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Empirical study

Daily interest, engagement, and autonomy support in the high school science classroom ☆

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ABSTRACT

The current investigation examined relations between high school students' daily and cumulative situational interest in science class and their engagement, as well as their perceptions of the motivational climate of the classroom. Two-hundred and eighteen high school students in 43 science classes participated in a diary study in which students provided reports of their classroom experiences after each class session for a six-week instructional unit. Multilevel modeling results suggested that interest during science class and behavioral engagement declined over the course of the unit. Daily and cumulative interest during science class predicted behavioral engagement (working hard, participating, and paying attention), cognitive engagement, and agentic engagement. Students' interest during science class also predicted perceptions that teachers engaged in the motivationally supportive practice of emphasizing student choice during the same and the following class day. Results suggested that the links between interest with working hard and perceptions of choice provision were stronger early in the instructional unit compared to later in the unit. Moreover, some variation was found in these relations depending on students' gender and ethnicity, as well as depending on the course content and level. Implications for practice, theory, and future research are discussed.

1. Introduction

What prompts students to engage in scientific questions and attempt to learn about various topics in science? Though there are many possible answers to this question, psychologists, teachers, parents, students, and even scientists themselves would likely point to the important role that interest plays in the classroom and beyond. Indeed, interest has long been argued to be an important predictor of students' engagement, learning, and achievement (e.g. Dewey, 1913; Hidi & Harackiewicz, 2000; Renninger & Bachrach, 2015; Schiefele, 2009). Though studies within kindergarten through 12th grade classrooms are scarce, the extant research suggests that interest is likely to support various forms of student engagement, enhancing attention, cognitive processing, involvement, and persistence (e.g. Ainley, Hidi, & Berndorff, 2002; Durik & Harackiewicz, 2007). Understanding this relation between interest and engagement in kindergarten (k) through 12th grade classrooms is important, as the behavior and cognitions that define engagement are closely linked with learning and achievement (e.g. Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Rotgans & Schmidt, 2011a, 2012).

Moreover, understanding the role of interest in the high school science classroom in particular is important given the increasing demand for individuals with knowledge in the areas of science, technology, engineering, and mathematics (STEM) in the current global marketplace (e.g., Bureau of Labor Statistics, 2011; National Science Board, 2010) relative to the modest number of students who pursue STEM careers (Organisation for Economic Co-operation and Development [OECD], 2006). This societal conundrum has led educational and psychological researchers to become increasingly concerned with understanding predictors of student engagement in STEM (Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008), particularly during high school, given theory and evidence suggesting that students clarify their career goals during this time (Gottfredson, 1981) and have higher odds of completing a STEM degree if they reported an interest in STEM at a time more proximal to college (e.g., Maltese, Melki, & Wiebke, 2014). Focusing on the function of interest in science class during high school may be especially important given current data suggesting that a large percentage of high school students may actually become less engaged in STEM fields from the start of high school to graduation

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(e.g., Morella, 2013). Moreover, a number of student and classroom factors, including the students' gender, ethnicity, or the specific content of the science course, may influence students' interest, engagement, perceptions of the environment, or the relations among those variables in ways that are specific to the science domain (e.g., Sinatra, Heddy, & Lombardi, 2015), making it all the more essential for researchers to focus specifically on the role of interest within the science classroom so that science-specific heterogeneity can be explored.

However, despite the importance and complexity of understanding the role of interest in the high school science classroom, the majority of the research linking situational interest, a temporary psychological state aroused by the context and often characterized by positive emotional tone (Ainley & Hidi, 2002; Schiefele, 2009), to learning-relevant behaviors has been conducted for text-based processing or outside of the k through 12th grade classroom. Given the long-standing concern about the generalizability of research based on college student samples in a university laboratory (e.g., Carlson, 1971; Dipboye, 1979; Sears, 1986) and growing empirical evidence that findings based on college student samples routinely differ in magnitude and direction when compared to findings based on non-college student samples (e.g., Henrich, Heine, & Norenzayan, 2010; Peterson, 2001), the limited research explicitly examining the role of interest in student outcomes within k through 12th grade classrooms is a concern. Findings related to the nature and consequences of interest among college science students are not unlikely to differ from those for younger students, given that college students have, more often than younger students, self-selected to pursue science coursework, while a significant proportion of science coursework is required at the high school level. Consequently, it is important to examine questions about the links between students' interest, engagement, and classroom perceptions across a variety of student samples and settings, and particularly in the high school context where research is lacking, if trustworthy guidelines for practice are to be eventually developed.

Further, few (if any) studies have explored the link between *daily* classroom interest and engagement over time. Given that it is engagement accumulated across individual days that will lead to achievement in science coursework and long-term investments in STEM, it would seem important to understand the extent to which students' interest in the science classroom predict engagement both on any given school day and cumulatively over time, as well as the extent to which such relations may change as a science course progresses and different contextual demands become salient.

Finally, while some interest research has focused on how situational interest is triggered by the environment (e.g., Linnenbrink-Garcia, Patall, & Messersmith, 2013; Rotgans & Schmidt, 2011a, 2011b), little is known about how students' interest may actually influence the environment. That is, in line with the notion of reciprocal determinism (e.g. Bandura, 1997) and the likelihood that students' motivation and learning in the classroom is best understood to unfold in a complex cyclical interaction between the student and the environment, it seems likely that teachers will be perceived to fluctuate in their support for interest and engagement from one day to the next in response to students' interest in the classroom. All in all, addressing these lingering issues is important to the extent that gaining insight into how situational interest functions to support high school science students' engagement in the classroom and perceptions of the environment both on a given day and cumulatively over time is likely to provide valuable information that can facilitate teachers practice and the development of precise interventions focused on enhancing science interest and engagement.

To address these limitations, in the present investigation we conducted a diary study in which high school science students reported on their experiences in science class every class day over the course of a six-week instructional unit. The goals of this investigation were three-fold: (1) to examine the relations between students' daily and cumulative experience of interest with behavioral, cognitive, and agentic aspects of engagement over time in authentic high school science classrooms, (2) to examine how students' daily interest experiences relate to and shape students' perceptions of their teachers' practices over time, and (3) to explore variations in such relations across time and across various characteristics of students (e.g., sex, ethnicity, and socioeconomic status) and science classrooms (e.g., content and level). The chosen design in which students' situational interest, engagement, and perceptions of the classroom environment were assessed repeatedly over days provided an opportunity to collect strong evidence regarding the predictive role of interest in explaining changes in engagement and perceptions of the context from one day to the next.

1.1. The role of interest in engagement and learning in school

Interest as a motivational variable represents a psychological state that potentially serves as an antecedent to engagement or predisposition to engage and reengage with particular classes of objects, events, or ideas over time (Hidi & Renninger, 2006; Schiefele, 2009). Interest is often conceptualized as a relational construct that reflects an affective-cognitive relationship between a person and an object, event, or idea (e.g., Krapp, 2002). In general, two forms of interest, individual and situational, have been identified in psychological and educational research to distinguish the momentary psychological state of interest from an enduring predisposition (e.g. Hidi & Renninger, 2006; Schraw, Flowerday, & Lehman, 2001). While *individual interest* is a relatively stable affective-evaluative disposition of the person involving regular positive feelings and value-related evaluations toward certain objects, events, or ideas over time (cf., Hidi & Renninger, 2006; Schiefele, 2009), in contrast, and more relevant to the day to day happenings in the classroom, *situational interest* refers to interest that primarily emerges from and is supported by the environment (Hidi & Renninger, 2006; Krapp, 2002). Situational interest is a momentary psychological state marked by positive emotional tone that is triggered by the environment (i.e. by the interestingness of the current content or activity) that may or may not last over time or re-occur when similar stimuli are presented.

Moreover, interest serves an important function in educational contexts, having consequences for students' learning outcomes. Years of research on interest as both a fleeting psychological state and an enduring disposition have suggested that interest supports an array of positive cognitive and behavioral outcomes that mediate the link between interest and learning (e.g. Ainley et al., 2002; Harackiewicz et al., 2008; Köller, Baumert, & Schnabel, 2001; Renninger, Ewen, & Lasher, 2002; Sansone, Smith, Thoman, & MacNamara, 2012). A substantial body of literature conducted for text-based processing has provided evidence for the benefits of situational interest in supporting engagement and cognitive processing, particularly in the form of enhanced attention and persistence (for reviews see Hidi, 1990, 2001; Schiefele, 2001, 2009; Schraw & Lehman, 2001). For example, using multiple assessments within a single daylong problem-based learning session for undergraduates, Rotgans and Schmidt (2011a) found that situational interest predicted achievement-related classroom behaviors and in turn achievement. In an experimental laboratory study, Durik and Harackiewicz (2007) found that situational interest was positively related to task involvement. Taken together, this research suggests that situational interest has the potential to shape students' engagement and learning-related behavior in the classroom.

Clearly, there has been substantial progress made in research focused on understanding the role of situational interest in learning-related behaviors. However, few studies have examined this process within an authentic high school classroom environment, where understanding interest processes may be particularly important. Moreover, engagement is routinely conceptualized as a construct involving multiple components, including a behavioral dimension focused on effort, attention, persistence, participation, and intensity, an emotional dimension that conceptually overlaps with situational interest and is focused on interest, enthusiasm, enjoyment, and other positive emotions, a cognitive dimension that includes attention to and regulation of the learning and thinking process, and an agentic dimension in which students actively attempt to influence the flow of instruction (Archambault, Janosz, Morizot, & Pagani, 2009; Fredricks, Blumenfeld, & Paris, 2004; Reeve & Tseng, 2011; Skinner, Kindermann, Connell, & Wellborn, 2009). Given the critical role that interest is expected to play in engagement and cognitive processing, it would seem important to explore the function of situational interest for the components of engagement in order to have a precise understanding of its role in supporting engagement in the classroom, though interest research has yet to adopt this differentiated view of engagement.

In addition, little (if any) research has explored the links between *daily* fluctuations in students' experience of situational interest and students' ongoing learning-related behavior. That is, the experience of situational interest is likely (virtually by definition) to fluctuate from one day to the next and from one setting to the next. We predict that even minor variation in students' experience of situational interest from one day to the next can subtly influence daily fluctuations in classroom engagement. Further, we also predict that any beneficial effects of situational interest on any particular day may accumulate over time and lead to adaptive learning-related behavior in that class as whole. However, the research designs that have been used to examine situational interest have not allowed investigators to explicitly test these predictions. This issue may be particularly important to address because day, person, and classroom level effects are conceptually and statistically independent (Reis, Sheldon, Gable, Roscoe, & Ryan, 2000). Whereas person (and classroom) level effects ask what interest during science class, averaged over time, can explain about how one student (or one classroom of students) behaves compared to another, day level effects address the extent to which interest during science class explains variation in a students' learning-related behavior relative to his or her own baseline. The fact that analyses at multiple levels of analysis are conceptually distinct is highlighted by research demonstrating different patterns of relations at day- versus trait-levels (e.g. Larsen & Cutler, 1996; Reis et al., 2000).

Finally, it remains a tenable possibility that the daily relations between interest and engagement vary over time in a classroom as instruction progresses and comes to a close, often ending with some form of evaluation. Thinking of the natural progression that occurs in most high school classrooms in which content is divided into units in which related content is delivered over days or weeks, becoming more complex as it progresses, and units end with a unit exam, we hypothesized that while interest may play a strong role in determining the extent to which students are engaged in the classroom early on in the unit, as the external consequences of mastering the material become more salient (i.e. as exam time approaches) interest may play a smaller role in determining students' learning-related behaviors. Such predictions seem reasonable in light of the multitude of behavioral research demonstrating that external consequences effectively control behavior and influence performance (e.g. Cerasoli, Nicklin, & Ford, 2014; Skinner, 1953) and interact in complex ways, sometimes undermining interest (e.g. Deci, Koestner, & Ryan, 1999). A recent meta-analysis focused on intrinsic motivation and extrinsic incentives provides support for this notion (Cerasoli et al., 2014). Though this synthesis of research did not specifically focus on interest, the conceptual link between interest and intrinsic motivation (intrinsic motivation being a state of wanting to perform a specific activity in a given situation out of interest; e.g., Ryan & Deci, 2000) allow the findings to serve as important groundwork for our predictions. Specifically, in support of our hypotheses, this meta-analysis suggested that although both intrinsic motivation and extrinsic incentives predicted variance in school performance, the relation between intrinsic motivation and performance was "crowded out," becoming less important when extrinsic motivation in the form of incentives for good performance were present. In contrast, intrinsic motivation was a stronger predictor of performance when incentives were less directly tied to performance. To address the many issues we have highlighted, the current investigation examined daily interest and behavioral, cognitive, and agentic components of engagement over time in high school science classrooms. Given the conceptual overlap between situational interest and emotional engagement, we opted not to examine the links between interest and affective engagement.

1.2. The relation between interest and the classroom climate

Given the potential of interest to support important academic outcomes, a critical task for psychologists has been to identify how situational interest can be supported in educational settings. Although empirical research examining classroom factors leading to situational interest in particular is relatively small, a large body of research focused on classroom support for interest-based motivation across various theoretical perspectives has converged on the overarching verdict that teachers who engage in practices that are supportive of students' experiences of autonomy facilitate students' interest and adaptive classroom attitudes and activity (e.g. Assor, Kaplan, & Roth, 2002; Benware & Deci, 1984; Black & Deci, 2000; Patall, Dent, Oyer, & Wynn, 2013; Reeve & Jang, 2006; Reeve, Jang, Carrell, Jeon, & Barch, 2004; Skinner & Belmont, 1993). In particular, the provision of student choice and control over work is a prototypical autonomy supportive practice commonly utilized by teachers (Flowerday & Schraw, 2000) and an important classroom climate predictor of situational interest and intrinsic motivation (e.g. Ciani, Ferguson, Bergin, & Hilpert, 2010; Linnenbrink-Garcia, Patall, & Messersmith, 2013; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008; Wijnia, Loyens, Derous, & Schmidt, 2015; see Katz & Assor, 2007; Patall, Cooper, & Robinson, 2008 for reviews).

While a good deal of research has accumulated to support the notion that autonomy relevant practices are likely to support an array of motivation outcomes, including interest, relatively little (if any) research has explored the extent to which students' interest during class time influences teachers' practice. Nevertheless, it would seem to be important to understand whether students' initial interest may influence teachers' autonomy-supportive practice in the classroom given that such practices, particularly choice provision, can trigger a sequence in which students' interest-based motivation may lead to engagement and learning. Moreover, while autonomy support is important across contexts, the increasing need for autonomy and independence as students enter adolescence (Eccles et al., 1993; Erikson, 1968) make understanding the predictors of teachers' choice provision particularly important in the context of secondary school classrooms. Likewise, given that discovery and innovation, recognition of ambiguity, and learning from past discoveries are all core values of science, teacher support of student autonomy would seem to be particularly important within science education.

Though research has yet to examine this issue directly, there is reason to believe students' interest in the science classroom will influence teachers' provision of student choice and in turn, students' perceptions of that practice. Broadly, social psychological research suggests that teachers or individuals in other positions of authority are more motivationally supportive in general, providing clearer feedback, more attention, and more opportunities for learning difficult material (e.g. Brophy & Good, 1970; Chaikin, Sigler, & Derlega, 1974; Cooper & Good, 1983; Rist, 1970; Rosenthal, 1974; Rubovits & Maehr, 1973) when they have more positive expectations of those in student or subordinate roles. To the extent that positive expectations may include teachers' perceptions that students are interested, this literature leads us to predict that students' daily situational interest will predict greater perceptions that teachers subsequently provide more student choice. More directly relevant, Skinner and Belmont (1993) revealed in path analyses that student behavioral engagement measured in the spring was associated with the teachers' autonomy supportive behavior with students during the subsequent fall. Pelletier, Séguin-Lévesque, and Legault (2002) found that when teachers perceived their students to be self-determined, they were more autonomy supportive in their teaching. Similarly, Pelletier and Vallerand (1996) found that when supervisors were led to believe that a subordinate was intrinsically motivated, that is, motivated out of internal factors like interest, they were more autonomy supportive and less controlling.

Thus, all in all it would seem that when students have a positive motivational orientation such as high interest or engagement, to the extent that teachers perceive it, they react by being more motivationally supportive, particularly in the form of autonomy-supportive practices. Thus, while we might hope that teachers would attempt to modify students' interest and other forms of motivation by using strategies intended to support such motivation, the research suggests that, at least in part, just the opposite is likely to occur. With this broader literature as a base, we predicted that science students' interest might exhibit a similar relationship with science teachers' provision of choices on a day to day basis. That is, on days that students experience situational interest, students might perceive teachers to react by providing more support for their autonomy in the form of a greater emphasis on student choice and control on the same and following class day. However, much like our predictions regarding the potential for the interest-engagement relation to vary over the course of an instructional unit, we thought it likely that the interest-teachers' choice provision relation would vary over a unit. That is, while teachers may be particularly receptive to students' interest early in an instructional unit, as external incentives and consequences for student learning (i.e. students doing well on unit exams) become more salient, teachers' motivational practice may be perceived to be influenced by student interest to a lesser extent.

1.3. Variation across science students and science classrooms

A number of student and classroom factors may be particularly important to take into consideration when exploring the form and function of interest, engagement, and perceptions of the classroom environment in the domain of science (e.g., Sinatra et al., 2015). Economic and social demands have led to a broad push within the United States to increase the number of individuals with STEM knowledge and who pursue STEM careers (Carnevale, Smith, & Melton, 2011; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Concerns about having a sufficient STEM workforce in the future have led to increased efforts to promote greater STEM engagement among all students, but especially among groups typically under-represented in STEM fields such as women, black and Hispanic individuals, and low income students (e.g., see Riegle-Crumb & King, 2010; Sinatra et al., 2015 for discussion). However, research suggests that students of various genders, ethnicities, and socioeconomic statuses are not equally interested in pursuing STEM fields (e.g., Lichtenberger & George-Jackson, 2013) and attempts to increase diversity in STEM fields have generally not been met with much success (e.g., Bidwell, 2015). Moreover, not all science fields are equally attractive to students. Research has long indicated that students have higher course enrollment and more favorable attitudes towards biology relative to other science fields like physics or chemistry (e.g., Häussler & Hoffmann, 2002; Osborne, Simon, & Collins, 2003; Whitefield, 1980), with women being particularly likely to favor biology topics (Su & Rounds, 2015).

Taken together, this evidence suggests that it is important to consider the role of students' gender, ethnicity, and socioeconomic status, as well as the nature and content of science courses, in research focused on students' psychological experiences in the science domain. Though we had limited information on which to base predictions regarding the role of student and course characteristics in interest relations, we predicted that situational interest may play an especially important role in supporting the daily engagement of female, black, Hispanic, and low-income students, individuals who have traditionally not demonstrated strong personal interest in science domains and thus may benefit more from the psychological support that comes from experiences of situational interest within the classroom context. Likewise, for similar reasons, we expected that situational interest may play an especially important role in supporting the daily engagement of students in required grade-typical and physical science as opposed to advanced or elective and biological science courses given the greater personal interest students typically demonstrate in advanced and biological science courses. Finally, we expected that female students in particular would potentially be less likely to perceive the classroom environment as responsive to their interest in science, given the long history of research suggesting that females have limited interest in pursuing science knowledge and careers (e.g., Su & Rounds, 2015). Given these considerations, we included a variety of student and class characteristics as control variables and moderators of the relations involving interest, engagement, and perceptions of the environment.

1.4. The present study

This study sought to contribute to the small body of classroom research that has explored the role of situational interest in the classroom for eliciting behavioral, cognitive and agentic components of engagement, as well as perceptions of the classroom climate. To address some of the limitations in past research, including the limited data linking interest, engagement, and classroom climate from real-life classrooms at the high school level and in science classrooms in particular, as well as the unknown role of time and level of analysis, the current investigation made use of a diary method that repeatedly assessed high school science students' experiences of interest during class. This method was also used to capture reports of students' behavioral, cognitive, and agentic engagement during class and their perceptions of science teachers' choice provision practices every class across a six-week instructional unit. The current design extends prior research by providing an opportunity to examine daily changes in engagement and perceptions of the climate as a function of interest on a given day, a subsequent day, and aggregated over time within an authentic high school science classroom. Moreover, the current investigation attempted to explore heterogeneity in those relations across student and classroom factors that might be especially pertinent to the science domain. As such, this investigation sought address the following questions:

(1) To what extent is students' experience of interest in the science classroom related to their behavioral, cognitive, and agentic engagement, both on a given day and over time, and do these relations change during the course of an instructional unit?
(2) To what extent is students' experience of interest in the science classroom related to their perceptions of teachers' provision of choices, both on a given day and over time, and do these relations change during the course of an instructional unit?
(3) Are the links between interest, engagement, and perceptions of teachers' provision of choice moderated by student or classroom characteristics, including students' sex, ethnicity, and socioeconomic status, or science class content and level?

2. Methods

2.1. Participants

Two-hundred and eighteen urban and suburban high school science students (13–18 years of age; 55% female) from 43 science classrooms across eight public high schools in two districts in the southwest region of the United States participated in a diary study in which they were asked to provide reports of their experiences after every science class during a six-week instructional unit between January 2012 and May 2014 (2306 total reports across all students). Forty percent of students were in the 9th grade, 25% were 10th graders, 18% were 11th graders, and 17% were 12th graders. The average grade point average (GPA) at the start of the study was 3.04 on a 4 point scale. 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. In our sample, at least 42% of participating students received free or reduced lunch (not all students reported their eligibility). Thirty-two percent of the students across these classes were Caucasian (n = 69), while 40% were Hispanic/Latino (n = 88), 10% were African American (n = 22), 4% were Asian (n = 8), and 13% were of mixed ethnicities or another ethnicity (n = 28). Two students did not share their ethnicity. A comparison of the racial and economic make-up of our student sample across both district's student demographics suggests that we successfully recruited a student sample that was representative of the student populations being served at these eight schools.

Each of the 43 classrooms was led by a different science teacher. The majority of the science classrooms were required survey science courses such as biology, chemistry, and physics (grade-typical biology: n = 7, pre-AP biology: n = 8, grade-typical chemistry: n = 5, pre-AP chemistry: n = 5; grade-typical physics: n = 6, pre-AP physics: n = 3, and integrated physics and chemistry: n = 3). A small number of courses covered advanced elective topics in the biological (e.g., anatomy: n = 2, aquatic science: n = 2), or physical sciences (e.g., engineering: n = 1, environmental systems: n = 1). All of the units in the science courses were consistent with Texas Essential Knowledge and Skills (TEKS) for science classrooms, which is the state's curriculum document. Examples of topics covered in science courses included cell structure and genetics in biology, how atoms form ionic and covalent bonds in chemistry, or the impact of human growth on aquatic systems in aquatic science. A wide range of pedagogical practices (i.e., group work, formative and summative assessment, classroom discussions, research projects, lab experiments, etc.) were used across the unit within these science classrooms. The number of students participating in the study from each class ranged from three to six. Approximately 47% of students were enrolled in a grade-level survey biology (16%), physics (15%), or chemistry (10%) or a combined physics and chemistry (6%) course and 38% were enrolled in an advanced (i.e., pre-AP) survey biology (19%), chemistry (12%), or physics (7%) course. The remaining 15% students were enrolled in one of the specialty topic science courses. Across grade-typical and advanced course levels, approximately 44% of students were in a biological sciences course, with the remaining 56% enrolled in a physical sciences course.

Participation was voluntary and students under the age of 18 secured parental permission to participate. In recruiting students, the project goal was to randomly select five student participants from each of the 43 classes among those students that volunteered to participate. In the majority of classrooms (38 of 43), at least five students volunteered to participate and students were randomly selected in cases where more than 5 volunteers were available. In some classes, less than five students volunteered. Four students participated in each of 5 classes and in 1 class just three students participated. Given the reduced student level sample size in six of the 43 classes, we allowed a total of six students to participate in each of 10 other classes. Five students participated in each of the other remaining classes (27). 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 = 10.45, SD = 9.62). Teachers were 25–66 years of age (M = 38; SD = 12.29). The majority of teachers were Caucasian (n = 30; 70%) and female (n = 31; 72%). One teacher was African American (2%), three were Asian (7%), four were Hispanic/Latino (9%) and five were of mixed ethnicities or another ethnicity (12%). Teachers received $50 for their participation in the study and schools received $100 for each participating teacher.

2.2. Procedure

Recruitment of participants for this study occurred in stages. Recruitment began with obtaining permission from two southwestern school districts followed by contacting high school principals, vice principals, and science chairs in order to obtain permission to meet with science teachers and recruit their participation in the study. Group information sessions were held at each of the eight schools that agreed to allow science teachers and students to participate. Teachers were informed that participation would involve the researchers collecting information about students' experiences in one of their classes, which the teacher would self-select, on a daily basis over the course of a six-week instructional unit. Teachers were also allowed to select the instructional unit during which the study occurred among those between January 2012 and May 2014. Allowing teachers to choose the participating class and control the timing of the study maximized the diversity of teachers willing to participate because some teachers were more willing to participate at certain times of year or with particular class sections. Given that most teachers appeared to select a class they considered a prototypical class and given that students were required to respond every day of a six-week instructional unit, we believe allowing teachers to make these selections had a minimal influence on the nature of the data and that the six weeks of data is likely to still be fairly representative of the school year as a whole.

Student participants were recruited via in-person visits to the class in which one member of the research team described the study and distributed a parent information letter and consent documents in both English and Spanish. To minimize teacher knowledge of which students were participating in the study, students were asked to return signed consent documents in a sealed envelope to a box located at the main office of the school. As previously described and by design, 5 students from each class typically participated in the study.

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, and free or reduced lunch eligibility. In addition, this initial meeting was used to establish the students' school and personal schedule and determine the ideal time for the student to receive and complete daily reports.

Following the start of the six-week instructional unit, students were emailed a survey asking them to respond to questions about their experiences in class and their teachers' choice practices after each class session for the unit during their first free period (i.e. non-instructional time). 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 six-week instructional unit, ranging between 11 and 17 report opportunities. 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 (Mean = 11; SD = 3.73; Mode = 10).

2.3. Measures

2.3.1. Student reported daily interest

Students' daily interest in science class was assessed with two items ("I felt interested today in science class" and "I enjoyed science class today") adapted from the Engagement versus Disaffection with Learning Student Report (e.g. Furrer & Skinner, 2003; Skinner & Belmont, 1993; Skinner, Kindermann, & Furrer, 2009). 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 scale for cross-sectional research have been established in previous studies (Furrer & Skinner, 2003; Skinner et al., 2009). Daily Cronbach's alphas ranged between 0.74 and 0.90 (mean $\alpha = 0.82$) for daily interest.

2.3.2. Student reported daily behavioral engagement

Students' behavioral engagement in science class was assessed with three items ("I worked as hard as I can in science class today", "I participated today in science class discussions", and "I paid attention today in science class") adapted from the Engagement versus Disaffection with Learning Student Report (e.g. Furrer & Skinner, 2003; Skinner & Belmont, 1993; Skinner et al., 2009). 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). For this investigation, given that each item reflects a rather distinct aspect of behavioral engagement, we opted to explore relations between daily interest and each aspect (item) of behavior engagement separately rather than creating a scale reflective of behavioral engagement as a whole.

2.3.3. Student reported daily cognitive engagement

Students' cognitive engagement in science class was assessed with four items measuring learning strategies (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", "When doing work for science class today, I tried to relate what I'm learning to what I already know", and "I made up my own examples to help me understand the important concepts in science class today") adapted from the Metacognitive Strategies Questionnaire (Wolters, 2004). This abbreviated scale is based on the widely used Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1993) and has been used successfully in prior research exploring student engagement (e.g. Reeve, 2013). 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 scale for cross-sectional research have been established in previous studies (Reeve, 2013; Reeve & Tseng, 2011; Wolters, 2004). We used this particular scale because it conceptualized cognitive engagement with several homogeneous items that reflected strategic learning (e.g., using elaboration-based learning strategies) and because it was short and appropriate for daily reporting. Daily alphas ranged between 0.80 and 0.92 (mean $\alpha = 0.86$) for daily cognitive engagement.

2.3.4. Student reported daily agentic engagement

Students' agentic engagement or "constructive contribution into the flow of the instruction they receive" (Reeve & Tseng, 2011) in science class was assessed with four items (e.g. "I let my science teacher know what I needed and wanted today", "During science class today, I expressed my preferences and opinions", "During science class today, I asked questions to help me learn", and "I let my science teacher know what I am interested in today") adapted from the Agentic Engagement Scale (Reeve & Tseng, 2011). 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 scale for cross-sectional research have been established in previous studies (Reeve, 2013; Reeve & Tseng, 2011). Daily alphas ranged between 0.72 and 0.87 (mean $\alpha = 0.80$) for daily agentic engagement.

2.3.5. Student reported daily teacher provision of choice

Students' perceptions of the extent to which the teachers provided opportunities for student choice and encouraged students to work in student determined ways was assessed with five items (e.g., "My teacher provided options for the kinds of assignments or activities I could do today" or "My teacher allowed me to choose how to do my work in the classroom today") designed explicitly for use in this diary study and based on prior measures used in cross-sectional research (e.g. Patall et al., 2013; Wellborn & Connell, 1987). 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).

Multilevel exploratory factor analyses (MLEFA) conducted on this measure of teachers' choice provision along with other teacher practices unrelated to the current investigation reported were conducted to establish the structure of the measure. The results of these analyses, as well as a full list of all teacher practice items, can be found in other reports of this investigation (Patall, Vasquez, Steingut, Trimble, & Pituch, submitted for publication) or requested from the first author. The daily alpha for choice provision ranged between 0.74 and 0.89 with a mean α of 0.83.

3. Results

3.1. Variance partitioning for situational interest and engagement

In order to gauge the within-person (daily) variation in students' situational interest during class, as well as engagement over the course of the six-week instructional unit, we began by testing a series of three-level regressions with days (within-students)

Table 1
Variance partition coefficients (VPC) and intraclass correlation coefficients (ICC).

	Day level	Student level		Class level
	VPC	VPC	ICC	VPC/ICC
Interest	0.46	0.43	0.54	0.11
Forms of engagement				
Working hard	0.59	0.37	0.41	0.04
Participation	0.52	0.43	0.48	0.04
Paying attention	0.57	0.38	0.43	0.05
Cognitive engagement	0.34	0.59	0.65	0.08
Agentic engagement	0.42	0.50	0.58	0.07
Choice provision	0.54	0.38	0.46	0.08

Note. Level 1 (daily reports) n = 2306 reports. Level 2 (students) n = 218. Level 3 (classes) n = 43. Calculation of the VPC and ICC is identical at the highest level of any model.

nested within pupils (between-students) and pupils nested within classes (between-classes) in which no predictors were entered. Variance partition coefficients (VPC; Goldstein, 2011), and intraclass correlation coefficients (ICC; Kreft & de Leeuw, 1998) were computed (see Table 1).[1]

VPCs suggested that between 34% and 59% of the variance in interest, thoughts and behavior is at the day level. A similar amount of variance is at the student level (VPCs ranged between 37% and 59%) and limited variability was observed at the classroom level (VPCs ranged between 4% and 11%). Results suggest there was a substantial proportion of daily variation in students' experience of situational interest in class and engagement over the course of the unit, in addition to a great deal of variation across individual students.

3.2. Change in situational interest and engagement over time

We continued our exploration of the data by examining how students' experiences of situational interest in class and engagement change over an instructional unit. To explore this question, we estimated a series of three-level regression models using the Mixed procedure in SPSS 21 in which we included response day to represent time over the course of the unit at level 1. We also included three control variables at the student level (level 2): student sex (0 = male, 1 = female), student ethnicity (0 = Caucasian or Asian, 1 = Black, Hispanic, or other ethnicity), and students' free or reduced price lunch eligibility (0 = eligible, 1 = not eligible), as well as two class level (level 3) control variables: whether the class was a biological science versus another science area (e.g., physics, chemistry, engineering, environmental science; 0 = non-biological focus, 1 = biological focus), and whether the class was advanced or grade typical (0 = grade typical, 1 = advanced). All variables were grand-mean centered. To accommodate for any missing data, we used a maximum likelihood estimation procedure with robust estimates of standard errors (REML). Because adjacent residuals in repeated measures data are usually correlated across measurement occasions, we specified an AR(1) correlated error structure.

Results (see Tables 2 and 3) suggested that situational interest and indicators of behavioral engagement (working hard, participation, and paying attention) during class declined across the six-week instructional unit. There was no systematic change in cognitive or agentic engagement across the six-week instructional unit. Sex predicted situational interest, participating, and agentic engagement such that female students reported less interest, participation, and agentic engagement across the six weeks than male students. Ethnicity predicted participation such that Caucasian and Asian students participated less than Black, Hispanic, and other minority students. Class type predicted attention and cognitive engagement such that students in advanced courses were more attentive and cognitively engaged than students in grade-typical courses.[2]

3.3. Relations between situational interest with engagement

Hypotheses about the relations between students' situational interest in class and their engagement were tested with a series of three-level random intercept only regressions. For each multilevel model, at level 1 we included time, daily situational interest in class, and the outcome reported on the previous day. The prior day's value for the outcome was entered to control for possible carryover effects from one day to the next (e.g. see Reis et al., 2000 for an example of this strategy). The most recent day of reporting was carried forward for the purposes of lagging when reports were missing. Including the prior day's outcome value allowed us to model change in the outcome from one report to the next as a function of students' experience of interest in class reported on the same day as the outcome. At level 2 and 3, we included the mean of in-class interest across days for each student and the mean of in-class interest across days and students within a class. Within-student results allowed us to assess day-to-day variation in student's engagement as a function of student's daily interest in class. Between-student results assessed relations between students' cumulative in-class interest with engagement aggregated across the six-weeks by calculating the mean for each participant across the 17 possible class days. Between-class results assessed the relation between each class's experience of interest with engagement by calculating the mean for each classroom across all participating students in each class and the 17 possible class days. In addition to mean interest, we also included five student or class characteristics (sex, ethnicity, free/reduced price lunch eligibility, class content, and class type) as control variables at the student and class levels (level 2 and 3).

To decompose between and within-person effects and reduce collinearity, daily within-student interest was person-mean centered (around each person's own average score), between-student mean interest were class-mean centered (around the average score for the class), and between-class mean interest were grand mean centered (around the sample mean). Time, the prior day's score for the outcome, and other student and class characteristics were grand-mean centered since they were mainly control variables in these models. Again we used the Mixed procedure in SPSS 21, a maximum likelihood estimation procedure with robust estimates of standard errors (REML), and specified an AR(1) correlated error structure. A separate model was estimated for each outcome (working hard, participating, paying attention, cognitive engagement, and agentic engagement). The results of these analyses can be seen in Table 4.

All five forms of engagement were positively predicted by students' situational interest in class on the same day, as well as individual students' interest during class aggregated across the unit and the classes' interest across the unit, controlling for time,

[1] Although classes were distributed across 8 schools and 2 school districts, random variance components for these levels were not included in models given the small number of units at each of these upper levels, the limited amount of variability that was observed at the class level, and to avoid overly complicated models with four or more levels.

[2] We examined whether student and class characteristics (sex, ethnicity, free or reduced price lunch eligibility, class content, and class type) moderated the change in interest or engagement over time during the instructional unit in a series of three-level regressions that added all interactions between time and each of the aforementioned variables to the previously described models. For these models, we specified random intercepts and random slopes for response day across individuals and classes. There was no evidence that any of the student or class characteristics moderated the trajectories of interest or engagement.

Table 2
Multilevel regressions with time predicting students' situational interest and behavioral engagement in science class.

Predictor	Interest		Working hard		Participation		Paying attention	
	b(SE)	*β*	*b*(SE)	*β*	*b*(SE)	*β*	*b*(SE)	*β*
Class level								
Intercept	2.95(0.08)		3.20(0.06)		2.88(0.07)		3.70(0.05)	
Class content	0.06(0.16)	0.02	0.16(0.13)	0.09	0.13(0.15)	0.05	0.05(0.10)	0.02
Class type	0.26(0.16)	0.11	0.21(0.13)	−0.10	0.21(0.15)	0.08	0.34(0.10)	0.17**
Student level								
Sex	−0.35(0.12)	−0.15**	0.06(0.12)	0.02	−0.30(0.13)	−0.11*	−0.15(0.10)	−0.07
Ethnicity	0.19(0.14)	0.08	0.26(0.13)	0.11*	0.11(0.15)	0.04	0.08(0.11)	0.04
Free/reduced lunch	−0.01(0.14)	−0.002	−0.01(0.14)	−0.004	−0.17(0.15)	−0.06	−0.12(0.11)	−0.06
Day level								
Time	−0.01(0.005)	−0.06***	−0.03(0.005)	−0.10***	0.01(0.005)	0.04*	−0.03(0.004)	−0.13***

Notes. Level 1 (daily reports) n = 2306 reports. Level 2 (students) n = 218. Level 3 (classes) n = 43. The "time" variable reflects the day of reporting across the 6 week instructional unit. For student sex, 0 = male and 1 = female. For student ethnicity, 0 = Caucasian or Asian and 1 = Black, Hispanic, or other ethnic minority. For free and reduced lunch eligible, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For class content, 0 = non-biological science and 1 = biological science. For class type, 0 = grade typical class and 1 = advanced class. *b* = unstandardized regression coefficient. *β* = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): $\beta = (b * sdx)/sdy$. Standard deviation values reflected the variability at the given level (not total variability). SE = standard error.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 3
Multilevel regressions with time predicting students' cognitive and agentic engagement in science class.

Predictor	Cognitive engagement		Agentic engagement	
	b(SE)	*β*	*b*(SE)	*β*
Class level				
Intercept	2.75(0.07)		2.50(0.07)	
Class content	0.14(0.14)	0.06	0.01(0.14)	0.01
Class type	0.32(0.14)	0.15*	0.19(0.13)	0.09
Student level				
Sex	−0.17(0.12)	−0.08	−0.22(0.11)	−0.11*
Ethnicity	0.15(0.14)	0.07	−0.11(0.12)	−0.06
Free/reduced lunch	0.03(0.14)	0.01	0.19(0.13)	0.09
Day level				
Time	−0.001(0.004)	−0.005	0.01(0.004)	0.03

Notes. Level 1 (daily reports) n = 2306 reports. Level 2 (students) n = 218. Level 3 (classes) n = 43. The "time" variable reflects the day of reporting across the 6 week instructional unit. For student sex, 0 = male and 1 = female. 0 = Caucasian or Asian and 1 = Black, Hispanic, or other ethnic minority. For free and reduced lunch eligible, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For class content, 0 = non-biological science and 1 = biological science. For class type, 0 = grade typical class and 1 = advanced class. *b* = unstandardized regression coefficient. *β* = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): $\beta = (b * sdx)/sdy$. Standard deviation values reflected the variability at the given level (not total variability). SE = standard error.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

the outcome on the prior class day, and the five student and class characteristics. Several patterns in the findings are worth noting. Namely, the effect of interest during class was generally stronger at the student level relative to the day level. This suggests that a students' experience of interest in class does generally accumulate and grow stronger in its relation with engagement aggregated over time. It is also worth noting that although many of the day level effects were small (βs ranged from 0.14 to 0.23), daily interest in class appeared to be about as good of a predictor as an identical measure of the student's own engagement during the prior class period. In some cases (e.g. paying attention during class) daily interest was a stronger predictor than the outcome from the prior class.

3.3.1. Variation in relations between situational interest and engagement across time

To explore our hypothesis that the daily relations between interest and engagement may vary over the course of an instructional unit, we estimated a series of three-level random intercept only regressions that included the interaction term between interest and time at the daily level only. That is, for these models we excluded the student-level and class-level interest predictors since the focus for these analyses was to examine whether the relation between daily interest and engagement varied across days. Otherwise, the model for each engagement outcome was identical to those previously described.

Results provided support for our hypothesis that the relation between daily interest and engagement would vary over an instructional unit. Namely, a significant interaction between daily in-class interest and time was found for working hard ($B = -0.02$, SE = 0.007, $\beta = -0.05$, $p < 0.007$), controlling for the prior day level of engagement and the five student and classroom characteristics, indicating that daily in-class interest predicted less of an increase in working hard as the unit progressed. To get a better sense of this interaction, we conducted simple slope analyses that tested the significance of the relation between daily interest and working hard early in the unit at day 3 and later in the unit on day 10. Whereas the coefficient for interest was $\beta = 0.23$ ($p < 0.001$) on day 3, it was slightly smaller by day 10 ($\beta = 0.15$, $p < 0.001$), though still statistically significant. Results suggest that daily in-class

Table 4
Multilevel regressions with situational interest in class predicting five forms of engagement in separate models.

Predictor	Working hard		Participation		Paying attention		Cognitive engagement		Agentic engagement	
	b(SE)	*β*	*b*(SE)	*β*	*b*(SE)	*β*	*b*(SE)	*β*	*b*(SE)	*β*
Class level										
Intercept	3.20(0.04)		2.90(0.05)		3.71(0.04)		2.75(0.04)		2.53(0.04)	
$Interest_{mean}$	0.38(0.08)	0.17^{***}	0.54(0.11)	0.22^{***}	0.43(0.08)	0.23^{***}	0.45(0.09)	0.23^{***}	0.47(0.07)	0.25^{***}
Class content	0.12(0.08)	0.05	0.09(0.11)	0.04	0.01(0.08)	0.01	0.10(0.09)	0.05	−0.01(0.08)	−0.01
Class type	0.09(0.08)	0.04	0.05(0.11)	0.02	0.26(0.08)	0.13^{*}	0.16(0.09)	0.08	0.06(0.08)	0.03
Student level										
$Interest_{mean}$	0.43(0.05)	0.25^{***}	0.54(0.07)	0.29^{***}	0.45(0.06)	0.31^{***}	0.36(0.06)	0.24^{***}	0.43(0.05)	0.30^{***}
Sex	0.20(0.07)	0.08^{**}	−0.11(0.10)	−0.04	−0.002(0.08)	−0.001	0.02(0.09)	0.01	−0.05(0.07)	−0.02
Ethnicity	0.14(0.08)	0.06	−0.03(0.11)	−0.01	−0.04(0.09)	−0.01	0.02(0.10)	0.01	−0.17(0.08)	-0.08^{*}
Free/reduced lunch	−0.01(0.08)	−0.003	−0.14(0.11)	−0.05	−0.11(0.09)	−0.06	0.02(0.10)	0.01	0.17(0.08)	0.08
Day level										
Interest	0.27(0.03)	0.17^{***}	0.39(0.03)	0.23^{***}	0.29(0.02)	0.22^{***}	0.20(0.02)	0.14^{***}	0.30(0.02)	0.23^{***}
Time	−0.01(0.005)	-0.05^{**}	−0.001(0.004)	−0.004	−0.02(0.005)	-0.10^{***}	0.01(0.003)	0.03^{*}	0.01(0.003)	0.04^{*}
Lagged outcome	0.25(0.02)	0.25^{***}	0.14 (0.02)	0.14^{***}	0.04(0.02)	0.04^{*}	0.22(0.02)	0.22^{***}	0.23(0.02)	0.23^{***}

Notes. Level 1 (daily reports) n = 2306 reports. Level 2 (students) n = 218. Level 3 (classes) n = 43. Each outcome was examined in a separate model that included situational interest in class, along with the lagged outcome, time, three student characteristics, and two classroom characteristics. The "time" variable reflects the day of reporting across the 6 week instructional unit. The "lagged outcome" variable reflects the prior day's value for the outcome. Interest in class was measured at the day level. The student-level in-class interest variable was created by computing the mean of interest across days for each student. The class-level in-class interest variable was created by computing the mean of interest across days and students within a class. To indicate that each of these variables were aggregates, the subscript "mean" was added to the predictor label. For student sex, 0 = male and 1 = female. 0 = Caucasian or Asian and 1 = Black, Hispanic, or other ethnic minority. For free and reduced lunch eligible, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For class content, 0 = non-biological science and 1 = biological science. For class type, 0 = grade typical class and 1 = advanced class. *b* = unstandardized regression coefficient. *β* = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): $\beta = (b * sdx)/sdy$. Standard deviation values reflected the variability at the given level (not total variability). SE = standard error.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

interest predicted increases in working hard more so early in an instructional unit compared to later in the unit. The interaction between interest and time was not statistically significant for other forms of engagement.

3.3.2. Variation in relations between situational interest and engagement across individuals and classrooms

In exploratory analyses, we examined whether student and classroom characteristics (sex, ethnicity, free or reduced price lunch eligibility, class content, and class type) might moderate the relations between interest and engagement in a series of three-level regressions that added interactions between daily interest, student mean interest, or class mean interest with each of the aforementioned variables. For these models, we specified random intercepts and random slopes for response day across individuals and classes. To simply each model, we examined interactions involving each student or class characteristic in separate models. When examining the role of student characteristics as moderators of the relation between interest and engagement, we specified interactions between the student characteristic and interest at both the day and student levels (daily interest, student mean interest). When examining the role of classroom characteristics as moderators of the relation between interest and engagement, we specified interactions between the class characteristic and interest at all three levels of analysis (daily, student mean, and class mean interest). Otherwise, models were identical to those previously described examining the main effects of daily, student mean, and class mean interest on engagement outcomes, controlling for time, the prior day's outcome value, and the five student and classroom characteristics.

A significant interaction between daily interest and ethnicity for cognitive engagement ($B = 0.12$, SE = 0.05, $\beta = 0.06$, $p < 0.04$) indicated that the increase in cognitive engagement as a function of daily interest was greater for Black, Hispanic, and other minority students compared to Caucasian and Asian students. Simple slope analyses suggested that whereas the coefficient for the relation between daily interest and cognitive engagement was $\beta = 0.17$ ($p < 0.001$) for Black, Hispanic, and other minority students, the coefficient for daily interest was $\beta = 0.08$ ($p = 0.006$) for Caucasian and Asian students. In addition, a significant interaction between daily interest and content for working hard ($B = -0.14$, SE = 0.07, $\beta = -0.05$, $p < 0.05$) indicated that the increase in working hard as a function of daily interest was greater for students in non-biological science courses compared to biological science courses. Simple slope analyses suggested that whereas the coefficient for the relation between daily interest and working hard was $\beta = 0.21$ ($p < 0.001$) for students in non-biological science courses, the coefficient for daily interest was $\beta = 0.12$ ($p < 0.001$) for students in biological science courses. Finally, a significant interaction between daily interest and course level for agentic engagement ($B = -0.09$, SE = 0.04, $\beta = -0.05$, $p < 0.04$) indicated that the increase in agentic engagement as a function of daily interest was greater for students in grade-typical courses compared to advanced courses. Simple slope analyses suggested that whereas the coefficient for the relation between daily interest and working hard was $\beta = 0.27$ ($p < 0.001$) for students in grade-typical courses, the coefficient for daily interest was $\beta = 0.19$ ($p < 0.001$) for students in advanced courses. There were no other interactions between student or class characteristics with interest at the student or class level.

3.4. Variance partitioning for perceived teacher provision of choice

Next, we conducted a series of analyses to explore our hypotheses that students' experience of situational interest would shape their perceptions of teacher provision of choice. First, in order to gauge the daily variation in perceptions of teacher choice provision over the course of the six-week instructional unit, we began by testing a three-level regressions with days (within-students) nested within pupils (between-students) and pupils nested within classes (between-classes) in an unconditional model in which no predictors were entered. Variance partition coefficients (VPC;

Goldstein, 2011), and intraclass correlation coefficients (ICC; Kreft & de Leeuw, 1998) were computed (see Table 1). VPCs suggested that 54% of the variance in perceptions that teachers provided choices was at the day level, 38% was at the student level and on 8% was observed at the classroom level. Results suggest there was a substantial proportion of daily variation in students' perceptions of their teachers' provision of choices, in addition to a great deal of variation across individual students.

3.5. Relations between situational interest and perceived teacher provision of choice

To test our hypotheses that students' greater situational interest in class would relate to their perceptions of teachers' engaging in more autonomy supportive practice in the form of choice provision, we conducted a series of three-level regressions identical to those previously described for engagement outcomes with one modification. Namely, we conducted two sets of multilevel regressions for perceived teacher provision of choice. One set of regressions included daily situational interest during class measured on the same day as the perceived practice outcome and the other set of models included daily situational interest during class measured on the class day prior to that in which the perceived practice was assessed. The results of these analyses can be seen in Table 5.

Controlling for time, the perceived teacher provision of choice on the prior class day, and the five student and class characteristics, students' situational interest during class significantly predicted perceptions that teachers provided greater opportunities for choices at day, student, and class levels in both the model in which interest measured on the same day as the perceived practice was included and in the model in which in-class interest for the class session prior to that for the perceived teacher practice was included. Not surprisingly, a weaker relation between interest and perceived provision of choice was found at the daily level when prior day in-class interest was entered as a predictor of perceived teacher provision of choice compared to models with same day interest as the predictor. These results suggest that students' experience of interest in class on any given day may influence the extent to which teachers (are perceived to) subsequently increase their support for motivation through providing choices on the same and following class day. The relation between interest and perceived teacher practices were generally stronger at student and class levels relative to the day level.

Table 5
Multilevel regressions with situational interest in class predicting perceptions of teacher provision of choice.

Predictor	Same day interest predicting choice		Prior day interest predicting choice	
	b(SE)	β	b(SE)	β
Class-level				
Intercept	2.47(0.03)		2.48(0.04)	
$\text{Interest}_{\text{mean}}$	0.32(0.07)	0.17***	0.30(0.07)	0.17***
Class content	−0.14(0.07)	−0.07	−0.14(0.07)	−0.07
Class type	0.04(0.07)	0.02	0.04(0.07)	0.02
Student-level				
$\text{Interest}_{\text{mean}}$	0.27(0.04)	0.20***	0.27(0.04)	0.20***
Sex	0.02(0.06)	0.01	0.01(0.07)	0.01
Ethnicity	−0.10 (0.07)	−0.05	−0.10(0.08)	−0.05
Free/reduced lunch	0.22(0.07)	0.11*	0.23(0.08)	0.12*
Day-level				
Interest	0.17(0.02)	0.13***	0.06(0.02)	0.04*
Time	0.01(0.003)	0.06***	0.01(0.004)	0.05**
Lagged outcome	0.32(0.02)	0.32***	0.31(0.02)	0.31***

Notes. Level 1 (daily reports) n = 2306 reports. Level 2 (students) n = 218. Level 3 (classes) n = 43. The "time" variable reflects the day of reporting across the 6 week instructional unit. The "lagged outcome" variable reflects the prior day's value for the outcome, perceived teacher provision of choice. Interest in class were measured at the day level. The day-level interest variable was measured on the same class day as the outcome in the first model and on the class day prior to the outcome in the second model. The student-level in-class interest variable was created by computing the mean of interest across days for each student. The class-level in-class interest variable was created by computing the mean of interest across days and students within a class. To indicate that each of these variables were aggregates, the subscript "mean" was added to the predictor label. For student sex, 0 = male and 1 = female. 0 = Caucasian or Asian and 1 = Black, Hispanic, or other ethnic minority. For free and reduced lunch eligible, 0 = not eligible for free/reduced lunch and 1 = eligible for free/reduced lunch. For class content, 0 = non-biological science and 1 = biological science. For class type, 0 = grade typical class and 1 = advanced class b = unstandardized regression coefficient. β = standardized regression coefficient. Standardized estimates were computed using the following formula (Hox, 2010): $\beta = (b * sdx)/sdy$. Standard deviation values reflected the variability at the given level (not total variability). SE = standard error.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

3.5.1. Variation in relations between situational interest and perceived provision of choice across time

As we had done with analyses exploring relations between interest and engagement, to explore our hypothesis that the daily relations between interest and perceived choice provision may vary over the course of an instructional unit, we estimated two three-level random intercept only regressions that included the interaction term between in-class interest (either same day or prior day) and time at the daily level only. Again, we excluded the student-level and class-level interest predictors in these models since the focus for these analyses was to examine whether the relation between daily interest and engagement varied across days. Otherwise, the model structure was identical to those previously described.

Results provided some support for our hypothesis that the relation between daily in-class interest and perceived choice provision would vary over an instructional unit. Namely, a significant interaction between prior day in-class interest and time ($B = -0.02$, SE = 0.005, $\beta = -0.06$, $p < 0.002$), controlling for the prior day level of perceived choice provision and the five student and classroom characteristics, indicated that prior day interest predicted a smaller increase in perceptions that teachers provided choices as the unit progressed. Again, we conducted simple slope analyses that tested the significance of the relation between prior day in-class interest and perceived choice provision early in the unit at day 3 and later in the unit on day 10. Whereas the coefficient for prior day interest was $\beta = 0.11$ ($p < 0.001$) on day 3, the coefficient for prior day interest was negligible by day 10 ($\beta = 0.01$, $p = 0.48$). Results suggest that students' interest predicted increases in perceptions that teachers provided choices during the following class day early in the instructional unit, but not later in the instructional unit. There was no interaction between same day interest and time for perceptions of choice provision.

3.5.2. Variation in relations between situational interest and perceived provision of choice across individuals and classrooms

Finally, in exploratory analyses, we examined whether student and classroom characteristics (sex, ethnicity, free or reduced price lunch eligibility, class content, and class type) might moderate the relation between in-class interest and perceptions of teachers' provision of choice in a series of three-level regressions that added interactions between daily interest, student mean interest, or class mean interest with each of the aforementioned variables. For these models, we specified random intercepts and random slopes for response day across individuals and classes. As we had done with models examining engagement outcomes, we examined interactions involving each student or class characteristic in separate models and included interactions with class mean interest only when examining the role of classroom characteristics.

Results suggested that the relation between prior day in-class interest and perceived choice differed by sex. A significant interaction between prior day interest and sex ($B = -0.12$, SE = 0.05, $\beta = -0.07$, $p < 0.03$), controlling for time, the prior day level of perceived choice provision, as well as the other four student and class characteristics, indicated that prior day in-class interest predicted an increase in perceptions that teachers provided choices more so for male compared to female students. Again, we conducted simple slope analyses that tested the significance of the relation between prior day in-class interest and perceptions of choice provision separately by sex. Whereas the coefficient for prior day interest was $\beta = 0.09$ ($p < 0.003$) for males, the coefficient for prior day interest was negligible for females ($\beta = -0.0003$, $p = 0.99$). Results suggest that male students perceived their teachers to increase their emphasis on student choice on days following those class sessions in which they felt interested. However, female students' in-class interest did not predict a change in perceived choice provision on the subsequent class day. No other interactions between student or classroom characteristics and interest were found.

4. Discussion

4.1. Empirical and theoretical contributions

The present investigation examined the role of high school students' daily and cumulative experience of situational interest during science class in their engagement and perceptions of the classroom climate. To explore these links, we used a diary method to track daily fluctuations in students' experience of interest in class, indicators of behavioral engagement (working hard, participation, and paying attention), cognitive engagement, and agentic engagement during science class over a six week instructional unit. We also tracked daily fluctuations in students' perceptions of the extent to which their teachers emphasized student choice, a practice routinely identified by motivation researchers to be relevant to the experience of autonomy and motivation. This investigation was unique in that it allowed us to explore the trajectories of students' experience of situational interest in class and engagement over time and examine relations for in-class interest both on a given day and over time within the context of an authentic high school science classroom. Thus, overall we sought to examine (1) the relations between students' daily and cumulative experience of situational interest with their behavioral, cognitive, and agentic engagement in authentic high school science classrooms over time, (2) how students' daily interest experiences relate to and shape perceptions of their science teachers' provision of choice over time, and (3) whether student and classroom characteristics, including students' sex, ethnicity, and free or reduced lunch eligibility, as well as the science class content and level (advanced or grade typical) moderate the relations among situational interest, engagement, and perceptions of teachers' choice provision.

In line with interest theories (Dewey, 1913; Hidi & Harackiewicz, 2000; Schiefele, 2009) and our hypotheses, results suggested that students' experience of interest during science class predicted all five forms of engagement assessed, both on a daily basis as well as cumulatively over the six-week instructional unit. That is, students' experience of interest in science class on any given day predicted an increase since the last class session in their participation, attention, and effort put forth toward work in class, as well as an increase in their use of cognitive learning strategies and attempts to influence the flow of instruction in ways that might maximize their learning experience (agentic engagement). We thought it was notable that the sizes of these daily effects, though small, were relatively similar to strength of the prior class day's outcome for predicting itself on the following class day. For some outcomes such as paying attention during class, daily interest was a notably better predictor than the outcome itself from the prior class, suggesting that it has as much or more influence than students' habitual ways of behaving in class.

Such findings provide insight into pathways through which situational interest may come to influence students' learning and achievement in the science classroom. These various forms of engagement are considered to be precursors to learning and achievement in school during adolescence, predicting high school grades and achievement test scores (Goodenow, 1993; Roderick & Engel, 2001; Willingham, Pollack, & Lewis, 2002), as well as attendance and graduation over the long term (Connell, Spencer, & Aber, 1994; Croninger & Lee, 2001). Agentic engagement is somewhat unique in that it not only represents a mechanism to achievement, but also a pathway by which students can influence the classroom environment and solicit greater motivational support from teachers (Reeve, 2013). This study suggests that the experience of interest during class time serves as a platform to set these pathways into motion each day.

Not surprisingly, not only did situational interest relate to students' engagement on any given day, but students and whole classes who experienced greater cumulative in-class interest across the six-week instructional unit reported greater engagement of all forms aggregated across the six weeks. In fact, the relations between situational interest and engagement were stronger once aggregated over time, a finding that may point to the relative strength of individual versus situational interest for supporting learning-related outcomes over the long-run (Hidi & Renninger, 2006).

However, we did not find that the relations between interest during science class and all forms of engagement was uniform over the course of instruction. Rather, interest during science class predicted a greater increase since the last class session in working hard early in the instructional unit compared to later in the unit. These results provide evidence for our expectation that interest would play a greater role in guiding students' engagement when the external consequences (i.e. performing well on the end-of-unit exam or making a good course grade for the grading session) of such learning were more distant. As the consequences of learning (or not learning) approached, we suspect that extrinsic motivation, that is, a state of wanting to perform a specific activity in a given situation for the sake of some external outcome (e.g., Ryan & Deci, 2000), became a more powerful predictor of students' learning related thoughts and behavior, subtly "crowding out" the role of interest. It is important to note here that the interest-engagement links always remained positive across the instructional unit and the change in the relation over time was small. Future classroom research might extend the results of this study by explicitly measuring or intentionally manipulating sources of extrinsic motivation simultaneously with constructs assessed in the current study so that this dynamic can be investigated in more depth.

Time was not the only factor to influence the relations between daily interest and engagement. Students' ethnicity, the content of the course, and the course level also influenced relations between daily interest and engagement. In line with our predictions, we found that daily interest was linked with increases in daily cognitive engagement more so for Black, Hispanic, and other ethnic minorities compared to Caucasian and Asian student counterparts. We also found that the daily interest was linked with increases in working hard more strongly in non-biological science courses compared to biological science courses. Finally, we found that daily interest was linked with increases in agentic engagement more strongly in grade-typical classes compared to advanced classes. We expect that these findings are relatively specific to interest and engagement within the science domain, reflecting our hypothesis that daily situational interest within the classroom is a particularly important elicitor of various forms classroom engagement among those individuals who have traditionally demonstrated less personal interest in pursuing expertise within science domains (e.g., Blacks and Hispanic individuals) or in courses that may overall be of less personal interest to students (required introductory science courses relative to advanced or elective courses and physical science courses relative to biological science). Such findings are encouraging as they suggest that situational interest most strongly elicits the science engagement of those most in need of support.

In addition to examining the links between students' experience of situational interest in class and their daily engagement, we also explored our hypothesis that daily interest might relate to and shape teachers' behavior as perceived by students in the class, such that teachers would react to students' interest by being more motivationally supportive. Results of this investigation supported our hypotheses, suggesting that students' daily experience of interest during science class predicted perceptions that teachers provided more choice opportunities during the same class session. Specifically, on days in which students' experienced greater interest in science class, they also reported increases over and above the prior class day in their perceptions that their teachers provided choices. This evidence suggests that on days in which students feel interested during class, they also perceive their teachers to be more motivationally supportive. Again, the relations between interest and perceived choice provision were stronger when aggregated over time, suggesting that students who cumulatively experienced greater interest in science class on average over the unit perceived that their teachers provided more choice opportunities on average over time.

The initial day level findings suggested that science teachers' might indeed be perceived as reacting to students' levels of interest, given our model in which the perceived teacher practice from the prior day was controlled so that changes in the practice from day to day as a function of interest could be modeled. Further, we thought that this model in which interest and perceived practice was measured on the same day was particularly appropriate in that it seems highly likely that teachers react and adjust their practice in the moment on a given day after appraising the emotional tone of students in the class. However, we also recognized that a stronger test of this hypothesis would be one in which the measurement of interest preceded perceptions of teachers' practice.

As such, we conducted a similar analysis after trading out daily in-class interest measured on the same day as the outcome, for interest in class measured on the class day prior to perceptions of science teacher's provision of choice. Not surprisingly, the effect of prior day interest on subsequent perceived teacher choice provision was weaker than that for same day interest. However, results suggested that students perceived their teachers to react to their interest in class by being more motivationally supportive. Specifically, prior day in-class interest predicted students' perceptions that teachers increased the extent to which they offered choices and encouraged students to work in their own way the following class day. It is worth noting that the size of the effects of prior day interest on subsequent perceived teacher choice provision was, overall, very small. However, we would argue that it is still meaningful as even small effects can lead to substantial gains when accumulated over time. Our analyses at the student level over a mere six weeks suggested that these effects do indeed grow stronger as they accumulate. Thus, it is not hard to imagine a science classroom in which good (high interest) days for students lead to more autonomy support in the future, which subsequently leads to better subsequent interest, engagement, and learning in a reciprocal snowballing effect that describes how students come to have a cumulatively positive experience in a class as a whole over the course of a school year. While such a pattern is likely important in any educational context, we believe it is particularly important within secondary science education where students are particularly likely to benefit from autonomy support.

That said, it is again important to note that the relation between situational interest during science class and perceptions that teachers provided choices was not uniform across the instructional unit or for both male and female students. Consistent with our hypotheses, interest during the prior science class predicted a greater subsequent day increase since the last class session in perceptions that teachers provided choice opportunities early in the instructional unit compared to later in the unit. We interpret this finding much like the change in the interest-engagement link over time. That is, we suspect that teachers become less reactive to students' emotional tone to direct their instruction as the external consequences of instruction and learning approach. This finding is consistent with research suggesting that the more teachers perceive pressures on them from school administration or circumstances, the less autonomous they are in their motivation for teaching, and the more they become controlling in their teaching (Pelletier & Sharp, 2009).

Consistent with our predictions, we also found that the link between interest and subsequent day perceptions of choice provision varied depending on the sex of the student. Namely, while interest during the prior science class predicted a greater subsequent day increase since the last class session in perceptions that teachers provided choice opportunities among male students, this relation was not apparent for female students. Results suggest teachers are particularly sensitive to fluctuations in interest of male students in science class. As previously introduced, we suggest that the difference in this interest-perceived teacher practice link relates to the widely reported finding that by adolescence, girls appear less interested in science compared to boys, and less likely to enroll in science courses and pursue science oriented careers (e.g., see Gardner, 1998). U.S. Census Bureau statistics for 1970–2010 suggest that women continue to pursue stereotypically female occupations with modest increases of women in STEM fields traditionally dominated by men. Given that such stereotypes are pervasive, as well as research suggesting that boys generally receive more attention when interacting with teachers compared to girls in the science classroom (Morse & Handley, 1985) and classrooms in general (e.g. Etaugh & Hughes, 1975; Leinhardt, Seewald, & Engel, 1979; Sadker, Sadker, & Zittleman, 2009), it is not surprising that science teachers are more reactive in terms of their motivational strategies to the interest of boys, those individuals for whom in-class interest may seemingly be most likely to lead to long-term investments in science. However, there may be alternative explanations for this finding that we want to mention, including the possibility that teachers are more reactive to the in-class interest of boys because they perceive boys to be more difficult to behaviorally and instructionally manage in the classroom (i.e. Myhill & Jones, 2006) or, given that we relied on student perceptions of teacher practice, that male students are differentially sensitive to changes in teachers' practice in response to their interest.

Finally, the diary design of our study afforded us with the opportunity to explore the trajectories of students' experience of interest and engagement during science class across an instructional unit. Results suggested that trajectories varied depending on the particular construct. Namely, in-class interest and all indicators of behavioral engagement declined across the instructional unit, while there was no change in cognitive or agentic engagement. These results are consistent with cross-sectional and traditional longitudinal educational research suggesting that students' science motivation decline across adolescence (e.g., Vedder-Weiss & Fortus, 2012) and student behavioral and emotional engagement in the classrooms in general decline markedly within secondary classrooms from the start to the end of the school year (Marks, 2000; Skinner, Furrer, Marchand, & Kindermann, 2008). This study highlights that the decline in science interest and engagement, though small, is evident even within a brief six-week instructional unit. In light of the known benefits of interest and engagement, the results of this investigation and others continue to highlight the need to consider how interest and engagement can be cultivated by the science classroom environment, perhaps in the reciprocal and self-sustaining fashion previously described.

4.2. Limitations and directions for future research

The current investigation has provided evidence that enhances our understanding of how daily interest in authentic high school science classrooms may function and relate to students' daily engagement and perceptions of the classroom climate, as well as the nature of such relations over time and across various individuals and course types. However, this investigation is not without many limitations. As such, it is imperative that future research replicate and extend the findings of the current investigation. In addition to the limitations and suggestions for future research already highlighted, one limitation of the current research is the reliance on student self-report. Relying exclusively on students' self-reports leaves open the possibility that response-bias and shared-method variance may be influencing the results. In particular, we believe that it would be particularly advantageous to use observations to explore the links between students' interest and subsequent teacher behavior in order to validate that student experiences of interest change actual teacher behavior and not just students' perceptions of teacher behavior. While there are examples of researchers using observation to determine teachers' autonomy supporting or thwarting practice (e.g. De Meyer et al., 2014; Jang, Reeve, & Deci, 2010), we know of no field research in which individual components of autonomy relevant practice (i.e. choice provision, rationales related to the importance of activities, perspective-taking) were observed as separate coding categories as they naturally occur in authentic classrooms. We believe that a nuanced understanding of how interest and engagement influences teachers' choice provision, as well as other motivational support strategies, requires detailed coding at the individual teacher strategy level. Along these same lines, future research might explore teachers' motivational practices outside of choice provision, as a number of practices have been proposed to be autonomy-supportive (e.g. Reeve & Jang, 2006; Reeve et al., 2004).

While one of the strengths of the current investigation is the diary design which allowed us to control for prior levels of the outcome variable in order to model change from one day to the next, such a design should not be taken to imply causation. It remains possible, for example, that students may become interested because they have been more behaviorally, cognitively, or agentically engaged on a given day, though prior traditional longitudinal evidence has also suggested that emotional engagement generally proceeds behavioral engagement (Skinner et al., 2008). As such, our understanding of the reciprocal effects of interest, engagement, and teacher practice may be enhanced by classroom-based research in which constructs are measured repeatedly within a single class session *and* over days. Such designs are disruptive and often undesirable from teacher and student perspectives, making the use of observation and very short but reliable self-report assessments imperative.

4.3. Conclusions

This investigation adds to the growing body of research exploring the role of interest in student engagement in the classroom and perceptions of the classroom. Given the obvious importance of the classroom climate and behaviors like working hard, paying attention, and using cognitive strategies to better learn course content, we believe the effort to continue to gain a nuanced understanding of the role of interest in these processes remains an important goal of educational research. However, the results of this study suggest there is much to be optimistic about. Provided teachers can trigger the interest of students within their science classrooms, situational interest provides the foundation on which students, particularly those who are most in need of support within the science domain, become behaviorally, cognitively, and agentically engaged and elicit environmental support.

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