



Multilevel Investigation of Students' Self-regulation Processes in Learning Science: Classroom Learning Environment and Teacher Effectiveness

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Abstract

This study aimed to investigate the role of students' classroom learning environment perceptions and teacher effectiveness in 7th grade students' self-regulation in science classes. Students' self-regulation was examined in terms of self-efficacy, achievement goals, and metacognitive strategy use which constitute important components of self-regulation. The relations of students' perceived classroom learning environment (i.e. student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity) and teacher effectiveness (i.e. teachers' beliefs, characteristics, and occupational well-being) to students' self-regulation were tested by conducting separate HLM analyses considering the nested structure of the data. To select a nationally representative sample, two-stage random sampling approach was used. Data were collected from 372 science teachers and their 8198 seventh grade students in Turkey. Results indicated that perceived classroom learning environment variables were good predictors of students' self-regulation in learning science. Among the learning environment variables, the task orientation appeared to be the most powerful predictor. Additionally, teacher variables were found to have direct relations with students' self-regulation and moderate the relationships between learning environment and self-regulation variables.

Keywords Classroom learning environment · Multilevel analysis · Science education · Self-regulation · Teacher effectiveness

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Introduction

Student self-regulation is at the heart of successful learning, and it has been the topic of educational psychology for a few decades. Pintrich (2000), based on social cognitive theory, defined self-regulated learning as “an active, constructive process whereby learners set goals for their learning, and then attempt to monitor, regulate, and control their cognition, motivation and behavior, guided and constrained by their goals and the contextual features in the environment” (p. 453). Accordingly, self-regulated learners are successful in activating and sustaining behaviors, cognitions, and emotions for achieving a learning goal (Zimmerman, 2000). Risemberg and Zimmerman (1992) suggested that self-regulated learners, who plan their learning, choose appropriate strategies to reach the goals they set, monitor their performance, make evaluations about their learning processes, are more likely to be successful than students who rely on teachers’ directions for performing the same functions. They feel self-efficacious in their learning (Pintrich, 2000). Actually, a substantial body of research demonstrated that high achieving students are more likely to use self-regulated learning strategies than low achievers (Ee, Moore, & Atputhasamy, 2003; Sungur & Gungoren, 2009). Thus, with an ultimate aim of improving students’ achievement related outcomes and their actual achievement, it is essential to examine students’ self-regulation. While examining self-regulation, since it is a tremendously extensive phenomenon which includes motivational, cognitive, and metacognitive dimensions, considering all these dimensions are difficult. Therefore, in the scope of the present study, based on Pintrich’s (2000) model guided by social-cognitive theory, students’ self-regulation was conceptualized in terms of three main components: self-efficacy, achievement goals, and metacognitive self-regulation: Bandura (1986) defined self-efficacy as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 391). More generally, self-efficacy emphasizes how confident people believe they are or how much control they believe they have in their ability to master a task and reach a goal (Bandura, 1997). Self-efficacy influences individual’s feelings, thinking, motivation, and behaviors (Bandura, 1993). For example, while people with strong self-efficacy are more likely to approach to challenging tasks to accomplish, those with lower level of self-efficacy tend to avoid challenging tasks (Bandura, 1994). According to Bandura (1977, 1997), efficacy beliefs are developed as individuals gain successful experiences, observe and compare the performance of others, receive verbal praise from others, and their physiological and emotional states contribute to the development of these beliefs.

As the second important component of self-regulation, achievement goals focus on the reasons of students’ desire to accomplish a specific task (Pintrich, 2000). Achievement goal theory suggests four types of achievement goals: mastery-approach goals, mastery-avoidance goals, performance-approach goals, and performance-avoidance goals (Elliot & McGregor, 2001; Pintrich, 2000). Students who set mastery-approach goals focus on learning, understanding, and mastering task while students who set mastery-avoidance goals tend to avoid misunderstanding, not learning, or not mastering the task (Pintrich, 2000). Moreover, when students set performance-approach goals, they compare their performance with other students, and try to superior and beat others, while students with performance-avoidance goals avoid inferiority and looking unsuccessful in class (Pintrich, 2000).

The other self-regulation component is metacognitive self-regulation (Pintrich, 2000). Metacognition deals with individual's knowledge and regulation of their own cognition (Flavell, 1979). Metacognitive learning strategies help students plan and monitor cognitive activities and check whether the cognitive goal is accomplished or not (Schraw & Moshman, 1995). Boekaerts (1997) indicated that metacognitive knowledge facilitates comprehension, monitoring, or assessing the conceptual and procedural knowledge related to the context. According to Boekaerts (1997), the level of students' metacognitive skills distinguishes them from their peers.

This study aimed to investigate aforementioned components of student self-regulation in relation to various teacher and student related variables. Teacher-related variables included teacher effectiveness variables (i.e. occupational well-being, implicit beliefs of ability, self-efficacy beliefs, and teacher characteristics). Student related variables included students' learning environment perceptions.

Classroom Learning Environment

According to social cognitive theory, human functioning can be explained as the reciprocal interactions between personal, behavioral, and environmental factors, and these factors both affect and are affected from each other (Bandura, 1986). Namely, Bandura (1986) suggested that (1) individuals' behaviors are shaped by their beliefs, thoughts, and affect, and these behaviors, in turn, influence their cognitive and affective reactions; (2) while individuals' beliefs, expectations, and cognitive competences are affected (apart from behaviors) from environmental factors, they may differently influence their social environment depending on their physical (e.g. race, age, and gender) and social (prestige and status) characteristics; and (3) individuals' specific actions have influence on their environment and they are also affected from environment. Thus, based on the social cognitive theory, it is reasonable to assume that classroom learning environment and teachers have influence on students' self-regulation in their learning. Indeed, the classroom context is among the most important factors affecting students' learning outcomes (Fraser & Walberg, 1991). Researchers' interest to examine the psychosocial aspects of classroom environment has been increased with the development of some instruments. While the early instruments focused on teacher-centered classrooms, the focus of more recently developed instruments has been student-centered classrooms based on students' and teachers' perceptions (Fraser, 2012). Among these instruments, What Is Happening in This Classroom (WIHIC) (Fraser, McRobbie, & Fisher, 1996) is one of the most widely used scales to assess students' and teachers' perceptions of psychosocial features of the classrooms. WIHIC includes most salient scales which were found as significantly associated with student's learning outcomes in previous research. Furthermore, WIHIC reflects the contemporary cognitive approach to science learning (Kim, Fisher, & Fraser, 2000). The research studies in the relevant literature (using WIHIC) revealed that classroom learning environment (CLE) was a strong predictor of students' academic achievement (den Brok, Telli, Cakiroglu, Taconis, & Tekkaya, 2010; Wolf & Fraser, 2008). Moreover, in the classrooms where students are supported to use autonomy, complex thinking skills, variety of strategies, and work cooperatively, students are expected to develop self-regulated learning strategies (Paris & Paris, 2001). However, in science education, there has been little empirical research with regard to the relation of CLE

and self-regulation dimensions. In this respect, it is possible to note a few studies on the association between perceived CLE and self-efficacy (e.g. Dorman, 2001; Dorman, Adams, & Ferguson, 2003), achievement goals (e.g. Arisoy, 2007; Church, Elliot, & Gable, 2001; Sungur & Gungoren, 2009), and metacognition (e.g. Schraw, Crippen, & Hartley, 2006). Although some of the dimensions (e.g. cooperation and teacher support) of CLE were sometimes found negatively associated with self-regulation variables (Dorman, 2001; Dorman et al., 2003), results mostly revealed positive relationship. Therefore, in order to improve the quality of instruction and reach educational goals, it is crucial to investigate the features of CLE that positively affect students' cognitive and affective learning processes.

Teacher Effectiveness

The focus of teacher effectiveness research has been on the teacher characteristics that have potential to influence students' learning outcomes (e.g. Bolyard & Moyer-Packenham, 2008). These studies mainly examined teachers' personality characteristics, teacher practices, and behaviors in learning environment (Patrick & Smart, 1998) and occupational well-being (Klusmann, Kunter, Trautwein, Lüdtke, & Baumert, 2008). However, teachers' beliefs are also important variables that influence students' learning processes (Tschannen-Moran, Hoy, & Hoy, 1998) and should be involved in the teacher effectiveness research.

Regarding teacher beliefs, according to Tschannen-Moran and Hoy (2001), teachers' effort, goal orientation, persistence, and resilience in teaching are influenced by their efficacy beliefs. Teachers' behaviors in the classroom were also affected from their sense of efficacy toward teaching (Ashton & Webb, 1986). Although many researchers assumed a positive association between teacher self-efficacy and student outcomes (e.g. Ashton & Webb, 1986; Tschannen-Moran et al., 1998), empirical studies examining these associations are so rare (see Klassen, Tze, Betts, & Gordon, 2011), and they yielded either positive or no significant relationship. Moreover, some studies showed that teachers' self-efficacy beliefs influence the association between learning environment and students' academic gains (e.g. Guo, McDonald Connor, Yang, Roehring, & Morrison, 2012; Hoy & Davis, 2005). Moreover, teachers' implicit belief about intelligence (intellectual ability) is associated with their behaviors and attitudes in the classroom (Lynott & Woolfolk, 1994; Shim, Cho, & Cassady, 2013). As Dweck and Leggett (1988) suggest, people may have implicit theories about personality, ability, motivation, and morality as well as intelligence. Teachers who hold incremental theory believe that students' intelligence is malleable, and they attribute students' success and failure to the degree of the effort students exert for learning. Teachers who hold entity theory, on the other hand, believe that intelligence is fixed and they attribute students' success and failure to their intelligence (Dweck, 1996). Therefore, teachers with incremental theory are more likely to create more qualified CLE and contribute to students' self-regulation processes in learning science.

With regard to occupational well-being some researchers identify effective teachers as those who experience low level of burnout and high satisfaction with job (Kyriacou, 2001; Maslach & Leiter, 1999). According to Farber and Miller (1981), a burned out teacher "may be less sympathetic toward students, may have

a lower tolerance for frustration in the classroom, may plan for their classes less often or less carefully, may fantasize or actually plan on leaving the profession, may feel frequently emotionally or physically exhausted, may feel anxious, irritable, depressed, and in general, may feel less committed and dedicated to their work” (as cited in Farber, 1982, p. 2). Moreover, teachers’ instructional performance and students’ learning outcomes are negatively associated with teacher burnout (Klusmann et al., 2008). Students’ educational gains are more likely to be enhanced in the schools with teachers highly satisfied with their job (Demirtas, 2010). Literature on teacher job satisfaction has indicated positive relationship between job satisfaction and performance at work (Ololube, 2006), self-regulation (Klusmann et al., 2008), self-efficacy (Caprara, Barbaranelli, Steca, & Malone, 2006), and student achievement (Klusmann et al., 2008). However, little is known about the influence of teacher burnout and job satisfaction on CLE and students’ self-regulation.

Lastly, teacher characteristics including teacher gender and experience are also regarded as important variables that affect students’ learning processes and CLE in various domains and grade levels across the world. Previous research generally indicated that, in some dimensions of CLE, female teachers were perceived as providing more favorable CLE than male teachers (den Brok, Fisher, Rickards, & Bull, 2006). Besides, as for the association between teacher experience and CLE in science education, research to date has showed mixed results (Levy, den Brok, Wubbels, & Brekelmans, 2003). Examining the relevant literature, one might well suggest that there has been little research which studied teacher gender and experience with respect to students’ self-regulation.

The Present Investigation

Self-regulation has been the interest of educational researchers and has not often been considered at the same time with classroom context. Therefore, this study will shed light on the literature by providing a comprehensive approach to predict students’ self-regulation by considering the quality of learning environment and teacher effectiveness. Additionally, although learning environment research exhibited a remarkable growth across the world over the past few decades (Fraser, 2002), it is relatively new in Turkey that only a few studies examined CLE in science education in the last decade (Arisoy, 2007; Rakici, 2004). Of these studies, some explored the relationship between CLE and students’ self-regulation (Sungur & Gungoren, 2009). However, to authors’ knowledge, none of these studies in Turkey examined the role of teacher effectiveness on the relationship between CLE and science learning self-regulation. As stated above, although it is commonly stated that teachers have an important role in students’ learning processes, few studies empirically examined this relationship. In science education, previous studies examining the influence of class or teacher variables on student outcomes have rarely used appropriate analysis methods to take nested data structure into consideration (Tas, Sungur, & Oztekin, 2016; Xin, Xu, & Tatsuoka, 2004). Similarly, in CLE research, while there has been an increasing attention among the researchers to employ hierarchical linear modeling (HLM) analysis method (den Brok et al., 2006), relatively few studies have applied this method in self-

regulation research (e.g. Pamuk, Sungur, & Oztekin, 2017; Peters, 2013; Yildirim, 2012). The data set obtained out of the students in the present study has a nested structure. In other words, students are nested in the classrooms. Therefore, students' responses to the instrument might be influenced by their classmates, which should be taken into consideration to obtain more precise results from the analyses. It has been considered to be essential to employ multilevel analysis methods when the structure of the data is nested (Raudenbush & Bryk, 2002). Moreover, multi-level analysis methods make it possible to test the cross-level interactions among the variables (Raudenbush & Bryk, 2002). In the present study, although these six aspects of self-regulation may together form a latent variable of self-regulation as they have some covariance, it was considered that the predictor variables may have differential predictive power on different aspects of self-regulation. Thus, using a latent variable to represent self-regulation would not provide detailed information as each aspect is conceptually different from each other. Therefore, it was decided to conduct separate HLM analysis with each aspect of self-regulation.

Additionally, the present study specifically focused on the science domain since self-regulation variables are strongly subject specific (Bong, 2001; Wolters & Pintrich, 1998). According to Wolters and Pintrich (1998), there are mean level differences in the motivational and cognitive components of self-regulated learning across different domains. Therefore, it is thought that the relation of students' self-regulation to teacher effectiveness and CLE are different than those in different domains such as language and math course. Results of many international studies such as Programme for International Student Assessment (PISA) 2009 (Ministry of National Education of Turkey [MONE], 2010) and Trends in International Mathematics and Science Study (TIMSS) 2007 (MONE, 2011) showed that the average science achievement score of students from Turkey were below the average score of participating countries. By aiming to increase students' achievement in science, Turkish science education curriculum has been revised in 2004 (MONE, 2005). The new science curriculum mainly focuses on student centered learning in which students take active role in their learning and responsible for constructing their understanding. Accordingly, the present curriculum is suggesting various strategies including self-regulation strategies. Therefore, examining the factors that are helpful to increase students' use of this self-regulation in learning science is expected to contribute to our understanding of the nature of students' science learning in Turkey.

In sum, this study aimed to contribute to the literature by examining the role of teacher effectiveness and perceived CLE in students' self-regulation, by extending the learning environment research in Turkey, and by being science subject specific. In addition to this comprehensive approach, multilevel analysis methods were used to obtain more robust results. Accordingly, the main research question that guided this current study is presented as follows: *To what extent do perceived classroom learning environment and teacher effectiveness (i.e. occupational well-being and beliefs) predict students' self-regulation in learning science?*

The proposed model for this research question is presented in Fig. 1. Arrows are presented from predictors to outcome variables and do not indicate causal relationships. Dashed arrows indicate interaction of level 1 and level 2 variables).

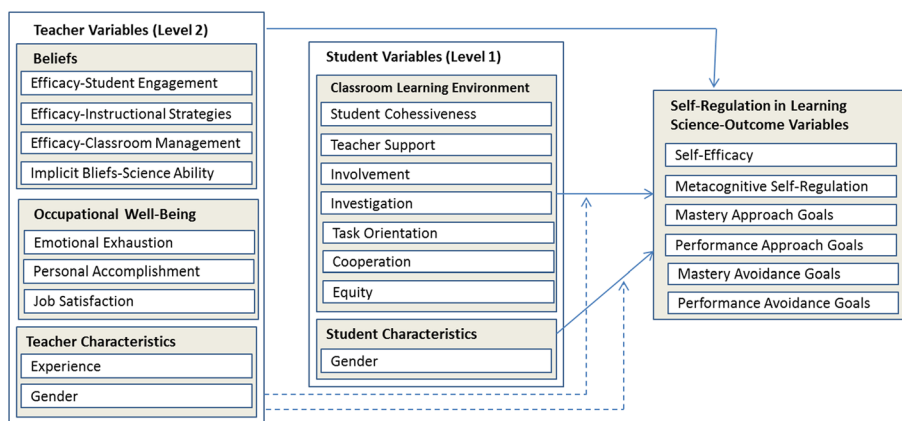


Fig. 1 The hypothetical model representing the interrelationships among self-regulation variables, CLE variables (level 1) and teacher variables (level 2)

Method

Participants

Sample of this study includes teachers and student participants. Two-stage simple random selection method was used to select the best representative sample of Turkish 7th grade students and science teachers. Accordingly, 400 out of 10,137 elementary public schools located in city centers and districts in Turkey were randomly selected from the national school list and one of the science teachers at these schools was also randomly selected. Having determined the teachers, one of each teacher's 7th grade classes was randomly selected; all students in these classes also participated in this study. With the contribution of Education Research and Development Department of National Ministry of Education, questionnaires for science teachers and students were sent to the selected schools by mail. Valid data were obtained out of 372 science teachers (46.2% males, 53.8% females) and their 8198 (55.9% female, 43.8% male, and 0.3% missing) 7th grade students. Ages of the participant teachers ranged from 22 to 65 ($M=35.92$, $SD=9.23$), and their experiences ranged from 1 to 38 ($M=12.07$, $SD=8.69$). Additionally, average student number in their classrooms was 29.41 ($SD=6.932$) and average weekly course hours of teachers was 23.24 ($SD=4.73$). Moreover, average age of student sample was 13.15 ($SD=0.48$) and the average of their science grade of previous semester was 3.66 ($SD=1.12$).

Data Collection Instruments

In this study, two different sets of instruments were used: one set was for students and the other was for teachers. Cronbach's alpha coefficients calculated for each subscale were presented in Table 1 and indicating that all scales have sufficiently high internal consistency.

Instruments for Students

Motivated Strategies for Learning Questionnaire Self-efficacy and metacognitive self-regulation subscales of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) were used to assess students' self-efficacy and metacognitive self-regulation in science, respectively. The MSLQ is a 7-point Likert type scale ranging from 1 (not at all true of me) to 7 (very true of me). Sample item for self-efficacy is "I'm confident I can understand the basic concepts taught in science course" and for metacognitive strategy use is "When studying for science course I try to determine which concepts I don't understand well".

What Is Happening in This Class Questionnaire Perceived CLE in science class was assessed by students' responses to WIHIC questionnaire (Fraser, Fisher, & McRobbie, 1996). WIHIC questionnaire consists of 56 items in 7 subscales, namely student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity. Each factor includes eight items. Students were asked to rate each item based on 5-point Likert scale ranging from 1 (never) to 5 (always). Higher points obtained from this scale indicate perception of higher quality of learning environment. A sample item is "The teacher takes a personal interest in me."

Achievement Goal Questionnaire Achievement Goal Questionnaire (AGQ), based on 2×2 achievement goal theory, was developed by Elliot and McGregor (2001). It consists of four factors: mastery-approach (three items), mastery-avoidance (three items), performance-approach (three items), and performance-avoidance (six items). The response scale is ranging from 1 (not at all true of me) to 5 (very true of me). A sample item includes "In science class, I want to learn as much as possible."

Instruments for Teachers

Teachers' Sense of Self Efficacy Scale Teaching self-efficacy of science teachers was assessed by the short form (12 items) of Teachers' Sense of Self Efficacy Scale (TSES) developed by Tschannen-Moran and Hoy (2001). TSES consists of three subscales: efficacy for student engagement (e.g. "How much can you do to motivate students who show low interest in schoolwork?"), efficacy for instructional strategies (e.g. "To what extent can you use a variety of assessment strategies?") and efficacy for classroom management (e. g. "How much can you do to control disruptive behavior in the classroom?") The TSES is a 9-point Likert scale ranging from "1 = nothing" to "9 = a great deal".

Implicit Theory of Science Ability Scale Science teachers' beliefs about whether students' ability in science can change or not were measured by adapting Implicit Theory of Intelligence-Others Form for Adults Scale (ITIS) (Dweck, 1999, p.178). The revised ITSAS with three items on a 6-point Likert scale was constructed by substituting the term "intelligence" with "science ability." Incremental theory items were not included in this study as mostly preferred by researchers (see Hong, Dweck, Chiu, Lin, & Wan, 1999). A sample item is "People have a certain amount of science ability and they

really cannot do much to change it.” The high scores on this scale indicate the belief that students' science ability is not fixed and can change.

Maslach Burnout Inventory To assess the burnout level of science teachers, emotional exhaustion (nine items; e.g. “I feel burned out from my work”) and personal accomplishment (eight items; e.g. “I deal very effectively with the problems of my students”) subscales of Educator Survey version of Maslach Burnout Inventory (MBI) (MBI-ES; Maslach & Jackson, 1981) was utilized. The MBI-ES was on a 5-point Likert scale ranging from 0 (never) to 4 (always). Higher scores on emotional engagement and lower scores on personal accomplishment are indicators of higher level of burnout.

Teacher Job Satisfaction Teachers' overall satisfaction about their job was measured by using a three-item 5-point Likert scale developed by Skaalvik and Skaalvik (2010). A sample item is “All things considered how much do you enjoy working as a teacher.” Higher scores on this scale indicate higher job satisfaction of science teachers.

Results

Descriptive Statistics

Descriptive statistics from students' data (Table 1) showed that mean scores on 7-point self-efficacy and metacognitive self-regulation strategies showed that 7th grade students had high level of confidence in learning science topics and tend to use metacognitive strategies in learning science topics at high levels. Regarding students' mean scores on achievement goal variables, it can be inferred that 7th grade students tend to set goals in science course as mastering task and deep understanding rather than avoiding from misunderstanding and not be able to mastering the task. Moreover, descriptive statistics also suggested that students perceived their learning environment as highly task oriented, cohesive, and equitable, but less teacher supportive and encouraging for investigation. Regarding teacher self-efficacy, science teachers had highest mean score on instructional strategies. Additionally, mean scores for student engagement and classroom management were also above the midpoint 5. The level of their implicit beliefs about ability implied that teachers generally believed that individuals' can increase their ability to learn science. Furthermore, mean scores of occupational well-being variables implied that science teachers had high level of satisfaction from their work and feel successful in job, while they reported low level of emotional exhaustion. These findings suggested that Turkish science teachers experienced high level of occupational well-being.

Inferential Statistics

Before conducting HLM analyses, all continuous variables were standardized to mean = 0 and SD = 1 (i.e. transformed to z scores) to make interpretations and comparison of regression coefficients of variables scaled in different intervals. Therefore, coefficients can be interpreted as standard deviation units, similar to the interpretation of a beta coefficient in ordinary least squares regression analyses. Additionally, student level continuous variables were grand mean centered and students' and teachers' gender

Table 1 Descriptive statistics, Cronbach's alphas, and ICCs

Student variables (level 1)		<i>M</i>	<i>SD</i>	Scale	Cronbach's alpha	ICC (ρ)
Self-regulation	Self-efficacy	5.23	1.27	1 – 7	0.93	0.11
	Metacognitive SR	5.07	1.22	1 – 7	0.89	0.08
	Mastery-approach	4.53	0.65	1 – 7	0.76	0.06
	Performance-approach	4.35	0.76	1 – 7	0.73	0.04
	Mastery-avoidance	3.74	0.99	1 – 7	0.73	0.03
	Performance-avoidance	3.97	0.81	1 – 7	0.77	0.05
Classroom learning environment	Student cohesiveness	4.04	0.64	1 – 5	0.78	
	Teacher support	3.61	0.91	1 – 5	0.88	
	Involvement	3.74	0.82	1 – 5	0.86	
	Investigation	3.63	0.86	1 – 5	0.88	
	Task orientation	4.25	0.63	1 – 5	0.81	
	Cooperation	3.78	0.77	1 – 5	0.84	
	Equality	3.99	0.83	1 – 5	0.88	
Teacher variables (level 1)						
Experience	Years of teaching	12.07	8.69	1 – 38		
Beliefs						
	Self-efficacy					
	Student engagement	6.52	1.09	1 – 9	0.76	
	Instructional strategies	7.40	0.94	1 – 9	0.80	
	Classroom management	6.99	1.08	1 – 9	0.85	
Implicit beliefs	Science ability	4.08	1.22	1 – 6	0.84	
Occupational well-being burnout	Emotional exhaustion	1.37	0.746	0 – 4	0.87	
	Personal accomplishment	3.16	0.428	0 – 4	0.77	
Job satisfaction	Job satisfaction	4.11	0.943	1 – 5	0.87	

variables were dummy coded: 0 = male, 1 = female. Firstly, six separate one-way random effects ANOVA models (null models) were built by using each dimension of self-regulation as an outcome variable. Intraclass correlation coefficients (ICC) computed by dividing second level variance (τ_{00}) to the overall variance ($\tau_{00} + \sigma^2$) were found to be ranging between 0.03 and 0.11 (see Table 1). After this step, model building strategies suggested by Raudenbush and Bryk (2002) were followed during the analysis process for each self-regulation variable, separately. Deviance analyses were also conducted to test whether each predictor variable significantly contribute to the model by comparing deviance statistics obtained from models before and after adding a particular predictor variable. Results of the final full models obtained for these six dependent variables are presented in Table 2. Findings for each dependent variable are explained below, separately.

Predicting Students' Self-efficacy Students' average *self-efficacy* was found to be positively related to teachers' *emotional exhaustion* ($\gamma = 0.032$) and *personal*

Table 2 Results of the HLM models for predicting students' self-regulation variables

	γ	SE
a. Results for self-efficacy		
Intercept	− 0.007	0.014
Emotional exhaustion	0.032*	0.014
Personal accomplishment	0.047**	0.015
Student cohesiveness	0.028*	0.011
Teacher support	0.021	0.014
Involvement	0.169***	0.014
Investigation	0.142***	0.015
Task orientation	0.348***	0.013
Experience	− 0.029**	0.010
Personal accomplishment	0.026*	0.011
Cooperation	− 0.116***	0.013
Equity	0.119***	0.014
Efficacy for IS	− 0.021*	0.010
	Level 1	Level 2
Explained variance	0.401	0.041
Residual variance	0.533	0.047
b. Results for metacognitive self-regulation		
Intercept	− 0.092***	0.016
Experience	− 0.034**	0.013
Personal accomplishment	0.039**	0.013
Gender-student	0.166***	0.019
Efficacy for IS	− 0.030*	0.015
Student cohesiveness	0.043***	0.011
Teacher support	0.031**	0.012
Involvement	0.059***	0.014
Investigation	0.290***	0.014
Efficacy for IS	− 0.025*	0.010
Task orientation	0.324***	0.013
Cooperation	− 0.059***	0.012
Equity	0.073***	0.013
	Level 1	Level 2
Explained variance	0.441	0.073
Residual variance	0.512	0.038
c. Results for mastery-approach goals		
Intercept	− 0.062***	0.015
Gender-student	0.124***	0.018
Experience	− 0.024*	0.012
Student cohesiveness	0.047***	0.011
Teacher support	0.008	0.013
Involvement	0.010	0.014
Task orientation	0.497***	0.014
Cooperation	− 0.028*	0.012
Equity	0.153***	0.014

Table 2 (continued)

	γ	SE
	Level 1	Level 2
Explained variance	0.461	–
Residual variance	0.484	0.026
d. Results for performance-approach goals		
Intercept	– 0.042*	0.017
Gender-student	0.086***	0.020
Student cohesiveness	0.033**	0.012
Involvement	0.020	0.015
Task orientation	0.370***	0.014
Efficacy for SE	– 0.044**	0.013
Job satisfaction	0.033**	0.013
Equity	0.066***	0.015
Efficacy for IS	0.037**	0.014
Personal accomplishment	– 0.028*	0.014
	Level 1	Level 2
Explained variance	0.233	–
Residual variance	0.714	0.021
e. Results for mastery-avoidance goals		
Intercept	– 0.065***	0.019
Gender-student	0.117***	0.023
Efficacy for SE	– 0.039*	0.017
Involvement	– 0.047**	0.017
Investigation	0.012	0.017
Task orientation	0.114***	0.014
Cooperation	0.178***	0.015
	Level 1	Level 2
Explained variance	0.079	–
Residual variance	0.884	0.035
f. Results for performance-avoidance goals		
Intercept	– 0.000	0.019
Gender-student	0.013	0.023
Student cohesiveness	0.043**	0.014
Involvement	– 0.044**	0.015
Task orientation	0.213***	0.016
Efficacy for CM	– 0.026*	0.013
Cooperation	0.143***	0.015
Equity	0.062***	0.016
	Level 1	Level 2
Explained variance	0.165	–
Residual variance	0.785	0.039

In each model, predictors which have nonsignificant fixed and random effects on an outcome variable were excluded from the final model. Only predictors in final model were included in the table

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

accomplishment ($\gamma = 0.047$). Moreover, *student cohesiveness* ($\gamma = 0.028$), *Involvement* ($\gamma = 0.169$), *investigation* ($\gamma = 0.142$), *task orientation* ($\gamma = 0.348$), and *equity* ($\gamma = 0.119$) were positively associated with *self-efficacy*. However, *cooperation* ($\gamma = -0.116$) was found as negatively related to *self-efficacy*. Results also yielded some cross-level interactions. Firstly, the *task orientation* slope coefficient model had two significant class level variables: *experience* ($\gamma = -0.029$) and *personal accomplishment* ($\gamma = 0.026$). Secondly, science teachers' *efficacy for instructional strategies* ($\gamma = -0.021$) moderated the effect of students' perceptions of *equity* in science class with *self-efficacy*.

Predicting Metacognitive Self-regulation Students' average score on *metacognitive self-regulation* was positively related to teachers' *personal accomplishment* ($\gamma = 0.039$) but negatively associated with *experience* ($\gamma = -0.034$). Additionally, among the eight level 1 variables: *gender* ($\gamma = 0.166$), *student cohesiveness* ($\gamma = 0.043$), *teacher support* ($\gamma = 0.031$), *involvement* ($\gamma = 0.059$), *investigation* ($\gamma = 0.290$), *task orientation* ($\gamma = 0.324$), and *equity* ($\gamma = 0.073$) were positively but *cooperation* ($\gamma = -0.059$) was negatively related to *metacognitive self-regulation*. Results also indicated some cross-level interactions: *efficacy for instructional strategies* was found as significant predictor of *gender* ($\gamma = -0.030$) and *investigation* ($\gamma = -0.025$) slope coefficient model.

Predicting Mastery-Approach Goals None of the level 2 variables significantly predicted students' average score on *mastery-approach goals*. Among the level 1 variables, *gender* ($\gamma = 0.124$), *student cohesiveness* ($\gamma = 0.047$), *task orientation* ($\gamma = 0.497$), and *equity* ($\gamma = 0.153$) were positively but *cooperation* ($\gamma = -0.028$) was negatively related to *mastery-approach goals*. Regarding cross-level interaction, *gender* slope coefficient model was found significantly associated with *experience* ($\gamma = -0.024$).

Predicting Performance-Approach Goals None of the level 2 variables significantly predicted students' average score on *performance-approach goals*. Moreover, results showed that among the eight level 1 variables, *gender* ($\gamma = 0.086$), *student cohesiveness* ($\gamma = 0.033$), *task orientation* ($\gamma = 0.370$), and *equity* ($\gamma = 0.066$) were positively and significantly related to *performance-approach goals*. Regarding moderation effects, *task orientation* slope coefficient model was found significantly associated with *efficacy for student engagement* ($\gamma = -0.044$) and *job satisfaction* ($\gamma = 0.033$). Moreover, *efficacy for instructional strategies* ($\gamma = 0.037$) and *personal accomplishment* ($\gamma = -0.028$) were also found to be significant predictors of the *equity* slope coefficient model.

Predicting Mastery-Avoidance Goals Results showed that none of the level 2 variables significantly predicted students' average score on *mastery-avoidance goals*. At level 1, *gender* ($\gamma = 0.117$), *involvement* ($\gamma = -0.047$), *task orientation* ($\gamma = 0.114$), and *cooperation* ($\gamma = 0.178$) were significantly and positively related to *mastery-avoidance goals*. Additionally, *efficacy for student engagement* ($\gamma = -0.039$) moderated the relationship between *gender* and *mastery-avoidance goals*.

Predicting Performance-Avoidance Goals Students' average score on *performance-avoidance goals* was not found to be significantly associated with any of the class

level variables. Moreover, at level 1, *student cohesiveness* ($\gamma = 0.043$), *involvement* ($\gamma = -0.044$), *task orientation* ($\gamma = 0.213$), *cooperation* ($\gamma = 0.143$), and *equity* ($\gamma = 0.062$) were found to be significantly related to *performance-avoidance goals*. *Efficacy for classroom management* ($\gamma = -0.026$) was moderated the relationship between *performance-avoidance goals* and *task orientation*.

Discussion

This study seeks to examine to what extent classroom learning environment and teacher effectiveness play a role in students' self-regulation. Results of one-way ANOVA models showed that significant variations did exist among the classes for each component of self-regulation. Therefore, it seemed reasonable to conduct HLM analyses. ICCs indicated that majority of students' perceptions of self-regulation are predicted by student level variables rather than class level variables. Finding small percent (3 – 11%) of variances due to class differences is not surprising when working with psychological constructs (e.g. Peters, 2013; Tas, 2008; Yildirim, 2012). HLM analyses with self-regulation components revealed that at student level, most of the CLE dimensions were significantly associated with students' self-regulation in learning science. These findings supported Haertel, Walberg, and Haertel's (1981) meta-analysis study indicating that student's perception of CLE was a good predictor of students' cognitive, affective, and behavioral outcomes.

Predicting Students' Self-Efficacy

Current results reveal that if students perceive CLE as more cohesive (cohesiveness) and involve in the classroom discussions, participate in classroom activities (involvement), have inquiry skills, and be able to use them in problem solving (investigation), they tend to develop higher confidence in learning science. Task orientation, among the all predictors, was the best predictor of the students' self-efficacy beliefs ($\gamma = 0.348$). Students who accomplish planned activities, carefully follow the class, and know the goals of the course (task orientation) are likely to be more self-efficacious in learning science. This finding was also consistent with related literature (Dorman, 2001; Dorman et al., 2003). Results also revealed that in the classrooms where students get equal learning opportunities, praise, help, and encouragement from science teacher (*equity*), students are more likely to develop higher confidence in learning science. These findings are in line with Dorman's (2001) and Dorman et al.'s (2003) studies which found positive association between self-efficacy and equity. Surprisingly, current findings also revealed that the association between student's self-efficacy and equity is weaker in the classrooms taught by the teachers who have higher confidence in using variety of instructional strategies to foster students' science learning. This finding can be explained as follows: in classrooms, there might be some situations in which teacher should use different instructional strategies to facilitate the learning of a group (or individual) of students. For example, if a student has a difficulty in solving a science problem because of his/her low ability in making calculations, teacher might give permission to this student to use a calculator. Furthermore, the teacher may mostly

communicate with and pay attention to the less able students. Thus, although using these kinds of instructional strategies might be perceived as less equal learning opportunities by the students, students of these teachers may develop higher self-efficacy. A considerable amount (40%) of the level 1 variance was accounted for these variables.

At the class level, science teachers' emotional exhaustion and personal accomplishment significantly predicted students' self-efficacy for learning science. Although these two variables are indicators of burnout, Maslach and Jackson (1981) stated that personal accomplishment dimension was independent of emotional exhaustion, and they cannot be regarded as the opposite constructs. Despite the lack of empirical studies examining this association, some researchers reported negative association between teacher burnout and students' affective outcomes (e.g. Klusmann et al., 2008; Maslach & Leiter, 1999). However, positive association found between emotional exhaustion and student self-efficacy was unexpected. A possible explanation to this finding based on Maslach and Leiter's (1999) reciprocal model is that some teachers might exert extra effort in teaching to be successful, such as spending more time with students, doing extra works, showing more interest to students' problems, and investing much into their teaching. While these teacher behaviors may contribute to teachers' feeling of emotionally frustrated, they are also potential factors to enhance students' confidence in learning science. Additionally, the influence of these teacher variables on students' self-efficacy was quite small (4%), which supports the findings of the literature review study by Klassen et al. (2011).

Results also showed that the association between task orientation and self-efficacy was moderated by teachers' experience and personal accomplishment. It suggested that, while the other variables were controlled, in the classrooms that were taught by more experienced science teachers, this association became weaker. Conversely, in the classrooms that were taught by the teachers who felt higher accomplishment in work, the relation of task orientation to student self-efficacy was stronger. These variables explained about 13% of the variation between classes in the relationship between self-efficacy and task orientation.

Predicting Students' Metacognitive Self-regulation

The results indicate that students are more likely to use metacognitive learning strategies in science classes where they have close relationships with classmates, involve in classroom discussions, do more inquiry, have problem solving skills, are more task oriented, have equal learning opportunities with the other students in the same classroom, and receive more support from teacher. CLE variables and gender explained 44% of the level 1 variance in the metacognitive strategy use. Among the CLE perception variables, task orientation was found to be the best predictor of using metacognitive learning strategies ($\gamma = 0.324$). Overall, these results suggested that in high-quality science CLE, students tended to use metacognitive strategies at higher levels. This finding has also been supported by several studies in Turkey (Sungur & Gungoren, 2009; Yilmaz-Tuzun & Topcu, 2010).

Additionally, female students were found to be better at planning, monitoring, and regulating their learning processes in science classes than males. Although previous

research yielded inconsistent results, the present study supports the findings of some research indicating that female students use metacognitive learning strategies more than males (Topcu & Yılmaz-Tuzun, 2009). Results of this study also showed that in the classrooms taught by the teachers with higher efficacy for instructional strategies, the association between gender and metacognitive self-regulation was weaker. It seems that using a variety of instructional strategies in science class, teacher could eliminate the gender gap in students' use of metacognitive strategies.

Another cross-level interaction was found for investigation: teachers' efficacy for instructional strategies weakened the association between metacognitive self-regulation and investigation. Although the effects were low (about 6%), this finding was surprising. A possible reason for this unexpected result might be that in these classes, besides investigation, students' metacognitive skills may also be improved by using different instructional methods. However, further research is needed to have a clear understanding of the underlying reasons.

At class level, 7% of the between-class variance was explained by teacher variables. Firstly, teacher experience was negatively associated with metacognitive self-regulation. This finding suggested that in the classrooms taught by inexperienced teachers, students are more likely to use metacognitive learning strategies. The educational reform of 2004 in Turkey resulted in great changes in elementary school science curriculum. While the previous curriculum was mostly teacher centered, the new curriculum is based on constructivist philosophy which focuses on students' active construction of knowledge and making inquiry. The innovations were simultaneously integrated into the teacher training programs in higher education; however, elementary science teachers were not provided with sufficient in-service teacher training programs (Tekbiyık & Akdeniz, 2008). Therefore, even when the curriculum changes, the experienced teachers may not easily give up the conventional methods that they use in the classroom over the years (Tekbiyık & Akdeniz, 2008), and in turn, they may fail to implement innovations and new strategies in their classrooms. Accordingly, they may not be as successful as novice teachers in encouraging students to plan, monitor, and evaluate the processes when constructing their knowledge in science. The other significant class variable was personal accomplishment. This result was expected because high level of personal accomplishment reflects the degree of teachers' positive evaluation of their performance and feeling energetic when teaching. Although there is a lack of studies directly examining the relation of teachers' personal accomplishment to students' metacognition, past research associated lower level of burnout with the positive student outcomes (Klusmann et al., 2008).

Predicting Students' Achievement Goals

At student level, task orientation had the most powerful effect on students' adoption of achievement goals. The highest influence of task orientation was on mastery-approach goals. Therefore, it might be suggested that students who perceive science classroom more task oriented are more likely to study to master a task and learn the subject. Equity and student cohesiveness were also found positively and significantly associated with achievement goals (except mastery-avoidance goals). These findings revealed that perceived CLE has a considerable predictive power in explaining students' achievement goals for science learning, as explained variances were ranged between 46%

(mastery approach) and 8% (mastery avoidance). It should be noted that CLE has the most influential effect on adopting mastery oriented goals. In general, this finding supports the previous studies which explored the influence of CLE on achievement goals (e.g. Ames, 1992; Sungur & Gungoren, 2009).

As for the gender-achievement goal relation, although literature has mostly yielded mixed results, this study supports the findings of some studies in which female students reported higher mastery-approach goals (Arisoy, 2007; Gherasim, Butnanu, & Mairean, 2012) and higher performance-approach goals (Tas, 2008), and in which no gender difference was found for performance-avoidance goals (Elliot & McGregor, 2001). On the other hand, some cross-level interactions were found for gender. Firstly, in the classrooms taught by more experienced teachers, the difference between female and male students' setting mastery-approach goals got smaller. Moreover, when students were taught by a teacher with higher efficacy for student engagement, the difference between female and male students' mastery-avoidance goals got smaller. This result is reasonable in the sense that since the teacher with a strong efficacy belief in student engagement feels confident in motivating all the students to learn science and creating a classroom climate that encourages all the students to do well in the class (Tschannen-Moran & Hoy, 2007), they tend to take individual differences into consideration to facilitate all students' learning. Thus, they may alleviate the gender difference in the classroom in terms of mastery-avoidance goal setting.

At the class level, results of HLM analyses revealed that none of the class level variables were significantly associated with the class mean variations in each achievement goal type, while some interactions were found. For example, in the classrooms taught by the teachers with strong efficacy beliefs for classroom management, the association between task orientation and performance-avoidance goals was found to be weaker than in the classrooms taught by the teachers with low efficacy belief for classroom management. For performance-approach goals and CLE relationships, four teacher variables were found as moderator. More specifically, results indicated that in the classrooms taught by the teachers with lower self-efficacy for engaging all the students or with higher job satisfaction, the influence of students' perception of task orientation on their setting performance-approach goals was higher. Besides, in the classrooms taught by the teachers who have higher self-efficacy for instructional strategies or have low personal accomplishment, the relationship between performance-approach goals and equity gets higher. These findings indicated that these teacher variables have very low moderation effects. Overall, results concerning the class (or teacher) level variables indicated that teacher characteristics do not play a very important role in students' adoption of achievement goals. Although their effects were very small, dimensions of teachers' self-efficacy beliefs, job satisfaction, personal accomplishment, and experience took some roles in moderating the relation of student gender and perceived CLE to achievement goals.

Implications

The results of this study indicated that the quality of perceived science CLE has substantial influence on students' self-regulation processes in learning science. Since

the aspects of CLE reflect the latest issues and innovations in science education, providing such a learning environment will enhance their service to students and improve the teaching and learning process in the classroom.

These results might provide some implications for science teacher educators as well. It might be suggested that pre-service science teachers need to be trained about how to create such a qualified CLE. In this respect, undergraduate courses with a specific focus on these aspects of CLE might be offered in teacher education programs. Moreover, strategies to create such a learning environment might be frequently emphasized in methodology courses. Pre-service teachers might also be encouraged to implement these strategies into their macroteaching in the teaching practice course, and through effective feedback, they might get well-informed about the dimensions of CLE addressed in the present study. Additionally, Turkish science teachers should be aware of the fact that female students have different self-regulation profiles than male students.

Literature on teacher quality has assumed strong influence of teacher characteristics on students' learning outcomes. However, teacher variables in the present study were found to have little influence on students' self-regulation processes. Anyway, among all teacher variables, subdimensions of teacher self-efficacy were found to be the most influential variables on self-regulation components. Additionally the moderator role of teacher self-efficacy should not be ignored when examining the linkage between CLE and self-regulation variables. Therefore, the results of this study are expected to provide guidance for further investigations. Additionally, considering these relations, there should be some regulations in pre-service and in-service science teacher training programs to foster their efficacy beliefs toward teaching science. For example, during the teaching practice course, in order to develop high level of teaching efficacy, preservice science teachers can be provided effective mentoring and given opportunities for teaching in the real classroom settings (Wan, 2005). Besides, a replication study might be carried out to generalize the results of this current study. Last but not least, different teacher variables need to be studied with student outcomes to assess their relation.

Limitations and Recommendations

The present study has also some limitations and recommendations. Firstly, since it is a cross-sectional study, it does not provide causal relationships. Secondly, the data rely on the students' and teachers' self-report. Therefore, classroom observations, diary writing, and think aloud methods might be beneficial for deeper understanding of these relations. Besides, since these variables have been rarely studied together in the studies across the world, it would be interesting to design and conduct replication studies in other countries, in other domains, and with other grades which might contribute to the generalizability of the results as well as our understanding of the issue under investigation. Here we need to point out that the six aspects of self-regulation would form a latent variable as they have some covariance. However, in order to obtain more detailed information for each variable, analyses were conducted separately for each aspect. As it was presumed, each model has presented different relationships which would be ignored if a latent variable was used.

Finally, researchers should be aware of the possible suppression effect when they use WIHIC questionnaire and AGQ. In this study, it should be noted that, from the statistical perspective, some unusual associations were found between some variables. Namely, for the variable pairs cooperation and self-efficacy, cooperation and metacognitive self-regulation, cooperation and mastery-approach goals, involvement and mastery-avoidance goals, and involvement and performance-avoidance goals, comparison of the correlation coefficient obtained from simple correlation analysis and standardized beta coefficient obtained from HLM analysis yielded opposite signs. These associations might point to the presence of negative suppression effect which “occurs when the sign of a regression weight of an IV is the opposite of what would be expected on the basis of its correlation with the DV” (Tabachnick & Fidell, 2007, p. 155). Suppression effect emerges when independent variables were highly correlated with each other, but weakly correlated with dependent variables. The similar suppression effects are seen in previous research that conducted multiple regression analysis with CLE variables (Dorman, 2001; Dorman et al., 2003; Wolf & Fraser, 2008) and achievement goal variables (Lau, Liem, & Nie, 2008). According to Pandey and Elliot (2010), excluding suppressor variable from a model may yield underestimated regression coefficients of the suppressed variables, decrease the predictive power of the model, and increase the probability of making type II error. A suppressor variable serves as an irrelevant variance cleaner, that is, it removes the outcome-irrelevant variation in another independent variable which may mask that variable's actual relationship with the dependent variable. Considering that, researchers should carefully interpret the results and inform the readers about this issue to avoid misinterpretations of unexpected results. Therefore, we avoided especially interpreting these abovementioned relations.

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