Journal of Educational Psychology
2018, Vol. 110, No. 2, 269–288

0022-0663/18/$12.00 http://dx.doi.org/10.1037/edu0000214

Daily Autonomy Supporting or Thwarting and Students' Motivation and Engagement in the High School Science Classroom

Erika A. Patall, Rebecca R. Steingut, Ariana C. Vasquez, Scott S. Trimble, Keenan A. Pituch, and Jen L. Freeman
University of Texas at Austin

This diary study provided the first classroom-based empirical test of the relations between student perceptions of high school science teachers' various autonomy supporting and thwarting practices and students' motivation and engagement on a daily basis over the course of an instructional unit. Perceived autonomy supporting practices were hypothesized to predict autonomous motivation and engagement outcomes, while perceived autonomy thwarting practices were hypothesized to predict controlled motivation and disaffection outcomes. In line with this prediction, multilevel modeling results based on regular reports of 208 high school students in 41 science classes across 6 weeks suggested that 4 perceived daily supports (choice provision, consideration for student preferences and interests, rationales for importance, and question opportunities) and 1 daily thwart (use of uninteresting activities) predicted changes in daily autonomous motivation and engagement. In contrast, changes in students' daily controlled motivation and disaffection were predicted primarily by 3 perceived daily thwarts (controlling messages, suppression of student perspectives, and use of uninteresting activities). Results also suggested that practices interacted such that the perception of thwarts generally bolstered desirable daily relationships between perceived supports and students' motivation and the perception of supports generally mitigated undesirable daily relationships between thwarts and motivation. Supplemental exploratory results suggested that the effects of choice and suppression of student perspectives may be heterogeneous and depend on the outcome and/or the presence of other practices. Implications of the findings are discussed.

Educational Impact and Implications Statement

The results of a 6-week classroom-based diary study with 208 high school students in 41 science classes suggested that students' autonomous motivation and engagement increased (since the prior class day) on days when students perceived their teachers to support their autonomy by providing choices, considering their preferences and interests in course activities, communicating rationales for the importance of activities, providing opportunities to ask questions, or avoiding uninteresting activities. In contrast, controlled motivation and disaffection increased on days when students' perceived their teachers to thwart their autonomy by using controlling messages, suppressing student perspectives, or using uninteresting activities. Students' perceptions that teachers' used thwarting practices simultaneously with supportive practices bolstered the desirable relationship between perceived supports and motivation, and mitigated the undesirable relationship between thwarts and motivation. Results suggest the importance of focusing motivation interventions on training high school teachers to implement specific daily practices geared at supporting students' experience of autonomy and minimizing the use of specific thwarting practices to both promote autonomous motivation and engagement and reduce controlled motivation and disaffection. Results highlight the importance of targeting a profile of autonomy-relevant practices that teachers use each day when attempting to maximize student motivation and engagement.

Keywords: autonomy support, autonomy thwart, teaching practice, motivation, engagement

A distressing pattern consistently found in education research is that motivation and engagement decline across grades, with the lowest levels among high school students, and from the start to the end of the school year within secondary classrooms (e.g., Eccles et al., 1993; Harter, 1981; Lepper, Corpus, & Iyengar, 2005; Skinner Furrer, Marchand, & Kindermann, 2008). Moreover, the steepest declines may occur for science, technology, engineering, and mathematics (STEM) fields (e.g., Gottfried, Fleming, & Gottfried, 2001; Gottfried, Marcoulides, Gottfried, & Oliver, 2009), as the percentage of students studying and earning degrees in nearly all STEM fields has remained stable or declined over time (Maltese & Tai, 2011; Organization for Economic Co-operation and Development, 2006). This decline is troubling given extensive evidence that motivation and engagement are central to learning and achievement (e.g., Archambault, Janosz, Fallu, & Pagani, 2009; Hughes, Luo, Kwok, & Loyd, 2008; Lepper et al., 2005; Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2012; Willingham,

This article was published Online First June 5, 2017.

Erika A. Patall, Rebecca R. Steingut, Ariana C. Vasquez, Scott S. Trimble, Keenan A. Pituch, and Jen L. Freeman, Department of Educational Psychology, University of Texas at Austin.

This research was supported by a grant from the William T. Grant Foundation (Project 180042).

Correspondence concerning this article should be addressed to Erika A. Patall, who is now at Rossier School of Education, University of Southern California, 3470 Trousdale Parkway, Waite Phillips Hall, Los Angeles, CA 90089-4036. E-mail: patall@rossier.usc.edu

Pollack, & Lewis, 2002). Moreover, the increasing demand for individuals with knowledge in STEM areas in the current global marketplace (see, e.g., Bureau of Labor Statistics, 2011) make addressing low motivation and engagement in science classrooms particularly important.

Given these circumstances, an important goal of educational and psychological research is to understand how to structure teacher practices and the classroom environment to support students' motivation and engagement and prevent declines especially common at the secondary level and in STEM areas. A substantial body of research grounded in self-determination theory (Ryan & Deci, 2000) has suggested that teachers who are perceived to engage in practices that are supportive of students' experiences of autonomy facilitate optimal functioning in the form of autonomous motivation and engagement (e.g., Assor, Kaplan, & Roth, 2002; Patall, Dent, Oyer, & Wynn, 2013; Reeve & Jang, 2006; Reeve, Jang, Carrell, Jeon, & Barch, 2004). In contrast, controlling teacher practices that thwart students' experiences of autonomy predict controlled motivation, which is driven by external consequences, and maladaptive functioning (e.g., Assor et al., 2002; De Meyer, et al., 2014; Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015; Reeve & Jang, 2006). While autonomy supporting and thwarting is important across contexts, the increasing need for autonomy and independence as students enter adolescence (Eccles et al., 1993; Erikson, 1968) make understanding the effects of teachers' use of autonomy relevant strategies particularly important in the context of secondary school classrooms. Likewise, given that discovery and innovation, recognition of ambiguity, and learning from past discoveries and failure are all central values of science (e.g., Allchin, 1999; Bartos & Lederman, 2014; Kuhn, 1962), support for personal autonomy would seem to be particularly important to science education.

However, limitations in the research on students' experiences of autonomy relevant teaching persist. In particular, the individual practices thought to support or thwart autonomy have been given inadequate attention in research based in a classroom context (and in STEM classes in particular) beyond retrospective, single survey, and cross-sectional designs. Moreover, existing research has failed to investigate within academic classroom contexts the extent to which students' experiences of various individual autonomy supporting and thwarting practices predict distinct motivation and engagement outcomes and the extent to which students' perceptions of autonomy supporting and thwarting interact to affect motivation and engagement. The current study sought to address these gaps by investigating the links between high school science students' perceptions of several autonomy relevant teaching practices and their motivation and engagement in a diary study that made use of repeated daily student reports across a 6-week instructional unit. The two main goals of this investigation were: (a) to examine the relationships between students' perceptions of a set of teaching strategies routinely identified as autonomy supporting or thwarting with students' daily autonomous and controlled motivation, engagement, and disaffection in authentic high school science classrooms and (b) to explore the extent to which perceived supportive and thwarting practices interact to predict students' daily motivation and engagement. The chosen design in which perceived teacher practice and students' motivation and engagement was assessed repeatedly over class days provided an opportunity to collect strong evidence regarding the predictive role of daily perceptions of teacher practice in explaining students' daily motivation and engagement in class.

Teacher Practices That Support or Thwart Autonomy

According to self-determination theory, autonomy, or the experience that one's behavior is volitional and self-endorsed, is central to adaptive functioning and well-being as one of three fundamental human needs, along with needs for competence and relatedness (e.g., Ryan & Deci, 2000). The experience of being controlled is the logical opposite of autonomy, reflecting the perception that behavior is coerced by an external force (e.g., by a teacher's directive or an offer of a reward), is done out of feelings of pressure, obligation, or guilt, or is done because of a lack of choice. Along these lines, research suggests that satisfying the need for autonomy is associated with engagement, well-being, and highly desirable internal forms of motivation (e.g., intrinsic motivation), while experiencing frustration of the need for autonomy is associated with poorer well-being and less desirable forms of motivation that are focused on acquiring rewards or avoiding undesirable consequences (e.g., Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011; Haerens et al., 2015; Patall et al., 2013; Reeve & Jang, 2006).

Teachers' practices and more proximally, student perceptions of teacher practice, predict students' autonomy satisfaction or frustration, and in turn, the nature of their motivation, engagement, well-being, and achievement (e.g., Assor, Kaplan, Kanat-Maymon, & Roth, 2005; Assor et al., 2002; Haerens et al., 2015; Jang, Kim, & Reeve, 2012; Patall, Cooper, & Wynn, 2010; Patall et al., 2013; Reeve & Jang, 2006; Reeve et al., 2004; Skinner & Belmont, 1993; Soenens, Sirens, Vansteenkiste, Dochy, & Goossens, 2012). Autonomy support in the classroom context reflects a motivational approach in which teachers identify, nurture, and develop students' inner motivational resources so that students perceive themselves as the initiator of their actions (Reeve, 2009). Autonomy supportive teachers are conceptualized as offering choices, encouraging students to work in their own way or at their own pace, and open and responsive to students' opinions and questions. Although such teachers attempt to structure course activities around students' interests whenever possible, they also provide meaningful rationales to explain the usefulness or importance of even "boring" course activities (see Reeve, 2009; Reeve & Jang, 2006; or Su & Reeve, 2011 for a review of autonomy supportive practices).

In contrast, controlling teachers thwart autonomy in that they are perceived to be dismissive of student perspectives and to pressure students to think, act, or feel in particular ways (Reeve, 2009). Relatively fewer studies have addressed practices thought to thwart autonomy or students' perceptions of controlling practices. However, explicitly controlling language (e.g., "you must" or "you should"), commands that pressure students to act in teacher sanctioned ways, rationales that emphasize the external consequences of compliance, suppression of students' questions and opinions, and the assignment of activities that appear meaningless or uninteresting are routinely included among practices expected to thwart students' experiences of autonomy (e.g., Assor et al., 2002, 2005; Reeve, 2009; Reeve & Jang, 2006).

Differential Associations for Autonomy Relevant Teacher Practices

Autonomy support and control have often been conceptualized as being on opposite ends of a continuum. However, more recently, theory and research has increasingly suggested that controlling behaviors cannot by equated with infrequent acts of autonomy support. Rather, research now suggests that students' perceptions of practices that thwart autonomy have a rather modest negative correlation with perceived practices that support autonomy and yield distinct effects (e.g., Bartholomew et al., 2011; Haerens et al., 2015; Jang et al., 2016). While contexts that support autonomy unlock internal motivational resources that allow an individual to thrive, contexts that thwart autonomy can lead to defensive reactions that promote externally focused motivation and ill-being (Deci & Ryan, 2000). Consistent with this, Bartholomew and colleagues (2011) found that perceptions of autonomy-supportive coaching was most closely related to athletes' daily experiences of need satisfaction, and in turn, daily psychological well-being, while perceptions of controlling coaching was most closely related to daily need thwarting, and in turn, daily psychological and physical ill-being. Using a retrospective survey, Assor and colleagues (2002) found that students' perceptions that teachers provided choices and fostered students' understanding of the relevance of course activities primarily predicted emotional, cognitive, and behavioral engagement, while perceptions that teachers intruded on students' behavior and suppressed student perspectives primarily predicted students' negative affect. Also in retrospective, cross-sectional research, Haerens and colleagues (2015) found that perceptions of physical education teachers' autonomy support were primarily related to autonomous motivation via need satisfaction, while perceptions of physical education teachers' controlling practice was primarily related to controlled motivation and amotivation via need frustration. Finally, Jang and colleagues (2016) found that Korean high school students' perceptions that teachers supported their autonomy predicted changes in need satisfaction that predicted changes in engagement over the course of a school semester, while perceived teacher control predicted changes in need frustration and subsequent disengagement.

Implicit in these findings and our discussion is the differentiated view of motivation and engagement outcomes that motivation scholars have come to accept. Self-determination theory differentiates more autonomous and more controlled forms of motivation. Intrinsic and identified forms of motivation represent more autonomous forms in which the regulation of actions is incited by the inherent satisfaction, interest, or enjoyment that a task brings (intrinsic) or one's personal value for tasks (identified). Introjected and extrinsic motivation represent more controlled or external forms of motivation in which action is driven by internally controlling consequences such as feelings of guilt, shame, or pride (introjected) or the desire to obtain rewards and avoid punishment from the environment (extrinsic; e.g., Ryan & Deci, 2000). Moreover, autonomous forms of motivation (intrinsic and identified) are particularly desirable in the classroom because research has routinely indicated that they are linked with a variety of desirable and adaptive outcomes, including creativity, academic engagement, deep conceptual learning strategies, and academic achievement (e.g., Corpus, McClintic-Gilbert, & Hayenga, 2009; Lepper, Corpus, & Iyengar, 2005; Otis, Grouzet, & Pelletier, 2005; Walker, Greene, & Mansell, 2006). In contrast, more extrinsic forms of motivation (introjected and extrinsic) are often linked with negative outcomes, including maladaptive learning strategies and attitudes, anxiety, poorer ability to cope with challenges, poor academic achievement, and even school drop-out (e.g., Lepper et al., 2005; Ryan & Connell, 1989; Vansteenkiste, Zhou, Lens, & Soenens, 2005; Walker et al., 2006).

The contrast between engagement and disaffection represents a similar juxtaposition of more and less desirable functioning. Engagement is typically conceptualized as a motivational construct that has a behavioral dimension that includes effort, persistence, intensity, and perseverance in the face of obstacles, an emotional dimension that includes enthusiasm, enjoyment, fun, and other positive emotions, and a cognitive dimension that includes attention to and regulation of the learning and thinking process (e.g., Skinner, Kindermann, Connell, & Wellborn, 2009). The opposite of engagement is disaffection, disengagement, or helplessness. Disaffection is not merely low levels of engagement of the various types. Rather, it is often operationalized in its behavioral form as giving up, just going through the motions, passivity, and lack of initiation, and in its emotional form as boredom, apathy, frustration, discouragement, or dejection (e.g., Miceli & Castelfranchi, 2000; Skinner et al., 2009).

In line with this current conception of the nature of teachers' motivating style and students' classroom experience, the dual-process model within a self-determination theory framework (e.g., Jang, Kim, & Reeve, 2016) explicitly asserts this differentiated view of teacher practice, student motivation, and student engagement. That is, teachers' motivating practice reflects the distinct processes of both perceived autonomy support and perceived autonomy thwarting. Student motivation and engagement can likewise be differentiated into need satisfaction, autonomous motivation, and engagement on the one hand, and need frustration, controlled motivation, and disaffection on the other hand. Thus, the dual-process model acknowledges that while the autonomy supportive teacher practices are likely to explain students' need satisfaction, autonomous motivation, and engagement, autonomy thwarting teacher practices explain students feelings of being controlled, frustrated, and disengaged.

All things considered, it would seem important to examine the extent to which perceptions of both autonomy supporting and thwarting practices differentially predict motivation and engagement outcomes, as each set of perceived practices are likely to differentially predict students' autonomous motivation and engagement versus controlled motivation and disaffection. However, despite the progress made in research focused on understanding autonomy relevant teaching behaviors, a number of limitations persist. Specifically, there is limited research in which perceptions of the specific practices that define both autonomy supportive and thwarting practices have been examined simultaneously within an authentic classroom environment to uncover differential links with students' motivation and engagement during class. Those studies that have explored this issue have generally relied on cross-sectional designs (e.g., Assor et al., 2002; Haerens et al., 2015; but see Jang et al., 2016 for a longitudinal example of the differentiated effects of perceived teacher autonomy support and control broadly defined rather than on specific practices within each category). Thus, current research is limited to the extent that a

single retrospective survey of students' experiences is limited for drawing conclusions about the predictive role of student perceptions of teachers' various daily practices in their daily motivation and engagement in the classroom. However, teachers' autonomy relevant practices in the classroom and students' perceptions of those practices is likely to vary from one class day to the next and even minor variation is likely to change a student's daily motivation and engagement relative to his or her own typical level, though research has yet to explore this possibility. It is important to note that questions regarding the extent to which perceptions of daily teacher practices predict students' daily functioning in the classroom are distinct from questions regarding the relationships between perceptions of teachers' average practice across a semester, school year, or other period of time and students' summative motivation and engagement. Moreover, the former can only be addressed by research that monitors perceptions of teacher practice and students' classroom functioning across multiple days.

With these conceptual and methodological considerations in mind, the current investigation utilized a 6-week diary study that included regular student reports to examine differential associations between perceived autonomy supporting and thwarting teacher practices and high school science students' autonomous motivation and engagement and controlled motivation and disaffection in the classroom. Prior research suggested that we should expect perceived practices routinely identified as supportive, such as providing choices, considering students' interest and preferences in classroom activities, giving rationales about importance or usefulness, and providing opportunities for and being responsive to questions, to be strong predictors of autonomous motivation and engagement. In contrast, perceived practices routinely identified as autonomy thwarting, such as controlling messages, suppression of student perspectives, and use of uninteresting activities, were expected to be strong predictors of controlled motivation and disaffection.

Reciprocal Effects Between Perceived Teacher Practice and Students' Motivation and Engagement

According to self-determination theory, one of the primary antecedents to students' daily motivation and engagement in the classroom is expected to be their perceptions of teachers' autonomy relevant practices (e.g., Cheon & Reeve, 2013; Jang, Kim, & Reeve, 2016). However, one limitation of prior research focused on autonomy relevant teacher practices is that it has infrequently considered the extent to which student motivation and engagement may also influence perceptions of teacher practice or even objective teacher practice. Although infrequently examined, some research has suggested that teachers' respond to students' engagement. For example, Skinner and Belmont (1993) revealed in path analyses that student behavioral engagement measured in the fall was associated with the teachers' autonomy supportive behavior with students during the subsequent spring. Pelletier, Seguin-Levesque, and Legault (2002) found that when teachers perceived their students to be autonomously motivated, they were more autonomy supportive in their teaching. Jang, Kim, and Reeve (2016) found that Korean high school students' disaffection (but not engagement) predicted increases in both students' perceptions of teacher control and decreases in perceptions of teacher autonomy support over the course of a semester.

With this prior cross-sectional and longitudinal research as a base, we predicted that science students' motivation and engagement would also predict their perceptions of teachers' autonomy relevant practice on a day-to-day basis. However, in line with the dual process model, we expected to observe a differential pattern of effects across various forms of motivation and engagement. Namely, we predicted that students' perceptions that teachers' engaged in autonomy supportive practices would increase on days when students experienced autonomous motivation and engagement. Likewise, we expected that students' controlled motivation and disaffection would predict an increase in perceptions that teachers engaged in thwarting practices.

Interactions Between Perceptions of Autonomy Supportive and Thwarting Practices

Given that relatively few studies have simultaneously examined both autonomy supportive and thwarting practices, the extent to which autonomy supportive and thwarting teaching practices may yield stronger or weaker effects depending on the extent to which they are perceived to be administered in combination is a related matter that has been left unaddressed in the literature. Self-determination theory and research generally suggest that autonomy support is most effective when a cluster of supportive practices is administered together (e.g., Deci, Eghrari, Patrick, & Leone, 1994; Patall et al., 2013). However, what happens to students' motivation and engagement in a real classroom where teachers are likely to use both supportive and thwarting practices to some extent? Research indicates that perceptions of autonomy supportive and thwarting practices are distinct dimensions of teaching that are only weakly correlated (e.g., Assor et al., 2002; Haerens et al., 2015). Thus, autonomy supportive and thwarting teaching practices are likely to vary in the extent to which they are perceived to co-occur, though we know nothing about their interactive effects on students' motivation and engagement. We would argue that this issue of interaction between perceived autonomy supporting and thwarting practice is likely to be particularly relevant to the science classroom, given the emphasis in science on both discovery and innovation, as well as using established rigorous methods, rules, and procedures (e.g., Allchin, 1999). The precarious balance between these core values in science might make it particularly likely for students to perceive science teachers as using both autonomy supportive and controlling practices during the same class.

With that in mind, our predictions about how students' perceptions of supportive teaching practices might interact with thwarting practices was relatively uncertain. One possibility is that the perceived presence of thwarting teaching practices might dampen any desirable effects of perceptions of supportive practice on autonomous motivation and engagement. That is, in the context of thwarting practices, students may experience autonomy support as ineffective or insincere, limiting its functional significance for enhancing autonomous motivation and engagement. Likewise, the perceptions of autonomy support may dampen undesirable effects of thwarting practices, allaying the association between perceived thwarting practices and students' controlled motivation and disaffection.

Alternatively, a contrast interactive pattern might emerge such that in the perceived presence of teachers' thwarting practices, perceived autonomy support may predict autonomous motivation and engagement even more strongly. That is, the co-occurrence

and contrast of autonomy supportive and thwarting teacher practices may lead students to more fully appreciate the value of supportive practices and experience them as even more motivationally supportive. Likewise, thwarting practices may seem even more controlling when they are perceived to co-occur with and can be contrasted against supportive practices, bolstering the undesirable association between thwarting practices and controlled motivation and disaffection. The present investigation allowed us to test these competing hypotheses.

The Present Investigation

The aim of the present study was to test a set of theory-based hypotheses regarding the association between daily student perceptions of autonomy relevant teaching with various forms of motivation and engagement, while addressing some of the limitations in prior research by using diary methods. Given self-determination theory's assumption that it is students' subjective experiences of teachers' practice, rather than some objective reality of teacher practice, that ultimately determines students' motivation and engagement, we focused on students' perceptions of autonomy relevant teaching in the current investigation. We hypothesized that daily student perceptions of supportive practices would positively predict daily autonomous motivation and engagement in the classroom, even after controlling for the outcome on the prior class session. In contrast, we expected that daily student perceptions of autonomy thwarting teaching would yield fewer or weaker associations with those adaptive outcomes. Rather, we expected thwarting practices to be the strongest positive predictors of daily controlled motivation and disaffection in the classroom. We also expected to observe reciprocal effects from students' daily motivation and engagement to perceptions of teacher practice mimicking the same differential patterns of effect. Given the various possibilities for the patterns of interaction between students' perceptions of autonomy supportive and thwarting teaching practices and the lack of theory and prior research to guide our predictions, we made no hypotheses regarding how autonomy supportive and thwarting teaching practices may interact in their prediction of students' motivation and engagement. Finally, to strengthen confidence in the findings, we explored these hypotheses after controlling for a variety of student and classroom characteristics (e.g., students' sex, ethnicity, free or reduced price lunch eligibility, age, and prior course grade, as well as classroom content difficulty, cohort, Title I status, and teacher years of experience), because prior research has suggested that these student and classroom factors may influence students' engagement and perceptions of the environment (e.g., Clotfelter, Ladd, & Vigdor, 2010; Eccles et al., 1993; Murdock, 1999; Solomon, Battistich, & Hom, 1996), particularly within the science domain (e.g., Patall, Vasquez, Steingut, Trimble, & Pituch, 2015; Sinatra, Heddy, & Lombardi, 2015).

Overall, we expected the current study to extend evidence related to autonomy relevant teaching by contextualizing the research within an authentic high school science classroom and providing an opportunity to examine the unique, reciprocal, and interactive daily effects involving perceptions of various autonomy supportive and thwarting practices and students' daily autonomous and controlled motivation, engagement, and disaffection in the classroom. Going beyond the existing research, the current design allowed us to examine the extent to which daily variations in students' perceptions of teaching practice (or motivation and engagement) was associated with corresponding changes in students' motivation and engagement outcomes (or perceptions of teacher practice) above or below their personal baselines for engagement and motivation (or perceptions of teacher practice). We felt that this level of specificity in context, predictors, outcomes, and timing would provide the best foundation for understanding how students' experiences of teacher practice shape their motivation and engagement.

Method

Participants

There were 208 urban and suburban high school science students (13 to 18 years of age; 54% female; 68% ethnic minority; at least 43% eligible for free or reduced lunch) from 41 science classrooms across eight public high schools in the southwest region of the United States participated in this diary study. Student participants were asked to provide reports of their experiences after every science class during a 6-week instructional unit between January 2013 and May, 2014 (2,176 total reports across all students).

Every classroom was led by a different science teacher. The number of students participating in the study from each class ranged from three to six. Approximately 56% of students were enrolled in a grade-level biology, physics, or chemistry course and 44% were enrolled in an advanced biology or chemistry course or a specialty topic science course (anatomy, environmental systems, engineering, or aquatic science). Thirty-two percent of the students across these classes were White, while 42% were Hispanic/Latino, 10% were Black, 2% were Asian, and 14% were of mixed ethnicities or another ethnicity. Two students did not share their ethnicity. Forty-two percent of students were in the 9th grade, 24% were 10th graders, 17% were 11th graders, and 17% were 12th graders. The mean grade point average (GPA) at the start of the study was 2.92 ($SD = 0.96$; minimum = 0.82, maximum = 4.0) on a 4-point scale.

Regarding the representativeness of our sample, the urban district from which students were drawn serves a population of students in which 52% are economically disadvantaged, 67% are Hispanic or Black, and 26% are White. The suburban district from which students were drawn serves a population of students in which 22% are economically disadvantaged, 28% are Hispanic or Black, and 63% are White. Thus, a comparison of the racial and economic make-up of our student sample across both districts' student demographics suggests that we successfully recruited a student sample that was representative of the student populations being served at these eight schools.

Participation was voluntary and students under the age of 18 secured parental permission to participate. In recruiting students, the goal was to randomly select five student participants from each class among students who volunteered to participate. In the majority of classrooms (35 of 41), at least five students volunteered to participate and students were randomly selected in cases where more than five volunteers were available. In the majority of classes, approximately five to eight students volunteered to participate. Five students participated in each of 25 classes and six

students participated in each of 10 other classes. In some classes, less than five students volunteered. Four students participated in each of 5 classes and in one class just three students participated. Despite randomly selecting among volunteers in classes in which we were able, given that participation was contingent on volunteering and a limited number of students in each class volunteered, this sample should not be mistaken for a true random sample and should be considered a convenience sample. Students were paid $5 for every survey completed and received a $50 bonus for completing all reports for which they did not have an excused absence from class.

Teachers' years of experience ranged from 0 to 40 ($M = 10.40$, $SD = 9.85$). Teachers were 25 to 66 years of age ($M = 38.12$, $SD = 12.49$). The majority of teachers (30) were White and female (30). One teacher was Black, three were Asian, three were Hispanic/Latino and four were of mixed ethnicities or another ethnicity. Teachers received $50 for their participation in the study and schools received $100 for each participating teacher.

Procedure

Recruitment of participants for this study occurred in stages. Teachers were recruited in group information sessions after obtaining permission from the two school districts, as well as individual high school principals, vice principals, and science chairs at each of the eight schools. During the teacher information session, teachers were informed that the purpose of the study was to examine the relationship between students' experiences in the classroom and their motivation and engagement. The diary methods involved in the study were also explained to teachers. Participating teachers selected the course that would participate in the study and the instructional unit during which the study occurred in consultation with the research team. Teachers were encouraged to view participation in the study as an educational experience, because they would be provided information about students' motivation and engagement at the end of the study and all the information collected as part of the study was confidential. With that in mind, the research team encouraged teachers to select their most typical course for participation that suited the study best for scheduling reasons and contained a diverse group of students. The research team discouraged teachers from selecting a course because they felt it was the one in which they or their students would perform best (or worst). Across all schools, approximately 50% of recruited teachers expressed willingness to participate and approximately 40% actually participated in the study.

Student participants were recruited via in-person classroom visits in which the study was described and a parent information letter and consent documents in both English and Spanish were distributed. Students were asked to return signed consent documents in a sealed envelope to a box located at the main office of the school.

Upon recruitment and selection, participating students first met with a member of the research team to learn about their responsibilities as a participant, as well as to receive and set-up an Apple iPod touch used to complete surveys for the duration of the diary study. During this initial meeting, student participants practiced using the iPod by completing a short background survey regarding their age, grade level, sex, ethnicity, eligibility for free or reduced lunch at school based on U.S. government policy, school GPA, and course grade for the most recent instructional unit. In addition, this initial meeting was used to establish the student's school and personal schedule and determine the ideal time for the student to receive and complete daily reports.

On every class day of the 6-week instructional unit, students were emailed during their first free period (i.e., noninstructional time) after the class session with a survey asking them to respond to questions about their teachers' practices and their experiences of motivation and engagement in class. All questionnaires were programmed using Qualtrics and completed by students online using the Apple iPod touch provided by the researchers. All classes met on a block schedule, approximately every other school day. The number of report opportunities varied depending on the class and number of class sessions that occurred in the particular 6-week instructional unit. The number of scheduled class sessions ranged between 11 and 17, with classes having between 8 and 17 opportunities to report on class experiences as a result of various disruptions to class sessions (Median = 14). Daily report surveys remained available for students to complete until the next class session began. The number of reports that student participants completed across the instructional unit ranged from 1 to 17 ($M = 10$, $SD = 3.77$; Mode = 10). Only one student completed just one report and this student's responses could not be used in the analyses.

This design of repeatedly sampling students' daily perceptions of the classroom environment and experiences of motivation and engagement during class over the course of a 6-week unit allowed us to confidently examine (given the many repeated reports) ongoing within-person covariation between daily perceptions of teacher practices and experiences of motivation and engagement. That is, repeatedly sampling of participants allowed us to explore whether, for example, daily variations in perceived practices were associated with corresponding variation in motivation and engagement above or below a student's personal baseline level. Given the intense nature of drawing repeated reports from student participants over a 6-week period, we necessarily limited the number of participating students in each classroom. Restricting the number of participants from each class naturally limited the conclusions we might draw about the perceptions of the classroom from the students in the class as a whole. However, our focus was on understanding within-person (daily) variability in perceived practice, motivation, and engagement rather than variability between students or classrooms of students.

Measures

Motivation. Students' daily motivation in science class was assessed with 12 items we adapted for our use in a daily diary design from the Academic Self-Regulation Questionnaire (Ryan & Connell, 1989). This measure assessed student motivation toward education in terms of why they worked on course work, participated in science class, and tried to do well on assignments for science class *that day*. Students indicated the extent to which they engaged in each activity for intrinsic ("because it was interesting and enjoyable"), identified ("because it was important and valuable to me"), introjected ("to avoid feeling guilty or anxious"), or extrinsic reasons ("because the situation forced me to"). Students rated the extent to which they agreed with each item on a 5-point Likert scale ranging from not at all *true* (1) to *extremely true* (5). The validity and reliability of the multiscale measure for cross-

sectional research has been established in previous studies (Ryan & Connell, 1989). However, given that we adapted and shortened the measures to use them in a diary design, we conducted factor and reliability analyses to confirm that these adapted measures were appropriate for our daily diary context.

To assess the factorial validity of daily measures of motivation, we conducted a multilevel confirmatory factor analysis (ML-CFA) with four factors at both the day and student levels in Mplus 6.12. Parameters were estimated using a maximum likelihood estimation procedure (i.e., MLR) that is robust to violations of both the assumptions of normality and independence of observations, and provides for optimal parameter estimates when data are missing at random. We examined both day- and student-level (by computing the mean across class days for each student) factor structures, as factor structures are not always identical at different levels of analysis. Given the complexity of modeling a three-level exploratory factor structure and because we had just 43 classes at Level 3, we used the TYPE = COMPLEX TWO LEVEL command in Mplus to adjust *SE*s and χ^2 tests of model fit, accounting for the clustering at the classroom level (Level 3). To obtain proper estimates at each level, we followed standard multilevel modeling practices and used group-mean centering for the items at both the day and student levels using the student as the group for the lowest level and the class as the group for the student level. A well-fitting model was defined by a comparative fit index (CFI) of approximately .95, root mean square error of approximation (RMSEA) around .05, square root mean square residual (SRMR) around .08, and factor loadings >.40 (Kline, 2010). Items were allowed to load only on their target factor (i.e., intrinsic, identified, introjected, or external) and factors were allowed to correlate.

Inspection of model fit indices (CFI) > .99, RMSEA = .011, and a SRMR = .018 for the day level and .023 for the student level) indicated that the model fit the data well (Kline, 2010). Factor loadings (i.e., standardized regression coefficients) at both levels suggested that items loaded sufficiently (>.65) onto their respective factors. The correlation between intrinsic motivation and identified regulation factors was .58 and the correlation between introjected and external regulation factors was .51. The correlation between other pairs of factors ranged between −.11 and .28.

For the purposes of this study and given that our hypotheses distinguished primarily between more and less autonomous forms of motivation, we created a composite autonomous motivation variable by averaging daily intrinsic motivation and identified regulation scales (mean daily α = .92) and a composite controlled motivation variable by averaging daily introjected and external regulation scales (mean daily α = .90). This approach is consistent with the use of this scale in cross-sectional and experimental research (e.g., Sheldon, Ryan, Deci, & Kasser, 2004; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004).

Engagement. Students' daily engagement in science class was assessed with 20 items we adapted for our use in a daily diary design from the Engagement versus Disaffection with Learning Student Report (Furrer & Skinner, 2003; Skinner & Belmont, 1993; Skinner et al., 2009) and the Metacognitive Strategies Questionnaire (Wolters, 2004). The Engagement versus Disaffection with Learning Student Report contains four scales from which we selected items and adapted for the daily context: behavioral engagement (3 items; e.g., "I worked as hard as I can in science class today"; "I paid attention today in science class"), emotional engagement (4 items, e.g., "I felt interested today in science class"; "I enjoyed science class today"), behavioral disaffection (3 items, e.g., "Today in science class I just did enough to get by"; "When I was in science class today, I was thinking about other things"), and emotional disaffection (6 items; e.g., "When I was in science class today, I felt bad"; "I felt unhappy in science class today"). Four items measuring learning strategies adapted from the Metacognitive Strategies Questionnaire were used to assess students' cognitive engagement in science class (e.g., "I tried to connect what I was learning in science class today with my own experiences"; "I tried to make different ideas fit together and make sense in science class today"). For all engagement items, students rated the extent to which they agreed with each item on a 5-point Likert scale ranging from *not at all true* (1) to *extremely true* (5). The validity and reliability of all engagement scales for cross-sectional research have been established in previous studies (Furrer & Skinner, 2003; Wolters, 2004). Again, given that we adapted and shortened the measures to use them in a diary design, we conducted factor and reliability analyses to confirm that these adapted measures were appropriate for our daily diary context.

We conducted a multilevel confirmatory factor analyses (ML-CFA) using MLR to examine the six factor structure at both day and student levels and the TYPE = COMPLEX TWO LEVEL syntax in Mplus to account for clustering at the classroom level. Again, items were group-mean centered for both the day and student levels using the student as the group for the lowest level and the class as the group for the student level. Items were allowed to load only on their target factor and factors were allowed to correlate. Inspection of fit indices for the model (CFI = .92, RMSEA = .03, and SRMR < .04 both for day and student levels) indicated that the model fit the data adequately (Kline, 2010). Factor loadings at both levels suggested that items loaded sufficiently (>.40) onto their respective factors.

Again, for the purposes of this study and given that our hypotheses distinguished primarily between engagement and disaffection, we created a composite engagement variable by averaging daily behavioral, emotional, and cognitive engagement scales (mean daily α = .89) and a composite disaffection variable by averaging daily behavioral and emotional disaffection scales (mean daily α = .87). Sizable correlations between factors supported this approach. The correlation between behavioral, emotional and cognitive engagement factors ranged between .42 and .66. The correlation between behavioral and emotional disaffection factors was .44. Moreover, using aggregated measures across types of engagement (and motivation) outcomes was an appealing approach given that it limited the number of statistical tests conducted and yielded excellent reliability characteristics.

Daily teacher practices. Students' perceptions of the extent to which their teachers used practices intended to support or thwart autonomy on a given class day was assessed with a measure designed explicitly for use in this diary study (see Appendix for final set of items) and based on prior measures used in cross-sectional research (Patall et al., 2013; as well as Assor et al., 2002, 2005; Connell, 1990; Katz, Kaplan, & Gueta, 2009; Reeve & Jang, 2006; Reeve et al., 2004; Reeve, 2006; Wellborn & Connell, 1987; Belmont, Skinner, Wellborn, & Connell, 1992). Twenty-six items assessed perceptions of five supportive daily practices and three thwarting daily practices hypothesized to be related to autonomy

need satisfaction and motivation based on prior research (e.g., Assor et al., 2002, 2005; Deci, Eghrari, Patrick, & Leone, 1994; Patall et al., 2013; Reeve, 2009; Reeve & Jang, 2006). Supportive practices included (a) provision of choices (3 items; e.g., "My teacher provided options for the kinds of assignments or activities I could do today"), (b) opportunities for students to work in their own way (3 items; e.g., "My teacher allowed me to choose how to do my work in the classroom today"), (c) consideration for student opinions, preferences, and interests (5 items; e.g., "My teacher structured class activities today around my interests"), (d) rationales regarding the usefulness and importance of course material (4 items; e.g., "My teacher explained how what we were learning today is important"), and (e) student question opportunities and responding (3 items; e.g., "My teacher acknowledged and responded to my questions in class today"). Thwarting teacher practices included (a) controlling messages (3 items; e.g., "My teacher was strict about me doing everything in his or her way today"), (b) suppression of student perspectives (3 items; e.g., "My teacher stopped me from expressing my opinions in class today"), and (c) uninteresting activities (2 items; e.g., "My teacher forced me to do uninteresting activities in class today"). Students rated the extent to which they agreed with each item on a 5-point Likert scale ranging from *not at all true* (1) to *extremely true* (5).

To assess the factorial validity of daily measures of perceived teacher practices, we conducted two multilevel exploratory factor analyses (Roesch et al., 2010) using the oblique geomin rotation and MLR in Mplus 6.12 to examine both day and student level factor structures. The first analysis included perceived supportive teacher practices and the second analysis included perceived thwarting teacher practices. These models varied in the number of factors specified at each level of the nested data structure (from 1 to 7 factors). Again, we used the TYPE = COMPLEX TWO LEVEL command in Mplus to account for the clustering at the classroom level and group-mean items for both the day and student levels using the student as the group for the lowest level and the class as the group for the student level. To determine the best-fitting model, we used a DCFI of .01 or greater as our model selection criterion (Cheung & Rensvold, 2002).

The results of ML-EFAs of these 26 items plus five additional items reflective of perceived teacher practices unrelated to this investigation supported a six factor structure for supports CFI = .98, RMSEA = .018, SRMR (day/student) = .007/.009) and a three factor structure for thwarts (CFI = .997, RMSEA = .012, SRMR (day/student) = .006/.003). All items loaded sufficiently (>.40) on the intended factor as expected with minimal cross-loadings, with the caveat that perceptions of provision of choice items and opportunities for students to work in their own way items loading on a single factor rather than two separate factors. Several items were retained only at the student level. These included one item assessing the provision of choice, two items assessing consideration for student interests and preferences, and one item related to teacher question opportunities and responding.

Supportive teacher practice factors were positively intercorrelated with small to medium correlations at the day (.14–.45) level. Likewise, thwarting teacher practice factors were positively intercorrelated with moderate correlations at the day level (.36–.46). In summary, perceived teacher practice variables were intercorrelated, but distinct (model fit deteriorated significantly if fewer or more factors were extracted). Correlations between all perceived practices are reported in the results.

Scale scores for each perceived teacher practice were calculated by taking the mean of all items loading above .40 on each factor. When factor analyses suggested that a slightly different version of a scale should be used at day versus student levels, we computed multiple versions of the scale to be used at the appropriate level. However, for the purposes of this investigation, we used only day level scales, though results were nearly identical using either version of the scales. For perceived supportive practices, the mean daily alpha was .83 for the provision of choice scale (5 items), .87 for consideration for student interests and preferences (3 items), .86 for rational provision (4 items), and .80 for question opportunities (2 items). For perceived thwarting teacher practices, the mean daily alpha was .67 for the controlling messages scale (3 items), .81 for suppression of student perspectives (3 items), and .82 for use of uninteresting activities (2 items).

Multilevel Analyses

We tested our main hypotheses about the relationships between students' daily perceptions of teacher practices and their daily experiences of motivation and engagement with a series of three-level (day, student, and class) regressions where the intercept was allowed to vary randomly using the Mixed procedure in SPSS 21. In line with recommendations from experts on conducting intensive longitudinal designs (e.g., Bolger & Laurenceau, 2013), we used hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) for our primary tests because it appropriately addressed nonindependence of observations and the hierarchically nested design of our data set in which lower level units (i.e., days) were nested within a second higher level unit (i.e., students) and students were nested within a third higher level unit (i.e., classrooms). HLM treats student and classroom as a random rather than a fixed effect, thereby permitting generalizations of the findings to a wider population.

For all multilevel models, at Level 1 (day level) we included time and the outcome reported on the previous day, in addition to daily perceived practice predictors (or daily motivation and engagement for our reciprocal models). We constructed the time variable by consecutively numbering each class session during the unit starting with zero. We opted to use class session as the time metric, as opposed to calendar days or school days elapsed, given Kim-Spoon and Grimm's (2016) recommendation to consider the dominant reasons for why changes in the outcome might occur when selecting a time metric. In our investigation, the dominant reason student motivation and engagement in science class was expected to vary is because of their experiences during science class sessions. The prior class session's value for the outcome was entered to control for possible carryover effects from one class day to the next (e.g., see Reis, Sheldon, Gable, Roscoe, & Ryan, 2000 for an example of this strategy). To minimize missing data, the most recent prior day of reporting was carried forward to the next available day of reporting for the purposes of creating lagged variables. Including the prior class session's outcome value as a predictor allowed us to predict day-to-day change in the outcome rather than sheer level (Cohen & Cohen, 1982) as a function of students' perceptions of teacher practices reported on the same class day as the outcome.

At Level 2 (student level), we included several control variables: student sex (0 = male, 1 = female), student ethnicity (0 = White or Asian, 1 = Black, Hispanic/Latino, or other ethnic minority), students' free or reduced price lunch eligibility (0 = not eligible, 1 = eligible), students' age, and students' course grade for the prior unit in all models. At Level 3 (class level), we included variables representing whether the class was advanced or grade typical (0 = grade typical, 1 = advanced), the cohort school year in which students participated in the study (0 = 2012–2013, 1 = 2013–2014), whether the classroom was in a school that had title I status or not (0 = no title I status, 1 = title I status), and teacher years of experience in all models.

To decompose within-student (day) effects from between-student effects, daily perceived practice predictors (or daily motivation and engagement predictors in reciprocal models) were student-mean centered (around each student's own average score). Time and the value of the outcome variable from the prior class session were grand-mean centered because they were simply control variables in these models, as were the nine other covariates. To treat missing data, we used a maximum likelihood estimation procedure with robust estimates of *SE*s (REML). Because adjacent residuals in repeated measures data may be correlated across measurement occasions, we specified an AR(1) correlated error structure (Bolger & Laurenceau, 2013).

Results

Preliminary Analyses

To gauge within-person variation from one class session to the next during the 6-week instructional unit compared with the variation across students and classrooms (over days), we computed variance partition coefficients (VPC; Goldstein, 2011) and intraclass correlation coefficients (ICC; Kreft & De Leeuw, 1998) for each perceived teacher practice and student self-reported engagement and motivation variable (see Table 1). VPCs suggested that between 39 and 56% of the variance in perceived teacher practices was at the day level, with a similar amount of variance at the student level and less variability at the classroom level. Similarly, VPCs suggested that between 32 and 40% of the variance in motivation and engagement was at the day level, with slightly more variance at the student level and more limited variability observed at the classroom level. Results suggested that there was a substantial proportion of daily variation in students' perceptions of their teachers' practices and their motivation and engagement over the course of the unit. Moreover, though variation at the class level was relatively small, it was still sufficiently large to warrant including a variance component at the class level (see Kreft & de Leeuw, 1998; Moerbeek, 2004).

Table 1
Variance Partition Coefficients (VPC) and Intraclass Correlation Coefficients (ICC)

Variable	Day level	Student level		Class level
	VPC	VPC	ICC	VPC/ICC
Daily teacher practices				
Choice	.52	.40	.47	.08
Interests	.43	.43	.57	.14
Rationales	.39	.45	.61	.16
Questions	.56	.37	.44	.07
Controlling messages	.48	.48	.52	.04
Suppression	.40	.57	.60	.03
Uninteresting activities	.42	.53	.58	.05
Daily engagement and motivation				
Engagement	.34	.55	.66	.11
Disaffection	.40	.56	.60	.04
Autonomous motivation	.34	.52	.66	.15
Controlled motivation	.32	.62	.68	.05

Note. Level 1 (daily reports) n = 2,026 to 2,176 reports. Level 2 (students) n = 208. Level 3 (classes) n = 41. Calculation of the VPC and ICC is identical at the highest level of any model.

Correlations Between Perceived Practices, Motivation, and Engagement

First, we computed correlations among the perceived daily teacher practices, engagement, and motivation variables (see Table 2). For these correlations, we group-mean centered variables using the student as the group to disentangle within-student from between-student relationships. As expected, all perceived daily practices hypothesized to be supportive of autonomy were positively correlated. Likewise, all the perceived daily practices hypothesized to be thwarting of autonomy were positively correlated. Of note, correlations among practices were modest, ranging from .12 to .33. As for correlations between supporting and thwarting practices, correlations generally hovered close to zero, ranging from −.18 to .08. Taken together, the modest values among perceived practices correlations suggest that it would be informative to investigate the effects of the seven teacher practices separately.

In line with our hypotheses, the four supportive daily practices were significant and positively correlated with daily engagement and autonomous motivation in class, while correlations with daily disaffection and controlled motivation hovered close to zero. Likewise, the three thwarting daily practices were significant and positively correlated with daily disaffection and controlled motivation in class. Correlations with daily engagement and autonomous motivation hovered close to zero for daily controlling messages and suppression of student perspectives, but were significant and positive for daily use of uninteresting activities.

We also computed correlations between students' perceptions of practices, motivation, and engagement aggregated across the unit and various student and classroom characteristics (see Table 3). There were a number of instances in which student and classroom characteristics (sex, ethnicity, age, free or reduced price lunch eligibility, prior course grade, type of course, teacher years of experience, school title I status, and cohort) significantly correlated with perceived teacher practices, students' motivation, or students' engagement. As such, we opted to include these variables as covariates in subsequent multilevel models.

Daily Perceived Practices as Predictors of Daily Motivation and Engagement

Next, hypotheses about the extent to which students' daily perceptions of teacher practices predict their daily experiences

Table 2
Means, SDs, and Correlations Among Daily Variables

Variable	*M* (*SD*)	1	2	3	4	5	6	7	8	9	10
1. Choice	2.47 (.96)	—									
2. Interests	2.05 (1.03)	**.33**	—								
3. Rationales	2.86 (1.05)	**.13**	**.17**	—							
4. Questions	3.63 (1.06)	**.18**	**.12**	**.22**	—						
5. Controlling messages	2.41 (.91)	*−.04*	*.04*	**.08**	**.07**	—					
6. Suppression	1.55 (.83)	*.01*	**.09**	*−.02*	**−.18**	**.25**	—				
7. Uninteresting activities	1.97 (1.08)	*−.04*	−.07	*−.03*	**−.13**	**.21**	**.26**	—			
8. Engagement	3.05 (.84)	**.18**	**.28**	**.31**	**.34**	**.06**	*−.04*	**−.21**	—		
9. Disaffection	1.91 (.75)	*−.01*	−.05	**−.05**	**−.09**	**.19**	**.26**	**.38**	**−.30**	—	
10. Autonomous motivation	2.94 (1.07)	**.15**	**.30**	**.26**	**.30**	*.04*	*−.03*	**−.22**	**.68**	**−.26**	—
11. Controlled motivation	2.30 (1.02)	*.02*	*.03*	*.03*	**.06**	**.25**	**.15**	**.22**	**.09**	**.27**	**.13**

Note. n = 1,998 to 2,176 reports. Correlations are computed with group-mean centered daily variables using student as the group. Italicized correlations are not significant. All other correlations (bolded) are $p < .05$.

of motivation and engagement were tested with four random intercept only three-level (day, student, and class) regressions that included all seven daily teacher practices. Results (see Table 4) largely confirmed our hypotheses that perceptions of daily autonomy supportive practices would primarily predict daily autonomous motivation and engagement, while perceptions of daily thwarting practices would primarily predict daily controlled motivation and disaffection, controlling for both time and the outcome on the prior class session, as well as a number of student and class characteristics. Specifically, all four perceived daily supportive practices (provision of choices, consideration for student interests, rationales about importance or usefulness, and question opportunities) predicted an increase in daily engagement since the prior class session, and all perceived daily supportive practices but the provision of choice predicted an increase in daily autonomous motivation from the previous class session. One perceived daily thwarting practice, daily use of uninteresting activities, also predicted a decrease in autonomous motivation and engagement since the prior class session.

Table 3
Means, SDs, and Correlations Among Student Demographic Variables and Aggregated Daily Variables

Variable	*M* (*SD*)	Sex	Ethnicity	Age	Free lunch	Prior unit course grade	Advanced course	Cohort	Title I school	Teacher experience
Sex	.54 (.50)	—								
Ethnicity	.63 (.48)	*.05*	—							
Age	15.54 (1.26)	*−.02*	*.10*	—						
Free lunch	.43 (.50)	*.02*	**.47**	*.009*	—					
Prior unit course grade	82.21 (18.10)	*−.05*	**−.16**	*.07*	**−.18**	—				
Advanced class	.44 (.50)	*−.04*	*.01*	*−.12*	*−.10*	*.06*	—			
Cohort	.58 (.49)	*.02*	*.06*	**.21**	**.16**	*.02*	**−.22**	—		
Title I school	.46 (.50)	*−.04*	**.37**	**.15**	**.43**	*−.01*	*.02*	**.22**	—	
Teacher experience	10.45 (9.53)	*.009*	**−.23**	**.18**	**−.23**	*−.03*	*−.13*	**.19**	**−.32**	—
Aggregated daily student perceived teacher practices, motivation, and engagement										
Choice	2.47 (.70)	*−.09*	*.11*	*.12*	**.23**	*−.04*	*−.01*	**.18**	**.18**	**−.15**
Interests	2.03 (.81)	*−.08*	*.11*	*.05*	**.23**	*−.05*	*−.07*	**.26**	**.26**	*−.11*
Rationales	2.85 (.85)	**−.14**	**.15**	*.05*	*.05*	*.03*	*.06*	*.14*	**.21**	*−.04*
Questions	3.60 (.75)	*−.01*	*−.13*	**.19**	**−.23**	**.28**	**.15**	*.08*	*−.05*	*.08*
Controlling messages	2.41 (.68)	*−.10*	*−.11*	*−.10*	*.07*	*−.07*	*.02*	*−.01*	*−.03*	*.01*
Suppression	1.55 (.67)	*−.07*	*.03*	**−.19**	*.12*	**−.16**	*−.07*	*.03*	*.02*	*−.05*
Uninteresting activities	1.96 (.86)	*−.05*	**−.24**	**−.18**	*−.06*	**−.13**	*−.06*	*−.06*	**−.21**	*.06*
Engagement	3.04 (.70)	**−.18**	*.09*	*.09*	*−.02*	*.13*	*.07*	*.07*	*.13*	*−.12*
Disaffection	1.91 (.61)	*.06*	**−.14**	*−.10*	*.03*	**−.16**	*−.08*	*.08*	*−.08*	*.03*
Autonomous motivation	2.92 (.89)	*−.12*	*.06*	*.08*	*−.06*	*.10*	*.06*	*.08*	*.09*	*−.08*
Controlled motivation	2.28 (.85)	*.06*	**−.19**	**−.15**	**−.19**	*−.01*	*.05*	*.05*	**−.23**	*.03*

Note. n = 199 to 208 students. Perceived teacher practice, engagement, and motivation variables were aggregated across class sessions for individual students. For student sex, 0 = male and 1 = female. For ethnicity, 0 = White or Asian and 1 = Black, Hispanic/Latino, or other ethnic minority. For free lunch, 0 = not eligible for free/reduced price lunch and 1 = eligible for free/reduced price lunch. For class type, 0 = grade typical class and 1 = advanced class. For cohort, 0 = 2012–2013 school year and 1 = 2013–2014 school year. For Title I school, 0 = not Title I status and 1 = Title I status. Students' age and prior course grade were measured continuously. Teacher experience was measured continuously as the number of years teachers' had been professionally teaching. Italicized correlations are not significant. All other correlations (bolded) are $p < .05$.

Table 4
Multilevel Regressions With Student Perceptions of Daily Teacher Practices Predicting Daily Student Motivation and Engagement

	Engagement		Disaffection		Autonomous motivation		Controlled motivation	
Fixed effects	*b*(*SE*)	β	*b*(*SE*)	β	*b*(*SE*)	β	*b*(*SE*)	β
Class level								
Intercept	3.06 (.05)		1.92 (.04)		2.96 (.07)		2.32 (.05)	
Advanced class	.07 (.10)	.04	−.09 (.09)	−.06	.06 (.15)	.03	.01 (.09)	.005
Cohort	−.08 (.15)	−.04	−.10 (.13)	−.05	−.12 (.22)	−.05	−.09 (.14)	−.04
Title I	.10 (.13)	.06	.01 (.11)	.004	.11 (.18)	.05	−.20 (.12)	−.10
Teacher experience	−.01 (.01)	−.07	−.002 (.005)	−.04	−.01 (.01)	−.09	−.01 (.01)	−.07
Student level								
Sex	−.17 (.08)	−.10*	.07 (.08)	.04	−.15 (.11)	−.07	.09 (.09)	.04
Ethnicity	.11 (.10)	.06	−.24 (.09)	−.16***	.08 (.13)	.04	−.10 (.11)	−.05
Age	.04 (.04)	.05	−.03 (.03)	−.05	.05 (.06)	.06	−.04 (.04)	−.05
Free/reduced lunch	−.08 (.10)	−.05	.13 (.09)	.09	−.12 (.13)	−.05	−.13 (.11)	−.06
Prior unit course grade	.002 (.002)	.04	−.005 (.002)	−.11*	.001 (.003)	.02	−.001 (.003)	−.01
Day level								
Choice	.07 (.02)	.05***	.01 (.02)	.01	.03 (.02)	.02	.02 (.02)	.01
Interests	.14 (.02)	.11***	−.01 (.02)	−.01	.23 (.02)	.13***	.01 (.02)	.01
Rationales	.16 (.02)	.12***	−.01 (.02)	−.01	.14 (.02)	.08***	.01 (.02)	.01
Questions	.13 (.02)	.11***	−.05 (.02)	−.05***	.14 (.02)	.10***	.02 (.02)	.02
Controlling messages	.003 (.02)	.002	.06 (.02)	.05***	.001 (.02)	.0004	.15 (.02)	.08***
Suppression	.002 (.02)	.001	.10 (.03)	.07***	.03 (.03)	.01	.04 (.03)	.02
Uninteresting activities	−.11 (.02)	−.09***	.21 (.02)	.19***	−.16 (.02)	−.10***	.14 (.02)	.09***
Time	−.005 (.003)	−.03*	−.0002 (.003)	.002	−.009 (.003)	−.04**	.001 (.003)	.005
Lagged outcome	.16 (.02)	.17***	.15 (.02)	.15***	.17 (.02)	.17***	.29 (.02)	.29***

Random effects	Variance	*SE*	Variance	*SE*	Variance	*SE*	Variance	*SE*
Class (Level 3) intercept	.03	.03	.02	.02	.10	.05	.001	.02
Student (Level 2) intercept	.28***	.04	.22***	.04	.45***	.07	.36***	.06
Day (Level 1)								
Residual	.16***	.006	.19***	.007	.27***	.01	.24***	.009
Autocorrelation	.01	.05	−.02	.06	−.03	.05	−.06	.06
Model Fit Statistics								
AIC	2249.14		2507.40		3155.64		2926.11	
BIC	2270.73		2529.00		3177.24		2947.71	

Note. Level 1 (daily reports) n = 1,652 to 1,654 reports. Level 2 (students) n = 190. Level 3 (classes) n = 41. The "time" variable reflects the day of reporting across the 6 week instructional unit. The "lagged outcome" variable reflects the prior class session's value for the outcome. For student sex, 0 = male and 1 = female. For student ethnicity, 0 = White or Asian and 1 = Black, Hispanic/Latino, or other ethnic minority. For free and reduced lunch status, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For advanced class, 0 = grade typical class and 1 = advanced class. For cohort, 0 = 2012–2013 school year and 1 = 2013–2014 school year. For Title I school, 0 = not Title I status and 1 = Title I status. b = unstandardized regression coefficient. β = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): β = (b*sdx)/sdy. AIC = Akaike's Information Criterion; BIC = Schwarz's Bayesian Criterion.
* $p < .05$. ** $p < .01$. *** $p < .001$.

In contrast, student perceptions for most of the daily supportive practices did not predict either daily disaffection or controlled motivation. Rather, all three perceived daily thwarting practices (controlling messages, suppression of student perspectives, and use of uninteresting activities) predicted an increase in disaffection since the prior class session, and two of three, controlling messages and use of uninteresting activities, predicted an increase in daily controlled motivation. Only one perceived daily supportive practice, question opportunities, predicted a decrease in daily disaffection and none predicted a change from the previous class session in daily controlled motivation.

For the covariates, sex predicted engagement such that female students reported lower engagement across the 6 weeks than male students. Ethnicity and prior unit course grade negatively predicted disaffection. That is, Black and Hispanic students and students with higher prior grades reported experiencing less daily disaffection across the 6 weeks compared with their White or Asian and lower achieving counterparts.

Daily Motivation and Engagement as Predictors of Composite Perceived Practices

To explore the extent to which students' daily experiences of motivation and engagement predicted perceptions of teacher practices we conducted two random intercept only three-level (day, student, and class) regressions. For this analysis, we created a composite autonomy supporting practices variable to serve as the outcome in one model by taking the mean of the four perceived supportive practices (mean daily α = .89) and a composite autonomy thwarting practices variable for the outcome in the second model by taking the mean of the three perceived thwarting practices (mean daily α = .83). For each multilevel model, at Level 1 (day level) we included time, daily autonomous motivation, controlled motivation, engagement, disaffection, and the outcome reported on the previous day. At Level 2 and 3 (student and class level), we included the same set of nine control variables as in previous models. As described previously, within-student (day)

effects were student-mean centered and covariates were grand mean centered.

Results (see Table 5) were consistent with our expectations. Students' daily autonomous motivation and engagement predicted greater perceptions that teachers' engaged in autonomy supportive practices the same day over and above perceptions of teacher autonomy support during the prior class session, time, and a variety of student and classroom characteristic covariates. Likewise, students' controlled motivation and disaffection predicted greater perceptions that teachers' engaged in autonomy thwarting practices over and above perceptions of thwarts during the prior class session, time, and a variety of student and classroom characteristic covariates. The size of these effects were similar to those observed for the effects of perceived daily practices on students' daily motivation and engagement. In addition, smaller effects emerged for students' daily disaffection on perceived daily autonomy supporting practices and students' daily autonomous motivation on perceived autonomy thwarting practices. Specifically, on days when students experienced greater disaffection, they perceived slightly greater autonomy support from their teachers that same day, even after accounting for their level of perceived autonomy support in the prior class session. Moreover, on days when students experienced greater daily autonomous motivation, they perceived slightly less autonomy thwarting practices that same day, controlling for their perceptions of autonomy thwarting during the prior class session. Results suggest that students' experiences of motivation and engagement reciprocally influence perceptions of teachers' practices, such that when students are motivated for autonomous reasons and remain behaviorally, emotionally, and cognitively engaged, teachers are perceived to respond in kind with practices that further support that motivation and engagement. Encouragingly, when students reported being particularly disengaged, they also perceived teachers as providing autonomy support, which may reverse such disengagement. How-

Table 5
Multilevel Regressions With Daily Student Motivation and Engagement Predicting Composite Perceived Teacher Practices

	Autonomy supports		Autonomy thwarts	
Fixed effects	*b*(*SE*)	β	*b*(*SE*)	β
Class level				
Intercept	2.77 (.05)		1.98 (.04)	
Advanced class	.05 (.09)	.03	−.02 (.08)	−.01
Cohort	−.19 (.13)	−.11	−.02 (.11)	−.01
Title I	.16 (.11)	.10	−.07 (.10)	−.05
Teacher experience	−.005 (.005)	−.06	−.001 (.005)	−.02
Student level				
Sex	−.06 (.07)	−.04	−.08 (.07)	−.05
Ethnicity	−.06 (.08)	−.04	−.17 (.09)	−.11
Age	.04 (.03)	.06	−.07 (.03)	−.11
Free/reduced lunch	.12 (.09)	.08	.14 (.09)	.09
Prior unit course grade	.00 (.002)	.00	−.004 (.002)	−.08
Day level				
Autonomous motivation	.13 (.02)	.10***	−.05 (.02)	−.04*
Controlled motivation	−.03 (.02)	−.02	.17 (.02)	.12***
Engagement	.32 (.03)	.19***	.04 (.03)	.02
Disaffection	.09 (.03)	.05**	.26 (.02)	.16***
Time	.006 (.003)	.04*	.005 (.002)	.03**
Lagged outcome	.20 (.02)	.19***	.24 (.02)	.24***
Random effects	Variance	*SE*	Variance	*SE*
Class (Level 3) intercept	.04	.02	.006	.01
Student (Level 2) intercept	.18***	.03	.21***	.03
Day (Level 1)				
Residual	.23***	.009	.16***	.006
Autocorrelation	−.06	.06	−.13**	.006
Model Fit Statistics				
AIC	3026.81		2361.10	
BIC	3048.81		2383.10	

Note. Level 1 (daily reports) $n = 1{,}826$ reports. Level 2 (students) $n = 191$. Level 3 (classes) $n = 41$. The "time" variable reflects the day of reporting across the 6 week instructional unit. The "lagged outcome" variable reflects the prior class session's value for the outcome. For student sex, 0 = male and 1 = female. For student ethnicity, 0 = White or Asian and 1 = Black, Hispanic/Latino, or other ethnic minority. For free and reduced lunch status, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For advanced class, 0 = grade typical class and 1 = advanced class. For cohort, 0 = 2012–2013 school year and 1 = 2013–2014 school year. For Title I school, 0 = not Title I status and 1 = Title I status. *b* = unstandardized regression coefficient. β = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): β = (b*sdx)/sdy. AIC = Akaike's Information Criterion; BIC = Schwarz's Bayesian Criterion.
* $p < .05$. ** $p < .01$. *** $p < .001$.

ever, when students' motivation is controlled and they are disengaged in class, teachers are perceived to respond in kind with controlling strategies.

Interactions Between Composite Perceived Autonomy Supportive and Thwarting Practices

Finally, to address our research question regarding the interaction between perceptions of autonomy supporting and thwarting practices, we estimated four three-level random intercept only regressions that each included an interaction term between the two clusters of perceived daily practices. For this analysis, we again used the composite autonomy supporting practices variable and the composite autonomy thwarting practices variable. These models were similar to those previously described, except that these models each included only the two composite daily practice variables and their interaction, along with time, the lagged outcome covariate, and other student and classroom characteristic covariates. A model was estimated for each motivation and engagement outcome (engagement, disaffection, autonomous motivation, and controlled motivation).

There was a significant interaction between perceived daily autonomy supportive and thwarting practices for autonomous motivation, in addition to significant main effects of both (see Table 6). To get a better sense of this interaction, we conducted simple slope analyses that tested the relation between perceived daily supportive practice and autonomous motivation at 1 *SD* above and below the mean of thwarting practices. Likewise, we tested the relation between perceived daily thwarting practice and autonomous motivation at 1 *SD* above and below the mean of supportive practices. Simple slope analyses revealed that perceived daily supportive practice predicted an increase in autonomous motivation since the prior class session to a greater degree when daily thwarting practices were perceived to also be high (1 *SD* above the mean; $\beta = .20$, $p < .001$) compared with low (1 *SD* below the mean; $\beta = .15$, $p < .001$). Moreover, perceived daily thwarting practice predicted a decrease in autonomous motivation from the prior class session when daily supporting practices were perceived to be low (1 *SD* below the mean; $\beta = -.07$, $p < .001$), but not when daily supporting practices were perceived to be high (1 *SD* below the mean; $\beta = -.02$, $p = .28$). There were no interactions between perceived daily supporting and thwarting found for engagement, disaffection, or controlled motivation. Results suggest that the student perceptions of teachers' supporting their autonomy has a particularly strong relationship with their daily autonomous motivation when contrasted against thwarting practices perceived on the same day. Likewise, any undesirable effect of students' perceptions that their teachers are using autonomy thwarting practices on their daily autonomous motivation was mitigated when students also perceived their teachers to be engaging in supportive practices on the same day.

Table 6
Multilevel Regressions With Composite Perceived Teacher Practices and Their Interaction Predicting Autonomous Motivation

Fixed effects	*b*(*SE*)	β
Class level		
Intercept	2.94 (.07)	
Advanced class	.08 (.14)	.04
Cohort	−.09 (.20)	−.04
Title I	.10 (.17)	.05
Teacher experience	−.01 (.01)	−.06
Student level		
Sex	−.14 (.10)	−.07
Ethnicity	.09 (.12)	.04
Age	.03 (.05)	.04
Free/reduced lunch	−.11 (.13)	−.05
Prior unit course grade	.001 (.003)	.02
Day level		
Daily supports	.36 (.03)	.17***
Daily thwarts	−.11 (.03)	−.05***
Supports × Thwarts	.13 (.05)	.04**
Time	−.01 (.003)	−.04**
Lagged outcome	.21 (.02)	.21***

Random effects	Variance	*SE*
Class (Level 3) intercept	.10	.05
Student (Level 2) intercept	.39***	.07
Day level (Level 1)		
Residual	.33***	.01
Autocorrelation	−.04	.06
Model Fit Statistics		
AIC	3729.49	
BIC	3751.48	

Note. Level 1 (daily reports) $n = 1{,}820$ reports. Level 2 (students) $n = 191$. Level 3 (classes) $n = 41$. The "time" variable reflects the day of reporting across the 6 week instructional unit. The "lagged outcome" variable reflects the prior class session's value for the outcome. For student sex, 0 = male and 1 = female. For student ethnicity, 0 = White or Asian and 1 = Black, Hispanic/Latino, or other ethnic minority. For free and reduced lunch eligibility, 0 = not eligible free/reduced lunch and 1 = eligible free/reduced lunch. For advanced class, 0 = grade typical class and 1 = advanced class. For cohort, 0 = 2012–2013 school year and 1 = 2013–2014 school year. For Title I school, 0 = not Title I status and 1 = Title I status. *b* = unstandardized regression coefficient. β = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): β = (b*sdx)/sdy.
** $p < .01$. *** $p < .001$.

Discussion

The present investigation examined the role of various perceived autonomy relevant teaching strategies in students' daily autonomous motivation, controlled motivation, engagement, and disaffection in authentic high school science classes, as well as reciprocal relationships among these variables. We used a diary method to track students' daily perceptions of teacher practices and experiences during science class over a 6-week instructional unit. We also explored how perceived strategies routinely identified as autonomy supporting or thwarting interact and whether the presence of one type of perceived practice moderates the relation of the other with students' motivation and engagement during class.

Fit of Data to Theoretical Predictions

Overall, the patterns of results supported our hypotheses and were consistent with the dual process model within self-determination theory (Jang et al., 2016). We found the expected differentiated effects in which changes in autonomous motivation and engagement were predicted primarily by daily perceptions of

autonomy supportive teacher practices, while changes in controlled motivation and disaffection were predicted primarily by daily perceptions of thwarting practices. More specifically, daily student perceptions that teachers' considered their preferences and interests, provided rationales about the importance of usefulness of course activities, and provided opportunities for and responses to questions consistently predicted increases in both autonomous motivation and engagement since the prior class session, and perceived choice opportunities predicted increases in engagement. In contrast, perceptions of these daily supportive practices generally did not predict controlled motivation and disaffection, with the one exception being that daily perceptions that teachers provided question opportunities negatively predicted disaffection. Rather, student perceptions of thwarting practices consistently predicted controlled motivation and disaffection. Specifically, controlling messages and use of uninteresting activities predicted an increase in both controlled motivation and disaffection since the last class session and suppression of student perceptions predicted an increase in disaffection. Among these thwarting practices, only daily perceptions that teachers' used uninteresting activities appeared to be pervasively detrimental, predicting a decrease in both daily engagement and autonomous motivation, in addition to predicting an increase in controlled motivation and disaffection. However, both controlling message sand suppression of students' perspectives were unrelated to engagement or autonomous motivation.

Regarding reciprocal effects, students' motivation and engagement also predicted changes in their perceptions of their teachers' autonomy relevant practice largely in the expected differentiated pattern. Namely, an increase in perceived autonomy support was predicted primarily by students' daily autonomous motivation and engagement, and to a lesser extent by daily disaffection. In contrast, an increase in perceived autonomy thwarting was predicted primarily by controlled motivation and disaffection, and negatively predicted by autonomous motivation to a lesser extent. One surprising finding regarding reciprocal effects was that students' disaffection predicted an increase in perceptions that teachers' engaged in autonomy supportive practices. This particular finding is somewhat inconsistent with prior traditional (nondaily diary) longitudinal evidence suggesting that disengagement predicts less autonomy support (e.g., Jang et al., 2016). Although surprising in the context of previous findings, we find this quite encouraging as it suggests that on days when students are actively disengaged during class, they perceive their teachers to react by increasing their support for autonomy during that same class session (presumably in an attempt to elicit engagement from students). We also note that we observed the expected relationship between students' autonomous motivation and engagement to perceived autonomy support on a *daily basis* even though some prior traditional longitudinal research examining reciprocal effects predicted by the dual process model (e.g., Jang et al., 2016) did not observe this relationship. Finally, it is also worth noting that the magnitude of effects in both directions were quite similar,[1] leading us to conclude that the students' experience of motivation and engagement may play an equally important role in the perceptions of the classroom environment as the classroom environment plays in students' experiences of motivation and engagement.

Taken together, evidence provided in this investigation is largely consistent with prior cross-sectional and longitudinal evidence and extends it by demonstrating the utility of the dual process model for day-to-day reciprocal links between students' perceptions of their teachers' autonomy-relevant practice, motivation, and engagement (e.g., Assor et al., 2002; Haerens et al., 2015; Jang et al., 2016). That is, the pattern of results suggests that there are largely divergent pathways to various aspects of students' functioning in the classroom. Students are likely to experience heightened behavioral, emotional, and cognitive engagement, as well as internal forms of motivation that spring from interest, enjoyment, and value on days when they perceive their teachers to use autonomy supportive practices like rationales, activities that consider students' interests, and questions, and to some extent, choices. However, the absence of these daily practices does not generally lead to students' disaffection and controlled motivation in class. Rather, it is when students perceive teachers to use explicitly controlling practices—controlling messages, suppression of student perspectives, and activities that seem uninteresting or meaningless—that students become behaviorally and emotionally disengaged and pursue school tasks for more external reasons. Likewise, students' behavioral, affective, and cognitive experiences predict their perceptions of the classroom environment (and possibly teachers' actual behavior). On days when students experience autonomous motivation and engagement, their perceptions that teachers are supportive of their autonomy increase. In contrast, on days when students experience controlled motivation and engagement in class, they perceive their teachers to be more controlling.

Interactions Between Perceived Supports and Thwarts

With the basic pattern of relationships between perceived teacher practices and students' motivation and engagement established, it was also clear that the interaction between perceived autonomy supportive and thwarting practices was somewhat complex. Given that science emphasizes both discovery and using established, rigorous procedures, there is likely to be many opportunities for both supporting autonomy (e.g., "design your own experiment on something related to what we have been studying today that interests you") and controlling behavior (e.g., "this is how you *need* to conduct this experiment if you want it to work") in science courses. With that in mind, our results suggested that we may not need to be quite so worried about students' perceiving their teachers to engage in autonomy thwarting practices on a given day as long as they also perceive teachers to engage in autonomy supportive practices. We found that perceived supportive practices predicted a greater increase in autonomous motivation on days when thwarting practices were perceived to be high compared with low. Likewise, students' perceptions that their teachers used thwarting practices only predicted a decrease in autonomous motivation on days when they perceived supportive

[1] To explicitly compare the magnitude of effects across reciprocal effects, we conducted additional multilevel models including the aggregated perceived autonomy supporting practice and perceived autonomy thwarting practice as predictors of each form of motivation and engagement. Autonomy support predicted autonomous motivation and engagement most strongly ($\beta = .17$ and .19, $ps < .001$) and controlled motivation and disaffection to a lesser extent or not at all ($\beta = .03$ and $-.01$, $ps = .03$ and .23). Autonomy thwarting predicted controlled motivation and disaffection most strongly ($\beta = .15$ and .23, $ps < .001$) and autonomous motivation and engagement to a lesser extent ($\beta = -.04$ and $-,04$, $ps < .005$ and .001).

practices to be low, but not on days when they were perceived supports to be high.

We found this interaction only for autonomous motivation. As such, results about the differential effects of these predictors are limited in scope. Nonetheless, these results suggest that the perceived contrast between autonomy supports and thwarts may have the desirable effect of heightening the significance of autonomy support for enhancing students' autonomous motivation. That is, in comparison with a controlling strategy that a student might have recently perceived in class, autonomy supportive strategies are perceived to be particularly supportive of a student's interests, values, and drive to engage in some class activity for internal reasons. The combination of perceived autonomy supporting and thwarting may also have the converse desirable effect of students being less sensitive to perceived controlling practices as long as they are accompanied by supportive practices. Perhaps in the context of perceiving teachers to use practices that support autonomy, teachers controlling practices are experienced as providing structure and organization, rather than attempts to control behavior and thwart students' autonomy. Despite these findings, we would not encourage teachers to intentionally use controlling practices, particularly given our findings that perceived daily thwarts clearly predicted daily disaffection and we found no evidence that perceived supports could mitigate that association. Likewise, there was no evidence that perceived supports and thwarts interacted to influence engagement and only limited evidence of interaction for controlled motivation, which we discuss next in reference to perceived suppression of student perspectives.

The Conundrum of Choice and Suppression

Another surprising finding was that daily perceptions of choice opportunities predicted increases in daily engagement, but not autonomous motivation and similarly, daily perceptions that teachers' suppressed student perspectives predicted an increase in daily disaffection, but not controlled motivation. To better understand these null findings, we conducted a number of exploratory analyses (a) examining the effects of perceived practices after decomposing the daily motivation outcomes into their constituents and (b) examining interactions involving these two particular practices and each of the other practices.

First, these exploratory multilevel model analyses revealed that students' daily perceptions that teachers provided choices predicted intrinsic motivation ($\beta = .04$, $p = .02$), but had no relationship with identified motivation ($\beta = -.0004$, $p = .98$). This finding suggests that choice provision is an autonomy supportive practice that is particularly predictive of forms of motivation based in positive emotions (i.e., interest and enjoyment) rather than value. This is consistent with prior research suggesting that choice provision is most strongly related to intrinsic motivation and less strongly related to motivation focused on the importance or value of the activity (e.g., Patall, Cooper, & Wynn, 2010; Patall et al., 2013).

Second, an exploratory multilevel model analyses also revealed that perceived choice provision interacted with perceptions of a number of other practices that changed its daily relationship with autonomous motivation. Specifically, daily perceptions that teachers' provided choices interacted with three other practices, perceived daily question opportunities ($\beta = .06$, $p < .001$), controlling messages ($\beta = .04$, $p < .009$), and use of uninteresting activities ($\beta = .03$, $p < .03$). Simple slope analyses suggested that perceptions of greater daily choice provision predicted greater autonomous motivation when opportunities to ask questions, controlling messages, or use of uninteresting activities were also perceived to be high (1 *SD* above the mean; βs = .07, .05, and .04, *p*s < .001, .01, and .02), but not when they were perceived to be low (1 *SD* below the mean; βs = −.04, −.02, and −.02; *p*s = .06, .30, and .41). Results suggest that students' perception that their teachers provided choices on a given day is specifically related to autonomous motivation during class when bolstered by the presence of another supportive practice (daily question opportunities) or contrasted against a thwarting practice (daily controlling message and uninteresting activities) on the same day.

One way to interpret this finding is to first note that, at times, choices can be overwhelming rather than motivating for students (e.g., Iyengar & Lepper, 2000; Patall, Cooper, & Robinson, 2008; Schwartz & Ward, 2004). However, when accompanied by another support that also serves to provide some structure (question opportunities), the motivating function of choosing can be revealed. That is, when students are provided with choices but are not allowed to ask questions about those choices or the activity, the choice might seem more arbitrary and less important, or students may lack confidence to make the "right" choice without the necessary information. If, on the other hand, students are provided with the opportunity to ask questions about their choice and the task, choosing may be more likely to be experienced as strategic, personal, and effective. Controlling messages may also be experienced similarly as a form of structure that can support the motivational benefits of choosing when the two are provided in combination. It is worth noting that this interpretation is consistent with research suggesting that students' motivation thrives after choosing in contexts in which they feel competent, but deteriorates after choosing if they do not feel competent (i.e., Patall, Sylvester, & Han, 2014).

Theoretically, choice is presumed to enhance the experiences of autonomy by allowing individuals to express the self and act in accordance with their personal preferences and interests (e.g., Katz & Assor, 2007; Patall et al., 2008; Ryan & Deci, 2000). Accordingly, researchers have long noted the possibility that providing choices may be particularly useful in the context of boring rather than interesting tasks because there is more opportunity to improve the task by incorporating personal preferences and interests in the context of a motivationally deprived task (e.g., Patall et al., 2013, 2010; Sansone, Weir, Harpster, & Morgan, 1992; Tafarodi, Milne, & Smith, 1999). In contrast, when a task is already interesting and autonomy-supportive by its very nature, choosing becomes an unnecessary expenditure of decision-making effort that may even diminish autonomous motivation. In fact, recent laboratory-based experiments have demonstrated that college students reported enhanced interest, perceived competence, value, and liking for a reading comprehension task after choosing aspects of the task only when the task was boring, but not when it was interesting (e.g., Patall et al., 2013). This investigation is in line with those findings, suggesting that within the science classroom, perceiving the opportunity to make choices about learning tasks and classroom activities may enhance autonomous motivation most in the context of activities that are perceived to be particularly uninteresting.

A final exploratory multilevel analysis revealed that perceived suppression interacted with perceptions of other practices that changed its daily relationship with controlled motivation. Specifically, daily perceptions that teachers' suppressed student perspectives interacted with two other practices, perceived choice provision ($\beta = .10$, $p < .001$) and question opportunities ($\beta = -.04$, $p < .02$). Perceptions that teachers' suppressed student perspectives during the class session predicted students' greater controlled motivation when opportunities to ask questions during class were perceived to be low (1 *SD* below the mean; $\beta = .05$, $p < .02$), but not when they were perceived to be high (1 *SD* above the mean; $\beta = -.02$, $p = .37$). Perceptions that teachers' suppressed student perspectives during class also predicted greater controlled motivation when the provision of choice was perceived to be high during the class session (1 *SD* above the mean, $\beta = .09$, $p < .001$). However, when daily perceptions of choice provision were low (1 *SD* below the mean), perceived suppression during the class negatively predicted students' controlled motivation ($\beta = -.06$, $p < .003$). Results suggest that the relationship between daily suppression and students' controlled motivation depends on the perception of other practices during the same class session, with the perception of question opportunities mitigating the undesirable effect of perceived suppression increasing controlled motivation, and the perception of choice opportunities magnifying that effect. The latter finding again highlights the very mixed benefits and detriments of having choices. Choices can often be experienced as overwhelming by students. When combined with the perception that teachers will not allow students to express their opinions, preferences, and feelings, the experience of being controlled and behaving merely to obtain rewards or avoid undesirable consequences is likely to be particularly robust.

Limitations and Implications for Future Research

Given the potential practical implications of understanding the links between teachers' practices and students' motivation, engagement, and achievement, it would seem imperative that future research replicate and extend the findings of the current investigation. Strengths of the current investigation include the simultaneous focus on various perceived autonomy supportive and thwarting practices, the intensive longitudinal design that allowed us to examine the extent to which daily variations in students' perceptions of teacher practice was associated with corresponding fluctuations in daily motivation and engagement in the classroom, and the fact that the study was situated within a heterogeneous set of science classrooms with students of various social, economic, and cultural backgrounds. Despite the strengths of the current design, the correlational nature of the design cannot be taken to imply causation. Consequently, findings of this investigation should be corroborated with experimental designs in authentic classroom contexts that isolate the effects of various autonomy relevant practices and allow for the interactions among them to be explored to best understand the effects of teachers' autonomy relevant practice. Thus far, intervention research focused on autonomy relevant teacher practice has generally focused on autonomy support as a whole or only one specific practice isolated from others (e.g., choice provision).

The reliance on student self-reports in the current investigation presents another significant limitation that needs to be addressed in future research. Although the focus on student perceptions of teachers' practice is reasonable given self-determination theory's assumption that it is students' subjective experiences that are the most powerful predictor of their motivation and engagement, relying exclusively on students' self-reports leaves open the possibility that response-bias and shared-method variance may influence the results. Accordingly, using independent observations of the classroom to explore the extent to which autonomy relevant teacher practice relates to students' motivation and engagement outcomes is an important next step in this scholarship, though we acknowledge that observations present their own unique set of limitations and biases. While there are examples of researchers using observation to determine teachers' autonomy supporting or thwarting practice (e.g., De Meyer et al., 2014; Reeve et al., 2004), we know of no research in which individual components of autonomy relevant practice were observed as separate coding categories and used as separate variables to predict outcomes. Given the complex dynamics that seem to play out between various autonomy relevant practices, we believe that a nuanced understanding of what makes for the best autonomy relevant teaching practice requires detailed coding at the individual teacher strategy level. This is likely to be particularly true for practices such as choice provision and suppression of student perspective, which this investigation highlighted as having particularly heterogeneous associations with other teaching practices and student outcomes.

In future research, we also encourage researchers to examine formally the extent to which need satisfaction and frustration mediates the daily relationships uncovered in this investigation. Though we selected the current set of perceived practices after reviewing previous research regarding practices that have been associated with students' perceived autonomy (e.g., Patall et al., 2013; Reeve & Jang, 2006), it is possible that various psychological processes mediate the relationships between perceived daily teaching practices and students' daily motivation and engagement. Moreover, we would be remiss if we did not point out that our list of autonomy supportive and thwarting practices is not comprehensive. Although we attempted to select the most central and promising strategies, motivation researchers have suggested a variety of additional practices, such as acknowledgment of negative affect, encouragement, perspective-taking, use of deadlines, and controlling rewards (e.g., Reeve, 2009; Reeve & Jang, 2006), that could be considered in future research focused on autonomy relevant teaching.

We also want to highlight that the nature of the design in the current investigation in which students were asked to provide reports multiple days a week for several weeks necessitated relying on a small sample of volunteers from each class. Likewise, teachers selected the participating class and were themselves volunteers. Though we attempted to recruit a diverse sample of teachers and adolescents (e.g., we randomly selected student participants among volunteers and approximately 40% of teachers across participating schools volunteered to participate), the voluntary and selective nature of the sample undoubtedly provides the opportunity for biased results that are idiosyncratic to the current sample. Future research should attempt to address this limitation with classes and samples that are randomly selected to the greatest extent possible.

Finally, although it was not the focus of this investigation, results also suggested that female students were less engaged in science class compared with male students. Given the continued

concern about engaging women in STEM (e.g., Bidwell, 2015), this finding highlights the need for future research to explore the benefits and detriments of autonomy relevant teaching practices in science domains particularly for female students and the contexts that might be most supportive of their motivation and engagement.

Conclusion

In conclusion, this investigation adds to the growing body of research exploring perceptions of autonomy relevant teaching and its reciprocal relations with adolescent students' motivation and engagement. This study goes beyond those previously conducted by using an intensive daily diary study to examine perceptions of various daily supportive *and* thwarting practices in an authentic academic classroom setting. Taken together, results suggested that students' perceptions of teachers' daily supportive and thwarting practices have distinct reciprocal relations with various aspects of students' motivation and engagement during class. While perceived supportive practices primarily predicted changes in daily autonomous motivation and engagement in class and vice versa, perceived thwarting practices primarily predicted students' daily controlled motivation and disaffection during class and vice versa. Moreover, the current investigation is the first to highlight that perceived supportive and thwarting practices interact and that the presence of both may yield benefits for students' motivation, though it is important to note that we found this interaction only for autonomous motivation. We hope that this investigation serves as a useful guide for future classroom-based theory and research focused on motivationally relevant instruction.

References

Allchin, D. (1999). Values in science: An educational perspective. *Science & Education, 8,* 1–12. http://dx.doi.org/10.1023/A:1008600230536

Archambault, I., Janosz, M., Fallu, J.-S., & Pagani, L. S. (2009). Student engagement and its relationship with early high school dropout. *Journal of Adolescence, 32,* 651–670. http://dx.doi.org/10.1016/j.adolescence.2008.06.007

Assor, A., Kaplan, H., Kanat-Maymon, Y., & Roth, G. (2005). Directly controlling teacher behaviors as predictors of poor motivation and engagement in girls and boys: The role of anger and anxiety. *Learning and Instruction, 15,* 397–413. http://dx.doi.org/10.1016/j.learninstruc.2005.07.008

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal of Educational Psychology, 72,* 261–278. http://dx.doi.org/10.1348/000709902158883

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin, 37,* 1459–1473. http://dx.doi.org/10.1177/0146167211413125

Bartos, S. A., & Lederman, N. G. (2014). Teachers' knowledge structures for nature of science and scientific inquiry: Conceptions and classroom practice. *Journal of Research in Science Teaching, 51,* 1150–1184. http://dx.doi.org/10.1002/tea.21168

Belmont, M. J., Skinner, E. A., Wellborn, J. G., & Connell, J. P. (1992). *Teacher as social context (TASC): Two measures of teacher provision of involvement, structure, and autonomy support*. Unpublished manuscript, Graduate School of Education and Human Development, Department of Psychology, University of Rochester.

Bidwell, A. (2015, February 24). STEM workforce no more diverse than 14 years ago. *US News and World Report*. Retrieved from http://www.usnews.com

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. New York, NY: Guilford Press.

Bureau of Labor Statistics. (2011). *Occupational outlook handbook*. Washington, DC: Author.

Cheon, S. H., & Reeve, J. (2015). A classroom-based intervention to help teachers decrease students' amotivation. *Contemporary Educational Psychology, 40,* 99–111.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal, 9,* 233–255. http://dx.doi.org/10.1207/s15328007sem0902_5

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2010). Teacher credentials and student achievement in high school: A cross-subject analysis with student fixed effects. *The Journal of Human Resources, 45,* 655–681. http://dx.doi.org/10.3368/jhr.45.3.655

Cohen, J., & Cohen, P. (1982). *Applied multiple regression/correlation analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Connell, J. P. (1990). Context, self and action: A motivational analysis of self-system processes across the life-span. In D. Cichhetti (Ed.), *The self in transition: From infancy to childhood* (pp. 61–97). Chicago, IL: University of Chicago Press.

Corpus, J. H., McClintic-Gilbert, M. S., & Hayenga, A. O. (2009). Within-year changes in children's intrinsic and extrinsic motivational orientations: Contextual predictors and academic outcomes. *Contemporary Educational Psychology, 34,* 154–166. http://dx.doi.org/10.1016/j.cedpsych.2009.01.001

Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: The self-determination theory perspective. *Journal of Personality, 62,* 119–142. http://dx.doi.org/10.1111/j.1467-6494.1994.tb00797.x

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11,* 227–268. http://dx.doi.org/10.1207/S15327965PLI1104_01

De Meyer, J., Tallir, I. B., Soenens, B., Vansteenkiste, M., Aelterman, N., Van den Berghe, L., . . . Haerens, L. (2014). Does observed controlling teaching behavior relate to students' motivation in physical education? *Journal of Educational Psychology, 106,* 541–554. http://dx.doi.org/10.1037/a0034399

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & Mac Iver, D. M. (1993). Development during adolescence. The impact of stage-environment fit on young adolescents' experiences in schools and in families. *American Psychologist, 48,* 90–101. http://dx.doi.org/10.1037/0003-066X.48.2.90

Erikson, E. H. (1968). *Identity: Youth and crisis*. Oxford, England: Norton & Co.

Furrer, C., & Skinner, E. A. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology, 95,* 148–162. http://dx.doi.org/10.1037/0022-0663.95.1.148

Goldstein, H. (2011). *Multilevel Statistical Models* (4th ed.). Hoboken, NJ: Wiley.

Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology, 93,* 3–13. http://dx.doi.org/10.1037/0022-0663.93.1.3

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., & Oliver, P. H. (2009). A latent curve model of parental motivational practices and developmental decline in math and science academic intrinsic motivation. *Journal of Educational Psychology, 101,* 729–739. http://dx.doi.org/10.1037/a0015084

Haerens, L., Aelterman, N., Vansteenkiste, M., Soenens, B., & Van Petegem, S. (2015). Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation. *Psychology of Sport and Exercise, 16,* 26–36. http://dx.doi.org/10.1016/j.psychsport.2014.08.013

Harter, S. (1981). A new self-report scale of intrinsic versus extrinsic orientation in the classroom: Motivational and informational components. *Developmental Psychology, 17,* 300–312. http://dx.doi.org/10.1037/0012-1649.17.3.300

Hox, J. J. (2010). *Multilevel analysis. Techniques and applications I* (2nd ed.). New York, NY: Routledge.

Hughes, J. N., Luo, W., Kwok, O.-M., & Loyd, L. K. (2008). Teacher-student support, effortful engagement, and achievement: A 3-year longitudinal study. *Journal of Educational Psychology, 100,* 1–14. http://dx.doi.org/10.1037/0022-0663.100.1.1

Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology, 79,* 995–1006. http://dx.doi.org/10.1037/0022-3514.79.6.995

Jang, H., Kim, E. J., & Reeve, J. (2012). Longitudinal test of self-determination theory's motivation mediation model in a naturally occurring classroom context. *Journal of Educational Psychology, 104,* 1175–1188. http://dx.doi.org/10.1037/a0028089

Jang, H., Kim, E. J., & Reeve, J. (2016). Why students become more engaged or more disengaged during the semester: A self-determination theory dual-process model. *Learning and Instruction, 43,* 27–38. http://dx.doi.org/10.1016/j.learninstruc.2016.01.002

Katz, I., & Assor, A. (2007). When choice motivates and when it does not. *Educational Psychology Review, 19,* 429–442. http://dx.doi.org/10.1007/s10648-006-9027-y

Katz, I., Kaplan, A., & Gueta, G. (2009). Students' needs, teachers' support, and motivation for doing homework: A cross-sectional study. *Journal of Experimental Education, 78,* 246–267. http://dx.doi.org/10.1080/00220970903292868

Kim-Spoon, J., & Grimm, K. J. (2016). Latent growth curve modeling and developmental psychology. In D. Cicchetti (Ed.), *Developmental psychopathology, Vol. 1, theory, and method* (3rd ed., pp. 986–1041). Hoboken, NJ: Wiley.

Kline, R. (2010). *Principles and practice of structural equation modeling* (3rd ed.). New York, NY: Guilford Press Publications.

Kreft, I., & de Leeuw, J. (1998). *Introducing multilevel modeling*. London, England: Sage. http://dx.doi.org/10.4135/9781849209366

Kuhn, T. S. (1962). *The structure of scientific revolutions* (1st ed.). Chicago, IL: University of Chicago Press.

Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology, 97,* 184–196. http://dx.doi.org/10.1037/0022-0663.97.2.184

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95,* 877–907. http://dx.doi.org/10.1002/sce.20441

Miceli, M., & Castelfranchi, C. (2000). Nature and mechanisms of loss of motivation. *Review of General Psychology, 4,* 238–263. http://dx.doi.org/10.1037/1089-2680.4.3.238

Moerbeek, M. (2004). The consequence of ignoring a level of nesting in multilevel analysis. *Multivariate Behavioral Research, 39,* 129–149. http://dx.doi.org/10.1207/s15327906mbr3901_5

Murayama, K., Pekrun, R., Lichtenfeld, S., & Vom Hofe, R. (2013). Predicting long-term growth in students' mathematics achievement: The unique contributions of motivation and cognitive strategies. *Child Development, 84,* 1475–1490. http://dx.doi.org/10.1111/cdev.12036

Murdock, T. B. (1999). The social context of risk: Status and motivational predictors of alienation in middle school. *Journal of Educational Psychology, 91,* 62–75. http://dx.doi.org/10.1037/0022-0663.91.1.62

Otis, N., Grouzet, F. M. E., & Pelletier, L. G. (2005). Latent Motivational Change in an Academic Setting: A 3-Year Longitudinal Study. *Journal of Educational Psychology, 97,* 170–183. http://dx.doi.org/10.1037/0022-0663.97.2.170

Organization for Economic Co-operation and Development (OECD). (2006). *Evolution of student interest in science and technology studies: Policy report*. Paris, France: Organisation for Economic Co-operation and Development Global Science Forum.

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). The effects of choice on intrinsic motivation and related outcomes: A meta-analysis of research findings. *Psychological Bulletin, 134,* 270–300. http://dx.doi.org/10.1037/0033-2909.134.2.270

Patall, E. A., Cooper, H., & Wynn, S. R. (2010). The effectiveness and relative importance of choice in the classroom. *Journal of Educational Psychology, 102,* 896–915. http://dx.doi.org/10.1037/a0019545

Patall, E. A., Dent, A. L., Oyer, M., & Wynn, S. R. (2013). Student autonomy and course value: The unique and cumulative roles of various teacher practices. *Motivation and Emotion, 37,* 14–32. http://dx.doi.org/10.1007/s11031-012-9305-6

Patall, E. A., Sylvester, B. J., & Han, C.-W. (2014). The role of competence in the effects of choice on motivation. *Journal of Experimental Social Psychology, 50,* 27–44. http://dx.doi.org/10.1016/j.jesp.2013.09.002

Patall, E. A., Vasquez, A. C., Steingut, R. R., Trimble, S. R., & Pituch, K. A. (2016). Daily interest, engagement, and autonomy support in the high school science classroom. *Contemporary Educational Psychology, 46,* 180–194. http://dx.doi.org/10.1016/j.cedpsych.2016.06.002

Pelletier, L. G., Séguin-Lévesque, C., & Legault, L. (2002). Pressure from above and pressure from below as determinants of teachers' motivation and teaching behaviors. *Journal of Educational Psychology, 94,* 186–196. http://dx.doi.org/10.1037//0022-0663.94.1.186

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The Elementary School Journal, 106,* 225–236. http://dx.doi.org/10.1086/501484

Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educational Psychologist, 44,* 159–175. http://dx.doi.org/10.1080/00461520903028990

Reeve, J., & Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of Educational Psychology, 98,* 209–218. http://dx.doi.org/10.1037/0022-0663.98.1.209

Reeve, J., Jang, H., Carrell, D., Jeon, S., & Barch, J. (2004). Enhancing students' engagement by increasing teachers' autonomy support. *Motivation and Emotion, 28,* 147–169. http://dx.doi.org/10.1023/B:MOEM.0000032312.95499.6f

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin, 26,* 419–435. http://dx.doi.org/10.1177/0146167200266002

Roesch, S. C., Aldridge, A. A., Stocking, S. N., Villodas, F., Leung, Q., Bartley, C. E., & Black, L. J. (2010). Multilevel factor analysis and structural equation modeling of daily diary coping data: Modeling trait and state variation. *Multivariate Behavioral Research, 45,* 767–789. http://dx.doi.org/10.1080/00273171.2010.519276

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57,* 749–761. http://dx.doi.org/10.1037/0022-3514.57.5.749

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55,* 68–78. http://dx.doi.org/10.1037/0003-066X.55.1.68

Sansone, C., Weir, C., Harpster, L., & Morgan, C. (1992). Once a boring task always a boring task? Interest as a self-regulatory mechanism. *Journal of Personality and Social Psychology, 63,* 379–390. http://dx.doi.org/10.1037/0022-3514.63.3.379

Schwartz, B., & Ward, A. (2004). Doing better but feeling worse: The paradox of choice. In P. A. Linley, S. Joseph, P. A. Linley, & S. Joseph (Eds.), *Positive psychology in practice* (pp. 86–104). Hoboken, NJ: Wiley http://dx.doi.org/10.1002/9780470939338.ch6

Sheldon, K. M., Ryan, R. M., Deci, E. L., & Kasser, T. (2004). The independent effects of goal contents and motives on well-being: It's both what you pursue and why you pursue it. *Personality and Social Psychology Bulletin, 30,* 475–486. http://dx.doi.org/10.1177/0146167203261883

Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational Psychologist, 50,* 1–13. http://dx.doi.org/10.1080/00461520.2014.1002924

Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology, 85,* 571–581. http://dx.doi.org/10.1037/0022-0663.85.4.571

Skinner, E. A., Furrer, C., Marchand, G., & Kindermann, T. A. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic? *Journal of Educational Psychology, 100,* 765–781. http://dx.doi.org/10.1037/a0012840

Skinner, E. A., Kindermann, T. A., Connell, J. P., & Wellborn, J. G. (2009). Engagement and disaffection as organizational constructs in the dynamics of motivational development. In K. R. Wenzel, A. Wigfield, K. R. Wenzel, & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 223–245). New York, NY: Routledge/Taylor & Francis Group.

Soenens, B., Sierens, E., Vansteenkiste, M., Dochy, F., & Goossens, L. (2012). Psychologically controlling teaching: Examining outcomes, antecedents, and mediators. *Journal of Educational Psychology, 104,* 108–120. http://dx.doi.org/10.1037/a0025742

Solomon, D., Battistich, V., & Hom, A. (1996). Teacher beliefs and practices in schools serving communities that differ in socioeconomic level. *Journal of Experimental Education, 64,* 327–347. http://dx.doi.org/10.1080/00220973.1996.10806602

Su, Y.-L., & Reeve, J. (2011). A meta-analysis of the effectiveness of intervention programs designed to support autonomy. *Educational Psychology Review, 23,* 159–188. http://dx.doi.org/10.1007/s10648-010-9142-7

Tafarodi, R. W., Milne, A. B., & Smith, A. J. (1999). The confidence of choice: Evidence for an augmentation effect on self-perceived performance. *Personality and Social Psychology Bulletin, 25,* 1405–1416. http://dx.doi.org/10.1177/0146167299259006

Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. M., & Deci, E. L. (2004). Motivating learning, performance, and persistence: The synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *Journal of Personality and Social Psychology, 87,* 246–260. http://dx.doi.org/10.1037/0022-3514.87.2.246

Vansteenkiste, M., Zhou, M., Lens, W., & Soenens, B. (2005). Experiences of autonomy and control among Chinese learners: Vitalizing or immobilizing? *Journal of Educational Psychology, 97,* 468–483. http://dx.doi.org/10.1037/0022-0663.97.3.468

Walker, C. O., Greene, B. A., & Mansell, R. A. (2006). Identification with academics, intrinsic/extrinsic motivation, and self-efficacy as predictors of cognitive engagement. *Learning and Individual Differences, 16,* 1–12. http://dx.doi.org/10.1016/j.lindif.2005.06.004

Wellborn, J. G., & Connell, J. P. (1987). *Manual for the Rochester assessment package for schools*. Rochester, NY: University of Rochester.

Willingham, W. W., Pollack, J. M., & Lewis, C. (2002). Grades and test scores: Accounting for observed differences. *Journal of Educational Measurement, 39,* 1–37. http://dx.doi.org/10.1111/j.1745-3984.2002.tb01133.x

Wolters, C. A. (2004). Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology, 96,* 236–250. http://dx.doi.org/10.1037/0022-0663.96.2.236

(*Appendix follows*)

Appendix

Items from the Daily Perceived Teacher Practice Measure

Provision of Choice

My teacher allowed me to choose which questions or parts of an assignment to work on today.

My teacher provided options for the kinds of assignments or activities I could do today.

My teacher allowed me to choose how to do my work in the classroom today.

My teacher allowed me to choose how to use my time for studying and classwork today.

My teacher encouraged me to work in my own way today.

Consideration for Student Interests and Preferences

My teacher structured class activities today around my interests.

My teacher took my preferences into consideration for assignments today.

My teacher worked my interests into his or her lesson(s) today.

Rationales Identifying Usefulness, Importance, and Relevance of Activities

My teacher explained how what we were learning today is important.

My teacher demonstrated how what we were learning today is useful.

My teacher explained how the course assignments today were important.

My teacher talked about the connection between what we are studying in school today and real life.

Student Question Opportunities

My teacher provided opportunities for me to ask questions today.

My teacher acknowledged and responded to my questions in class today.

Controlling Messages

My teacher was strict about me doing everything in his or her way today.

The language my teacher used today included how I "should" or "ought" to do things.

My teacher told me to work on the assignments today because she or he said so.

Suppression of Student Perspectives and Controlling Activities

My teacher stopped me from expressing my opinions in class today.

My teacher stopped me from asking questions in class today.

My teacher prevented me from expressing complaints or talking about my negative feelings during class today.

Meaningless or Uninteresting Activities

My teacher forced me to study boring topics today.

My teacher forced me to do uninteresting activities in class today.

Received November 17, 2015
Revision received April 26, 2017
Accepted May 8, 2017 ■