class. The class (teacher) level variances for engagement dimensions were as follows: agentic engagement ($\tau_{00} = .05$, $\chi^2 = 305.08$, df = 133, $p < .001$), behavioral engagement ($\tau_{00} = .03$, $\chi^2 = 253.30$, df = 133, $p < .001$), cognitive engagement ($\tau_{00} = .03$, $\chi^2 = 253.08$, df = 133, $p < .001$), and emotional engagement ($\tau_{00} = .05$, $\chi^2 = 333.33$, df = 133, $p < .001$). These findings suggested that conducting HLM analysis was appropriate for the engagement dimensions. The intra-class correlation (ICC) is stated as the proportion of second-level variance (τ_{00}) to the total variance ($\tau_{00} + \sigma^2$) in the model. Accordingly, 5% of the total variance in agentic engagement, 4% of the total variance in behavioral engagement, 3% of the total variance in cognitive engagement, and 6% of the total variance in emotional engagement existed among classes, which means these variabilities might be explained by the second level variables.

Previously conducted means as outcomes model and random coefficients model for agentic engagement suggested that while none of the teacher-level variables predicted the intercept of students' agentic engagement, level one variables of *self-efficacy*

($\gamma = .36$, se = .02, $p < .001$), *mastery approach goals* ($\gamma = .12$, se = .02, $p < .001$), *mastery avoidance goals* ($\gamma = .09$, se = .02, $p < .001$), and *performance approach goals* ($\gamma = .06$, se = .02, $p < .01$) were positively and significantly correlated with *agentic engagement* (see Table 2). However, none of the level one slopes varied significantly among classes. Since there were no random slopes in agentic engagement dimension of students' engagement, there is no need to build an intercepts and slopes as outcomes model for agentic engagement.

For behavioral engagement, final version of intercepts and slopes as outcomes model indicated that students' self-efficacy ($\gamma = .34$, se = .02, $p < .001$), mastery approach goals ($\gamma = .37$, se = .02, $p < .001$), performance approach goals ($\gamma = .06$, se = .02, $p < .001$), and mastery avoidance goals ($\gamma = .04$, se = .01, $p < .01$) correlated positively (see Table 2). None of the teacher-level variables predicted students' behavioral engagement in science classes and again none of them were significant for the randomly varying slopes of self-efficacy-behavioral engagement, mastery approach goals-behavioral engagement, and performance approach goals-behavioral engagement. Therefore, it is not appropriate to talk about the moderation effect of level two variables on the slopes of random predictor variables. Nevertheless, the results of the final form of intercepts and slopes as outcomes model indicated that slopes of self-efficacy ($\chi^2 = 176.04$, $p < .01$), mastery approach goals ($\chi^2 = 190.75$, $p < .01$), and performance approach goals ($\chi^2 = 163.67$, $p < .05$) still varied significantly among classes and these teacher-level variables of the present study were unable to capture this variability.

Intercepts and slopes as outcomes model specified for *cognitive engagement* suggested that among five level one variables, *self-efficacy* ($\gamma = .41$, se = .02, $p < .001$), *mastery approach goals* ($\gamma = .23$, se = .02, $p < .001$), *mastery avoidance goals* ($\gamma = .11$, se = .02, $p < .001$), and *performance avoidance goals* ($\gamma = .09$, se = .02, $p < .001$) were positively and significantly correlated with *cognitive engagement* (see Table 2). Moreover, students' average scores on *cognitive engagement* significantly but negatively associated with teachers' efficacy for student engagement ($\gamma = -.03$, se = .01, $p < .01$). Results of final full intercepts and slopes as outcomes model also suggested some cross-level interactions. Firstly, teachers' job satisfaction moderated the relationship between mastery approach goals and cognitive engagement ($\gamma = .04$, se = .02, $p < .05$) significantly. Secondly, teachers' efficacy for student engagement moderated the relationship between performance avoidance goals and cognitive engagement ($\gamma = .03$, se = .01, $p < .05$). R^2 values indicated that approximately 9% of the between class variance in cognitive engagement was explained by the teachers' efficacy for student engagement variable.

Students' average scores on *emotional engagement* correlated positively and significantly with students' *self-efficacy* ($\gamma = .34$, se = .02, $p < .001$), *mastery approach goals* ($\gamma = .29$, se = .02, $p < .001$), *mastery avoidance goals* ($\gamma = .07$, se = .02, $p < .001$), and *performance approach goals* ($\gamma = .04$, se = .02, $p < .05$) were positively and significantly correlated with *emotional engagement*. For teacher-level variables, emotional engagement correlated positively with teachers' *mastery approaches to instruction* ($\gamma = .04$, se = .02, $p < .05$) but negatively with teachers' *efficacy for student engagement* ($\gamma = -.06$, se = .02, $p < .01$) (see Table 2). Obtained results of final full intercepts and slopes as outcomes model suggested some cross-level interactions among the predictors of emotional engagement. The dimensions of teachers' collective efficacy moderated the relationship of teacher-level predictors with emotional engagement. Teachers' analysis of teaching tasks ($\gamma = .03$, se = .02, $p < .05$) moderated the relationship between self-efficacy and emotional engagement significantly. Secondly, teachers' collective efficacy as a science teacher group ($\gamma = .04$, se = .02, $p < .05$) moderated the relationship between mastery approach goals and emotional engagement. R^2 values showed that approximately 9% of the between class variance in emotional engagement was explained by the teachers' mastery approaches to instruction and efficacy for student engagement variables.

Discussion and Conclusions

Agentic Engagement

For agentic engagement, HLM analysis suggested that none of the teacher-level variables predicted students' agentic engagement. The limited number of studies investigating the upper level predicted effects on student engagement did not include agentic engagement in their studies. Therefore, the findings of the current study could not be compared with any previously conducted studies. It is recommended that this

Table 2 Final estimations of fixed effects for the dimensions of students' science engagement

	Agentic engagement		Behavioral engagement		Cognitive engagement		Emotional engagement	
Fixed effects	γ	SE	γ	SE	γ	SE	γ	SE
Model for class means intercept	.036	.021	.049	.014	.041	.015	.044	.018
Teachers' efficacy for student engagement					−.034**	.015	− .055**	.017
Teachers' mastery approaches to instruction							.040*	.019
Self-efficacy	.358***	.017	.338***	.016	.405***	.015	.336***	.018
Task analysis							.031*	.015
Mastery approach goals	.122***	.018	.368***	.020	.232***	.019	.292***	.022
Teachers' job satisfaction					.040*	.016		
Group competence							.042*	.017
Mastery avoidance goals	.093***	.015	.043**	.014	.113***	.018	.068***	.014
Performance approach goals	.062**	.018	.064***	.015			.039*	.018
Performance avoidance goals					.091***	.018		
Teachers' efficacy for student engagement					.032**	.014		
Explained variance (R^2) Level 1	22.4%		43%		38.5%		35%	
Level 2	–		–		9%		9%	

Only predictors in final models were included in the table. Predictors that have no coefficient value in the table were excluded variables from the related model because of its non-significant fixed and random effect on outcome variable.

*$p < .05$, **$p < .01$, ***$p < .001$

study is replicated with similar samples to be able to make subtle discussions and interpretations.

Concerning student-level variables, current study, showed that students' agentic engagement in science classes was predicted by students' self-efficacy beliefs, mastery approach goals, mastery avoidance goals, and performance approach goals. These results, in general, are in line with the previous research (Hıdıroğlu, & Sungur, 2015; Hıdıroğlu, 2014). These studies revealed that students who are willing to learn and master the material (mastery approach orientation) are likely to express their preferences and manipulate the flow of the course according to their learning style. In the present study, it was also found that students who are avoiding not learning and not mastering (mastery avoidance-oriented students) and students who strive for besting others and getting the top grades in normative scoring (performance approach-oriented students) as well as mastery approach-oriented students tend to have higher levels of agentic engagement. At this point, it is worth mentioning that since agentic engagement is a relatively new dimension for student engagement (Reeve & Tseng, 2011), studies investigating the relationships between achievement goals and agentic engagement are rare. Accordingly, there is limited available study to compare results of current study in terms of the relationship between achievement goals and agentic engagement. Thus, dearth of studies regarding agentic engagement necessitates further research to make detailed interpretations and comparisons.

Behavioral Engagement

Concerning behavioral engagement dimension of students' engagement in science class, the final model suggested that none of the teacher-level variables predicted behavioral engagement. Another inference from this finding was that a great majority of the variance lied within classes for behavioral engagement. This finding was surprising because a recent study conducted by Uden and his colleagues (van Uden et al., 2014) indicated that teacher proximity and influence explained 29% of the variance in students' behavioral engagement at the group level. However, it should be mentioned that Uden and colleagues (van Uden et al., 2014) studied with students from vocational school and they were all high school students. In addition, the teacher-level variables were different than those included in the current study. Thus, further research is needed in terms of behavioral engagement and teacher-level predictors in Turkey to be able to make better comparisons and deeper interpretations.

For student-level predictors of behavioral engagement, students' self-efficacy beliefs in science, mastery approach goals, mastery avoidance goals, and performance approach goals positively correlated with their behavioral engagement. Concerning the relationship between students' self-efficacy and behavioral engagement, the findings of the study were in line with the previous studies (Bandura, 1997; Hıdıroğlu, 2014; Ryan & Pintrich, 1997). With regard to the relationship between students' behavioral engagement and achievement goals, at first glance, the relationship between mastery approach goals and behavioral engagement seems logical because mastery-oriented students value learning and try to master the task for the sake of learning. Consistent with this assertion, previous empirical research also demonstrated a positive link between mastery approach goals and behavioral engagement (Patrick, Ryan, & Kaplan, 2007). However, the study presented above did not make a distinction between mastery approach and mastery avoidance goals. Therefore, it is not possible at the moment to discuss findings of this study regarding mastery avoidance goals. Although findings of the current study indicated a positive relationship between mastery avoidance goals and behavioral engagement, it is relatively low in comparison with the relationship between mastery approach goals and behavioral engagement. On the other hand, previous results suggested that performance goals associate with maladaptive patterns of behavior. Indeed, Ryan and Pintrich (1997) found that students with performance approach goals indicated maladaptive patterns of behavioral engagement such as avoiding help-seeking. At this point, it is important to note that, according to goal theorists (see Schunk, 2012), students may have multi-goals at the same time. Therefore, students may have both performance and mastery approach goals and their goals may lead them to behaviorally engage in science classes. Thus, positive relationship between various achievement goals and behavioral engagement is not surprising though.

Cognitive Engagement

HLM analysis conducted for students' cognitive engagement in science classes suggested that at the teacher level, only teachers' efficacy for student engagement associated negatively with students' cognitive engagement. This means that students taught by teachers who are less confident in engaging students' in science class were found to be more cognitively engaged in science classes. This finding is somehow contrasting with the limited literature on the relationships between teacher variables and students' cognitive engagement. Uden and his colleagues (van Uden et al., 2014) reported a positive relationship between teacher self-efficacy and students' cognitive engagement. However, in their hierarchical linear modeling analysis, they entered their teacher-level variables in a cumulative order and they found that significant effect of teacher self-efficacy on students' cognitive engagement waned when they entered teachers' interpersonal relationship variables (i.e. influence and proximity) in the analysis. In the current study, the items measuring cognitive engagement generally focused on cognitive strategies students' use while they are studying for science classes; not the strategies they use while they were in the science class (e.g. "When doing schoolwork, I try to relate what I'm learning to what I already know", When I'm working on my schoolwork, I stop once in a while and go over what I have been doing"). Therefore, if highly efficacious teachers cover all the aspects of the science topic of the day engaging their students, then students may use cognitive strategies less while studying for science class. Another explanation for this finding may be that according to Raudenbush et al. (Raudenbush, Rowan, & Cheong, 1992), what teachers' believe concerning their confidence may not be compatible with how they perform teaching in the classroom. Similarly, what students perceive regarding the practices of their teachers may not be the same as teachers' beliefs about their practices. Further research is needed related to the relationship between teacher beliefs and students' cognitive engagement. To be able to reach more tenable conclusions, more research is needed both in national and international context.

With regard to student-level predictors, HLM analysis suggested that students' science self-efficacy, mastery approach goals, mastery avoidance goals, and performance avoidance goals were positively linked with cognitive engagement explaining

38.50% of its variance. The positive link found between self-efficacy and cognitive engagement was in line with relevant literature (Hıdıroğlu, 2014). Concerning the relationship between achievement goals and cognitive engagement, these findings partly support the findings of previous studies because the relationships between achievement goals and cognitive engagement have been investigated for three decades but a consensus on these relationships was not reached. Early researchers did not make a distinction between approach and avoidance distinction of student goals and examined the relationships under the names of task (mastery) and ego (performance) goals (Nolen, 2003). Additionally, related research suggested mixed results. In one of the studies, for example, Meece et al. (Meece, Blumenfeld, & Hoyle, 1988) found that students setting high levels of task mastery goals were more cognitively engaged in science activities. In another study, Nolen (2003) reported that both task (mastery approach) orientation and ego orientation (performance approach) correlated positively with deep strategy use but the correlation was stronger between deep strategy use and task orientation in science-learning environment. Overall, these findings support the findings of the present study in terms of the relationship between mastery approach goals and cognitive engagement. However, current findings failed to demonstrate a significant relationship between performance approach goals and cognitive engagement. Concerning avoidance goals, present study suggested that both mastery and performance avoidance goals correlate positively with cognitive engagement. These findings are reasonable in competitive and examination-oriented learning environments: This study was conducted in Turkey where a competitive education system existed (Sungur & Senler, 2009). In Turkey, students are subject to a series of examinations for placement of high schools and then for universities. Therefore, such norm-referenced ranking examinations may motivate students to use more cognitive strategies to avoid not learning and not looking dumb in the eyes of other students in science classes. Moreover, a related construct, metacognition, was found to have positive associations with avoidance goals in previously conducted studies in Turkey (see Kıran, 2010). Although previous studies conducted in countries where competition is not emphasized in education system suggest negative relationships between avoidance goal orientations and adaptive outcomes, Turkish students' avoidance goals appear to Ccorrelate positively with cognitive engagement.

Emotional Engagement

For the last dimension of students' engagement, HLM analysis suggested that students' emotional engagement correlated positively with teachers' mastery approaches to instruction This finding suggests that the students of teachers perceiving themselves to use mastery-oriented instructional approaches at higher levels in science teaching were more likely to be emotionally engaged. Explicitly, these students appear to feel that science class is fun and they like learning science. This finding is reasonable and supported previous findings regarding the influence of teachers' mastery instructional approaches on students' emotional engagement (Anderman & Patrick, 2012). For instance, students perceiving their teachers' instructional approach in science classes as mastery oriented are found to display positive school-related affections (Kaplan & Midgley, 1997) and feeling of belonging to school (Anderman & Anderman, 1999).

Concerning the relationship between teachers' self-efficacy and students' emotional engagement, unlike the expected positive relationship, emotional engagement significantly but negatively associated with teachers' efficacy for student engagement. This finding implies that in classes where teachers feel more confident in engaging students to science classes, students feel less emotionally engaged. Students' love and sympathy to science classes decrease in the presence of high teacher confidence for engaging them in science classes. This finding was not supported by the related literature. For example, in a recent study, Uden and his colleagues (van Uden et al., 2014) reported that teacher self-efficacy associated positively but weakly with students' emotional engagement. The same group of researchers reported another significant positive relationship between teacher self-efficacy and student emotional engagement when student emotional engagement was measured from the teachers' perspective. Despite the contrary findings in the literature, negative relationship between students' emotional engagement and teachers' efficacy for student engagement could be reasonable considering Turkish context: Turkish teachers generally use teacher-centered instruction and students are accustomed to receiving information passively (Gökçe, 2006; Özmen, 2003). Teaching-learning process in Turkey may be summarized as transmitting knowledge from the source (teacher) to the receiver (students). On the contrary, in a learning environment where teachers are striving to engage students in science class and students are expected to be active, Turkish students may not feel comfortable. They may feel that they may not succeed. Therefore, in student-centered learning environments, students may feel anxious and may not emotionally engage in science classes because of being used to experiencing teacher centered instruction so far. Another explanation for the unexpected finding may be that what teachers believe they are capable of and what they perform in the classroom may not be the same and students' perceptions of these performances may not be the same as teachers' feelings about their performances (Raudenbush et al., 1992). However, these explanations are not more than speculations and more research is needed in Turkish context with different samples to shed more light on this relationship.

For students' emotional engagement in science classes, students' self-efficacy, mastery approach goals, mastery avoidance goals, and performance approach goals were found as positively correlated with emotional engagement. These four student-level variables accounted for approximately 35% of variance in students' emotional engagement in science class. Explicitly put, these findings suggested that students who have high self-efficacy in science were more emotionally engaged. In a similar way, students setting more mastery approach, mastery avoidance, and performance approach goals were found to be more emotionally engaged in science classes. For the relationship between students' science self-efficacy and emotional engagement, findings of the present study were supported by the relevant literature (Schunk & Mullen, 2012). For achievement goals, the present study showed that students' mastery approach, mastery avoidance, and performance approach goals positively associated with students' emotional engagement. For mastery and performance approach goals, findings of the present study supported the previous studies: For example, Murayama and Elliot (2009) reported that while mastery and performance approach goals correlated positively with students' emotional engagement, performance avoidance goals correlated negatively. In the current study, on the other hand, the link between performance avoidance goals and students' emotional engagement was found to be non-significant.

Concerning mastery avoidance goals, current findings suggested a positive relationship with emotional engagement. However, the strength of the relationship was relatively low. As stated in previous sections, studies investigating the relationships between achievement goals with using approach avoidance distinctions and engagement constructs are rare. Though not the same but in Turkey, previous researchers reported positive relationships between avoidance goals and adaptive patterns of behavior (see Kıran, 2010). Thus, avoidance goals might correlate positively with adaptive outcomes in Turkish context within competitive educational system. More research is needed regarding the relationships between the avoidance dimensions of achievement goals and engagement constructs in different contexts to be able to make deeper interpretations.

Different from the other dimensions of engagement, teacher-level variables moderated the relationships between student-level predictors and emotional engagement. The relationship between students' self-efficacy and emotional engagement was moderated by teachers' collective efficacy for task analysis and the relationship between mastery approach goals and emotional engagement was moderated by teachers' collective efficacy for group competence. These moderation effects suggested that the relationship between students' self-efficacy and emotional engagement was stronger in classes where teachers have high collective efficacy in analysis of teaching tasks. Similarly, the relationship between students' mastery approach goals and emotional engagement was stronger in classes where teachers' collective efficacy for group competence is higher. These findings are reasonable because theoretically, teachers' collective efficacy has been suggested to be related to various student outcomes including student achievement, school dropout/attendance, college attendance, and student course selection (Goddard, Hoy, & Hoy, 2004). Thus, expecting a direct relationship or a moderation effect of teachers' collective efficacy on student outcomes is not illogical. Despite theoretical assertions, on the other hand, collective efficacy lacks studies in terms of examining the relationships between teachers' collective efficacy and student outcomes other than student achievement. More research is needed to make better explanations and talk about possible relations of teachers' collective efficacy to student outcomes. Moreover, qualitative studies may reveal the origin of interrelationships between teachers' collective efficacy and student-level outcomes such as emotional engagement.

Implications and Recommendations

The present study investigated the antecedents of students' science engagement from a motivational perspective including both teacher and student-level predictors. As the statistical method, namely HLM, used in this study considers the relatedness among the responses of students, more robust results were obtained. Thus, this situation is supposed to prevent the overestimation of the relationships among the variables, especially between the teacher motivation and student engagement. The findings of the models indicated that the majority of variability in students' science engagement lied within classes. Thus, the results implied that in order to enhance students' engagement in science, the focus should be given on student motivation rather than teacher motivation. In the current study, among student-level variables, science self-efficacy was found as the most prominent predictor of all engagement dimensions.

Accordingly, it is suggested that science teachers should provide students with task and activities in an increasing order of difficulty so that students can experience a sense of accomplishment in these activities improving their self-efficacy. Indeed, according to Bandura (1997), sources of self-efficacy include mastery experiences (past accomplishments) as well as vicarious experiences (learning from the models), verbal persuasions, and emotional arousal (stress, fatigue, anxiety, etc.). Previous research indicated that among these sources, mastery experiences are the most powerful source of self-efficacy beliefs. Thus, using hands-on activities or problem-based learning approach can help development of students' self-efficacy beliefs in science. In problem-based learning, for example, students deal with ill-structured problems while working in small groups. They can approach the problem from different aspects proposing different solutions. As they gather information from different sources, their approach to problem or the solution proposed may change. In this way, students can realize that learning is under their own control and if they show necessary effort, they can accomplish the task successfully (*mastery experience*). At this point, it is important to note that the problems posed to students should not be far beyond their capabilities. The challenge provided should be optimal so that they can experience a sense of accomplishment. Additionally, in a problem-based learning environment, as students interact with their peers, they can also learn from each other (*vicarious experience*). During the problem-based learning implementation, teachers are expected to act as a guide and give corrective feedback. The *verbal persuasions* and feedback provided by teachers can also enhance students' self-efficacy reducing their stress and anxiety in science classes (*emotional arousal*). Apart from fostering students' self-efficacy, such learning environments can also encourage students to adopt mastery goals in science classes. Indeed, classroom environments providing students with challenging and curiosity invoking tasks with ample time, emphasizing the link between efforts and accomplishments, encouraging group work, and cooperation rather than competition are expected to support mastery goal orientation (Ames, 1992). In the present study, students' mastery goals as well as performance goals were found to be influential in several dimensions of science engagement. Because previous research consistently demonstrates a positive link between mastery goals and adaptive outcomes, current study suggests creating learning environments conducive to adoption of mastery goals as well. Moreover, current findings also demonstrated that teachers' mastery approaches to instruction influence positively students' emotional engagement in science classes. Accordingly, science teachers' are advised to pay attention on the value of learning and avoid comparing students based on their test results. In this way, students' may develop positive attitudes and emotional engagement in science classes (see Table 2).

This study suggests some further recommendations; this study was based on quantitative data collected by self-report questionnaires. Additionally, these data were analyzed by advanced regression techniques. Both self-report questionnaire data and regression techniques are limited in terms of providing cause-effect relationships for the revealed relationships in the current study. Thus, future researchers are advised to use longitudinal designs or qualitative techniques to provide more reliable grounds for causality. In addition, students' self-efficacy and goal orientations were considered as the motivational variables in this study. Motivation is a multifaceted construct and includes many dimensions to be investigated in relation to engagement. This study was limited to two motivational constructs but researchers may examine different motivational constructs in the future studies. Moreover, this study was limited to seventh-grader students and science domain. Antecedents of engagement may vary according to grade level and academic domain. Future studies may focus on different domains and different age groups in their studies to reveal the relationships between motivational constructs and engagement dimensions.

Despite these limitations, we believe that this study adds depth to the multilevel modeling studies' literature in science education for Turkey. Previous studies mostly focused on predicting science achievement through multilevel modeling using the data obtained from international student assessments (PISA, TIMMS, etc.). The teacher and student variables of this study are different from these studies. An emphasis on motivational constructs is salient. Teachers, school administrators, and families may benefit from the findings which mainly state that majority of the variance in science engagement dimensions lies within classes. Improving science self-efficacy and having students set mastery goals may contribute to their engagement in science classes. Unfortunately, specified teacher-level variables covered in the present study could not capture any of the second level variability among classes. It indicated that other teacher-level variables can be influential in explaining the class-level differences for students' behavioral engagement in science classes

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