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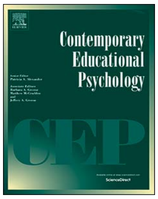

Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts

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ABSTRACT

The reciprocal relations of motivation with affective, behavioral, and cognitive engagement were tested. Engagement, conceptualized as processes that indicate productive participation in learning activities, was measured using the Activity Engagement Survey with students participating in a variety of activities in both schools and a museum. The multifaceted nature of engagement and the consistency of this structure across contexts and activities was examined over six different science activities on six different days within classrooms (Study 1, sixth graders from 10 different schools) and over two different science museum exhibits in one day (Study 2, fifth graders). These age groups were chosen because they are a pivotal time in science motivation. A series of confirmatory factor analyses were conducted to investigate the nature of affective, behavioral, cognitive, and overall engagement. A bifactor model with both affective and combined behavioral-cognitive factors along with an overall engagement factor had the best fit across all eight activities. Reciprocal relations between motivation (measured at Time 1 and Time 3) and engagement (at Time 2) were tested using Structural Equation Modeling. Results indicate that, in school settings (Study 1), self-efficacy was negatively related and mastery goals were positively related to affective engagement, whereas overall engagement predicted all forms of motivation. In the museum exhibits (Study 2), self-efficacy was positively related to overall engagement and performance-approach goal orientations were positively related to behavioral-cognitive engagement.

1. Introduction

The nature and structure of engagement in academics has been studied over the last three decades (Christenson, Reschly, & Wylie, 2012; Corno & Mandinach, 1983, 2004; Fredricks, Blumenfeld, & Paris, 2004; Fredricks et al., 2011). Most of the work to date has focused on the causes or antecedents of engagement (Eccles & Wang, 2012; Gonida, Kiosseoglou, & Voulala, 2007; Greene, Miller, Crowson, Duke, & Akey, 2004; Meece, Blumenfeld, & Hoyle, 1988), and recently there was a charge to refine the definition of engagement (Azevedo, 2015; Christenson et al., 2012; Eccles & Wang, 2012; Li, 2011). In the epilogue of the 2012 Handbook of Research on Student Engagement, Christenson et al. presented thirteen “recommendations to advance the quality and utility of research on the construct of student engagement” (p. 815). In the current study, we focus on three highlighted research issues: (1) What is engagement (how is engagement distinct from motivation and self-regulated learning)?; (2) Where does engagement occur (how does it compare across contexts, age, and time)?; and (3) Can we assess the multidimensional (affective, behavioral, cognitive) nature of engagement in young learners (i.e., not just in college students)? In considering these questions, we also tested the reciprocal relations between motivation (achievement goals and self-efficacy) and the different forms of engagement.

1.1. Definition of engagement

1.1.1. What is engagement

Engagement has been defined in many fundamentally different ways. We define *engagement as the intensity of productive involvement with an activity*. Our definition includes one’s involvement, focus, participation, and persistence on a task, all of which have been implicated in learning (Carini, Kuh, & Klein, 2006; Finn, Pannozzo, & Voelkl, 1995; Fredricks et al., 2004, 2011). For reasons outlined below, this definition is importantly different from prior definitions of engagement as commitment, attendance, motivation, social interaction, or depth of information processing stemming from self-regulated learning (Corno & Mandinach, 1983, 2004; Fredricks et al., 2004).

Regarding commitment, one could be committed to an academic

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task but still be distracted, for example because of side conversations. In other words, commitment may be a useful immediate precursor but itself is not a necessary component of engagement. In a similar way, attendance (e.g., Assor, Kaplan, & Roth, 2002) is an immediate prerequisite, but itself no indicator of the quality of engagement during learning.

Our proposed definition of engagement also diverges from engagement conceptualized as motivation and depth of learning indicated by self-regulated learning (Corno & Mandinach, 1983; Greene et al., 2004; Winne & Hadwin, 1998). Instead, we think about motivation as a preexisting learner characteristic that *produces* engagement and self-regulated learning as the *type of* engagement process. For example, a survey item included in engagement scales such as “My schoolwork helps in things I do outside of school” (Darr, 2012) is indicative of the usefulness, or utility value, of schoolwork (Eccles et al., 1983; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006), which should *predict* engagement. This kind of inclusion of motivation and self-regulated learning as ‘engagement’ has led to a lack of a clear definition and measures that are incomparable across studies (Azevedo, 2015; Christensen et al., 2012; Eccles & Wang, 2012; Fredricks et al., 2004).

Through the lens of self-regulated learning, engagement is a reiterative cyclical feedback loop between monitoring and control during learning, leading to calibration or adjustment of the learning strategy, and continued monitoring and control towards learning goals (Winne & Nesbit, 2010; Zimmerman, 1989, 2006). However, before applying self-regulated learning strategies, one should be at least minimally involved (engaged) with the task. In line with this view, some engagement measures used self-regulated learning strategies as indicators of cognitive engagement (Corno & Mandinach, 1983; Meece et al., 1988; Reeve & Tseng, 2011) under the logical assumption that if one is employing deep cognitive strategies then one is engaged. However, the flip of that cannot be assumed – that if one is engaged, one is using deep cognitive strategies.

We avoid conceptualizing engagement as deep versus shallow processing (e.g., Johnson & Sinatra, 2013) because engagement should be aligned with the requirements of the task at hand (Gong & Levy, 2009; Jacoby, 1983). For example, some mathematics skills, such as acquiring the capacity to remember and recognize patterns or formulas or learning about certain scientific content (e.g., learning chemical naming conventions), might primarily require attention, intent focus, and rehearsal. Simply put, engagement, as conceptualized here, refers to the involvement with activity. However, involvement with the materials does not necessarily translate into effort. Many learning tasks do not require exerting effort in the form of “trying as hard as I can” or “working hard”, but just require attention and on-task behaviors, and include experiencing affect.

1.1.2. Where does engagement occur

Engagement and learning can occur everywhere, both in and out of school. To produce a more general theoretical understanding, we sought to capture qualities of engagement that occur across learning settings and are indicative of productive involvement with the learning materials. The bulk of engagement research has focused on academic or school-related engagement during homework, schooltime, or computer-based learning, (Assor et al., 2002; Carini et al., 2006; Christenson et al., 2012; Corno & Mandinach, 1983, 2004; Eccles & Wang, 2012; Finn et al., 1995; Fredricks et al., 2004, 2011; Gonida et al., 2007; Greene et al., 2004; Ladd & Dinella, 2009; Linnenbrink, 2007; Meece et al., 1988; Nystrand & Gamoran, 1991) and has missed out-of-school learning settings (Valentine, DuBois, & Cooper, 2004), such as summer camps, after-school programs, museums, and non-fiction book reading. A more general understanding of engagement requires studying both school and out-of-school learning environments using conceptualizations and measures that can apply to both.

Another important divergence in our conceptualization of engagement from prior views is that we considered engagement as occurring within and emanating from learner-activity interaction in particular. By contrast, we considered learner-peer, learner-educator, learner-parent relationships to be supporting engagement and perhaps predicting engagement, but not part of the definition of engagement as is sometimes done (Appleton, 2012; Finn & Voelkl, 1993). For example, items such as ‘peer/family support for learning’ (Appleton, 2012) and ‘People care about each other in this school’ (Darr, 2012) are indicative of social support or school belongingness that lead to engagement in particular learning activities but are not in and of themselves engagement because *engagement* requires an activity with which to be engaged.

1.1.3. Can we assess the multidimensional nature of engagement?

The conceptualization of engagement as a multidimensional construct is not new (Archambault & Dupéré, 2017; Fredricks et al., 2004; Patall, Vasquez, Steingut, Trimble, & Pituch, 2016). Our conceptualization of engagement considers three components of engagement (affective, behavioral, and cognitive) as conceptually separate, though related. Logically, one could be behaviorally active but not cognitively or emotionally engaged in the task at hand. Similarly, one could be emotionally involved while not thinking about the learning task. Finally, one could be thinking about materials and experiencing emotions, without implementing learning behaviors (e.g., writing). To date, many studies examined one or two dimensions of engagement (c.f., Fredricks et al., 2011; Ladd, Herald-Brown, & Andrews, 2009; Li, Lerner, & Lerner, 2010), and perhaps confounded their measurement. In the current study, we extend this line of work to measure all three simultaneously to understand how they empirically co-occur. Although logically separable, it is also possible (as we found in both studies) that cognitive and behavioral engagement co-occur as one factor.

Our definition of *cognitive engagement* is in line with the process-oriented approach to cognitive engagement (also substantive engagement in Nystand & Gamoran, 1991). Cognitive engagement reflects the extent to which one is thinking about the learning activity, or attending and focusing on the task (Posner, 1980; Posner, Snyder, & Davidson, 1980; Rueda, Posner, & Rothbart, 2004). This is differentiated from cognitive strategy-use and the type of cognitive processes (e.g., rehearsal, elaboration, or organization) (Greene et al., 2004; Pintrich 1989, 2000b; Winne & Hadwin, 1998), which will vary by the type of task. Participants paying attention, thinking, and intently learning a new phenomenon might not necessarily be employing deeper cognitive processing in the form of “elaboration”, and some activities that require thinking and analyzing might not require “organization”. In the Fredricks et al. (2011) compilation of engagement measures, this confounded nature of cognitive engagement with self-regulated learning and motivation is prominent. Cognitive engagement items tend to include a self-regulated learning component (e.g., School Engagement Measure – MacArthur “When I read a book, I ask myself questions to make sure I understand what it is about.”), or a motivational component such as desire for effort exertion (e.g., Student School Engagement Survey “How important do you think an education is?”). Extracting such motivational or self-regulated learning processes, cognitive engagement is cleanly *thinking and paying attention*.

In our conceptualization of *behavioral engagement*, we focused on what students involved in the learning activity would look like or be doing. Diverging from research examining behavioral engagement *in school* as students' attendance and conduct (Assor et al., 2002; Christensen et al., 2012; Finn, 1989; Fredricks et al., 2011), we focused on observable behaviors of engagement include reading aloud, raising a hand, and talking to the teacher or a peer about the materials as indicating in-class engagement (Behavioral Observation of Students in Schools (BOSS): Shapiro, 1996). Similar to the BOSS and High School Survey of Student Engagement Social/Behavioral/Participatory engagement scale (see Fredricks et al., 2011), we included conversation about the topic as an indicator of behavioral engagement, but rather than focusing on interactions with teachers, we included talking with peers or adults (e.g., a teacher or museum docent) about the activity to enable use across formal and informal contexts.

Measures of *affective engagement* tend to assess general positive affect towards school, the class, peers, and teachers (e.g., "I like", "am excited", "am happy", etc.) (Fredricks et al., 2011; Skinner, Wellborn, & Connell, 1990), at times combined with either motivational factors such as interest or boredom (Park, Holloway, Arendtsz, Bempechat, & Li, 2012) or behavioral engagement such as participation (Skinner et al., 1990). Such measures of affective engagement consist of broader positive and negative reactions to academics or school. We drew on work from the emotional circumplex to conceptualize *engagement emotions*, (Feldman Barrett & Russel, 1999; Yik, Russell, & Steiger, 2011), according to which emotions can be categorized by their level of activation (activated/aroused or deactivated/unaroused) and valence (positive or negative). We sought to tap into the four major dimensions identified by the circumplex: positive-activated (e.g., excited), positive-deactivated (e.g., calm), negative-activated (e.g., annoyed), and negative-deactivated (e.g., tired). Within the literature there are some mixed findings as to which types of emotion lead to better performances. Whereas Carver and Scheier (1990) proposed that positive affect can decrease learning as the experience of positive emotions signals that one is making sufficient progress towards one's goals, more recent research suggests positive emotions about a class (e.g., enjoyment, hope, & pride) lead to higher levels of both academic performance and behavioral and cognitive engagement (Ben-Eliyahu & Linnenbrink-Garcia, 2011; Linnenbrink, 2007; Pekrun, Elliot, & Maier, 2009; Pekrun, Goetz, Titz, & Perry, 2002) by expanding a person's openness to learn and incorporating new materials (c.f. broaden-and-build, Fredrickson, 1998). While negative emotions negatively predict academic performance and behavioral and cognitive engagement (Ben-Eliyahu & Linnenbrink-Garcia, 2011; Linnenbrink, 2007; Pekrun et al., 2002, 2009), certain negative activated emotions (e.g., confusion) may lead to more in-depth inquiry about the learning materials (D'Mello & Graesser, 2012). Furthermore, boredom is an especially important engagement emotion because it is a strong indicator of detachment from the ongoing activity, whereas other forms of negative deactivated emotions (e.g., tired) may be more indicative of a lack of engagement for other reasons (e.g., lack of sleep). As with other forms of engagement, affective engagement arises as part of the dyadic interaction between learner and activity as an influential component of the learning process. This view of affective engagement is in contrast to that recently expressed by Eccles and Wang (2012, p. 143) who "see affect as both a precursor and a consequence of engagement rather than as a part of engagement." However, it aligns well with research on flow, according to which learners feel positive emotions during the learning activity to the extent that they lose sense of time, and become fixed and enamored by the task (Abuhamdeh & Csikszentmihalyi, 2012; Csikszentmihalyi, 1990).

The research on flow, however, suggests the possibility of a holistic kind of engagement that is not just the sum of affective, behavioral, and cognitive engagement, and that is the phenomenological experience of intrinsically motivated activity (Nakamura & Csikszentmihalyi, 2014). It involves positive approach emotions, similar to our conception of affective engagement. It also involves cognitive and behavioral engagement, especially related to intense and focused concentration. Most importantly, it is conceptualized as one coherent factor, rather than separate affective, behavioral, and cognitive components.

In summary, building on previous work examining engagement, we propose that affective, behavioral, and cognitive engagement occurs when learning during in-class and out-of-school activities (Assor et al., 2002; Christenson et al., 2012; Corno & Mandinach, 1983, 2004; Fredricks et al., 2004, 2011; Gonida et al., 2007; Greene et al., 2004; Ladd & Dinella, 2009; Shapiro, 1996). By querying students about their engagement along those three dimensions at multiple times in classrooms and museum exhibits, we could consider whether engagement occurs as a single construct as suggested by flow research or whether it is multidimensional (organized by affective, behavioral, and cognitive engagement dimensions). We also examine whether this multidimensional structure is consistent across activities, time, and learning settings (e.g., in and out of school).

1.1.4. *Specificity of measurement*

An additional consideration that arises when measuring engagement is the specificity of measurement (Ben-Eliyahu & Bernacki, 2015). Much of the research to date has assessed behavioral, cognitive, and affective engagement in relation to a course, domain, school, or academics (Ainley & Ainley, 2011; Christenson et al., 2012; Fredricks et al., 2004, 2011). However, engagement that occurs *during* activities captures the ways in which activities influence the learner's motivations. This is similar to what Pekrun (2006) calls "activity emotions" which are on-task emotions, and are differentiated from "outcome emotions" that occur prior to or after participating in an activity. We extend Pekrun's approach to also include behaviors and cognitions. In this way, we propose that engagement processes (affective, behavioral, and cognitive) are activity processes that emanate from within the learning situation as a result of the learner-activity interaction.

1.2. *Motivation and engagement*

A highly-studied antecedent of engagement is motivation (Anderman & Midgley, 1997; Jones, Johnson, & Campbell, 2015; King & Datu, 2017; Martin, Yu, Papworth, Ginns, & Collie, 2015; Patall et al., 2016). Drawing on theories of volition and self-regulation (Kuhl, 1984), we reasoned that motivation instigates engagement (see Fig. 1). Without the desire or drive to learn, engagement will not occur. As a critical validation of the engagement construct and dimensions, we tested whether there would be differential relations in how motivation predicts affective, behavioral, and cognitive engagement; and in turn, how the different components of engagement predict motivation. Prior work found that different forms of motivation such as interest and autonomous motivation predict engagement (King & Datu, 2017; Patall et al., 2016). To investigate the reciprocal relations between motivation and engagement, we drew on well-established and highly studied achievement motivation constructs: mastery and performance-approach goal orientations, and self-efficacy.

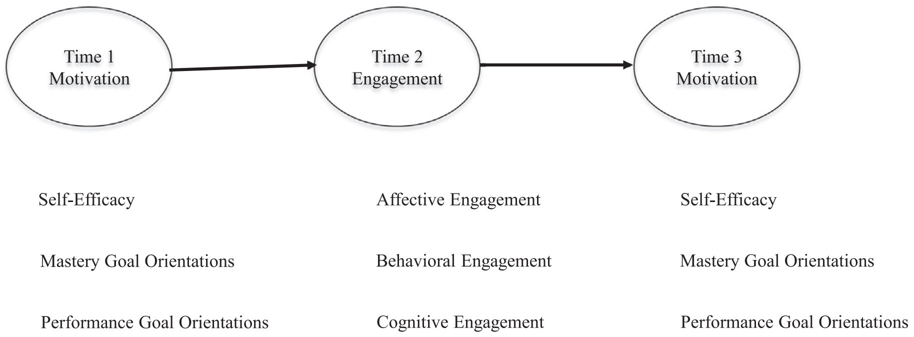

Fig. 1. Theoretical model for the reciprocal relations between motivation and engagement.

Goal orientations are a general approach or focus that students have for their academic work. Mastery goal orientations refer to the desire to learn and develop while performance-approach goal orientation is the focus on outshining others by appearing smarter or better (Ames, 1992; Dweck & Leggett, 1988; Pintrich, 2000a). Although other goal orientations have also been conceptualized and studied, these two are the ones that are regularly found to be positive predictors of learning (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002). Surprisingly, only a few studies investigated the relations between goal orientations and engagement. These studies point to endorsement of mastery goal orientations positively related to engagement (Dupeyrat & Mariné, 2005; McGregor & Elliot, 2002; Payne, Youngcourt, & Beaubien, 2007; Senko, Hulleman, & Harackiewicz, 2011; Urdan 1997). Performance-approach goal orientations have been found to be positively, negatively, or unrelated to achievement outcomes (McGregor & Elliot, 2002; Senko et al., 2011), and perhaps influenced by preference for the learning context or task (Ben-Eliyahu & Linnenbrink-Garcia, 2013; Fulmer, D'Mello, Strain & Graesser, 2015).

Self-efficacy is one’s self-evaluation about competence regarding specific tasks or activities (Bandura, 1977). That is, it is the extent to which one evaluates oneself as good at a task. Self-efficacy is a potent predictor of achievement outcomes (Schunk, Pintrich, & Meece, 2010; Valentine et al., 2004).

In the current study, we were interested in whether different types of motivation predict affective, behavioral, and cognitive engagement, and how engagement, in turn predicted changes in levels of these motivations. Focusing first on the types of motivation that predict engagement, self-efficacy has been positively associated with achievement outcomes (Schunk et al., 2010; Valentine et al., 2004), and the underlying mechanism may be through increased engagement. Therefore, we hypothesized that self-efficacy would predict higher levels of behavioral and cognitive engagement. For mastery goal orientations, given the positive valence emitted by mastery goals (Pekrun et al., 2009), we hypothesized that mastery goal orientation endorsement would predict all three forms of engagement, but especially affective engagement. For performance goal orientations, because the focus is on appearance and other's evaluation, we predicted it would be related to behavioral engagement. Behavioral engagement entails an external enactment thereby fulfilling the need to be seen by demonstrating competence (McGregor & Elliot, 2002).

In terms of considering the reciprocal relations, we hypothesized that affective engagement would be positively related to mastery goal orientations. Positive affect leads to broader learning repertoires (Fredrickson, 2013) which focus the learner on learning (Linnenbrink & Pintrich, 2002). Based on this line of research, affective engagement would lead to a desire to develop and learn, namely mastery goals. We also reasoned that cognitive engagement would focus the learner on learning and developing. Finally, we hypothesized that all three forms of engagement would be positively related to self-efficacy because the more the learner is engaged, the better they would feel about their ability to complete the tasks.

2. The purpose of the current study

Given our clear conceptualization of affective, behavioral, and cognitive engagement (distinct from deeper processing or simply showing up), our main research question was: *Is engagement separable into affective, behavioral, and cognitive components across a variety of activities?* We hypothesized that engagement is composed of facets (The Multidimensional Hypothesis) and explored the empirical patterns of this structure by using a series of factor analyses. We investigated whether engagement has three clearly distinct facets; yet, realizing the complicated nature of engagement we also investigated whether they combine. For example, separateness is illustrated in a situation when one completes tasks even if bored or cognitively disengaged, separating behaviors from affect and cognitions. However, facets could combine for example, when reflecting, one draws inferences from behaviors to cognitions. Especially when learning conceptually complex content, science learning environments are often structured so that thinking is supported during the active parts of the task so that behavior and cognition go together.

We were also interested in whether the dimensional structure of engagement changes across days and activities (The Consistency Hypothesis). Our expectation was to find that high-level structure of engagement is generally consistent across samples and activities in schools (Study 1) and museums (Study 2). We considered that while levels of engagement might change across situations and individuals, the components of engagement could remain consistent – is engagement separated into similar dimensions across learning sessions and contexts? This high-level consistency would suggest our conceptualization of task engagement is broadly useful. At a more practical level, it would also suggest that our engagement survey could be meaningfully used to measure and compare engagement across a variety of contexts and activities in and out of school (Valentine et al., 2004). However, it is possible that some specific indicators of engagement might be less relevant in some contexts, and thus the consistency of relative loading of all items within each construct is a separate question. As long as most items show consistent loading, the overall consistency hypothesis can be meaningfully tested.

To investigate these questions, we examined children’s engagement within multiple specific science activities in a widely used science curriculum within public schools (Study 1, sixth graders) and multiple museum exhibits (Study 2, fifth graders). Science classes and activities lend themselves well for the purpose of studying engagement, as children have been shown to hold various levels of interest, value, and capability in science (Bybee & McCrae, 2011; Sjoberg & Schreiner, 2010). Furthermore, recent attention on the state of science learning and science education in the United States and worldwide raises the importance of understanding what helps to scaffold learners’ engagement in science across their educational trajectory, as it relates to future achievement and potential career opportunities, especially during 5th and 6th grades as these are pivotal ages for disengagement from science (NSF, 2009; NRC, 2012).

2.1. Model testing: Confirmatory factor analysis

To examine the structure of engagement using the Engagement Activity Survey developed for the current study, we used Confirmatory Factor Analysis (CFA). CFA is often used in psychometric evaluations of instruments to determine the underlying structure of a scale because this technique can illuminate the number of underlying latent dimensions present in the instrument as well as the indicator-to-dimension (item-to-factor) relationship (Brown, 2006). Specifically, when validating theoretical constructs, CFA provides both convergent and discriminant evidence for proposed constructs. Convergent evidence is indicated through factor loadings that show strong inter-correlations with other items and factors theorized to be related (Brown, 2006). In the current study, for example, we would expect the behavioral items to be more strongly correlated with each other than with the affective or cognitive engagement items. In addition, discriminant evidence is indicated when factor loadings are not highly correlated with factors and items that are hypothesized to be different (Brown, 2006); for example, between cognitive and behavioral items.

While we hypothesized that engagement is multidimensional (The Multidimensional Hypothesis), we first considered the possibility that engagement is a unidimensional construct (see Fig. 2). This unidimensional model was then contrasted with several possible multidimensional models. The simplest non-hierarchical multidimensional model is a Correlated Traits Model (see Fig. 3, Model A-B-C), so named because the latent trait is partitioned into separate correlated traits (Reise, Moore, & Haviland, 2010). The correlated traits model tests whether or not engagement is separable into affective, behavioral, and

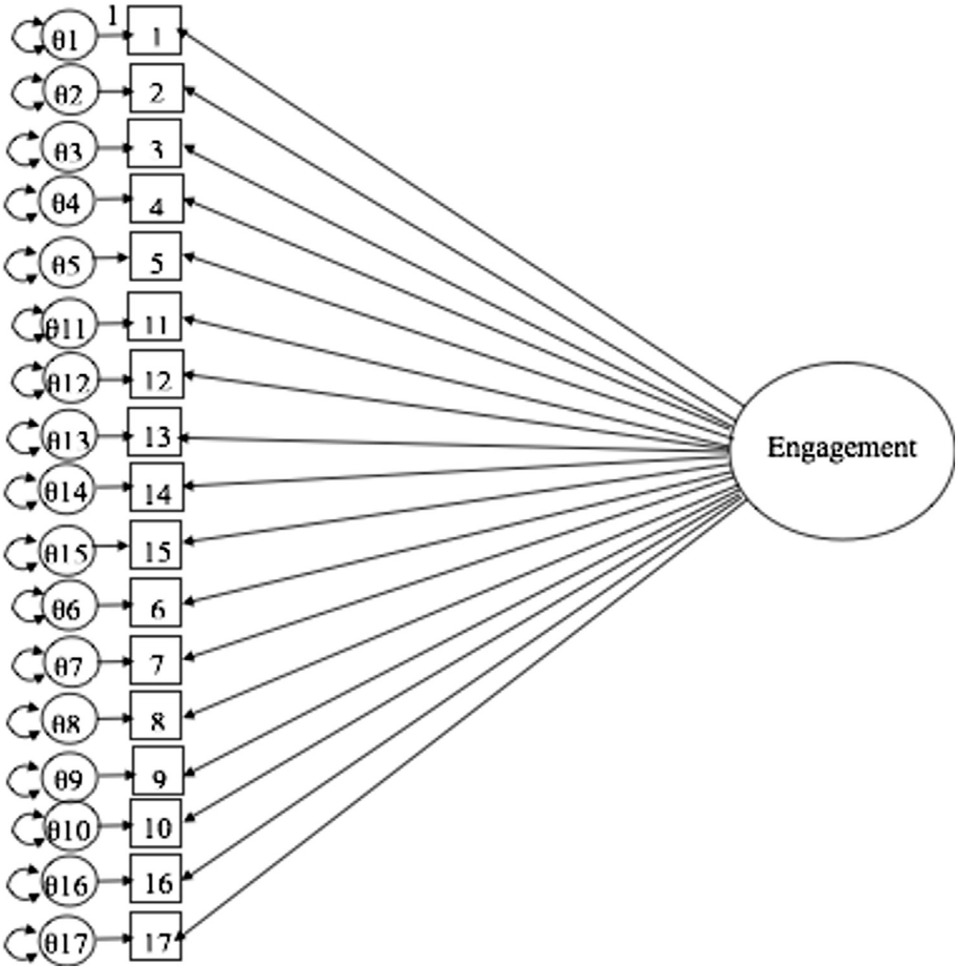

Fig. 2. Unidimensional Model – Engagement as one single factor.

cognitive dimensions because the model assumes that each item is a weighted linear function of affective engagement, behavioral engagement, cognitive engagement, two of these, or all of these.

We also considered engagement as a higher-order latent factor of the more specific affective, behavioral, and cognitive engagement factors (see Fig. 4, Model A-B-C). This would be done by examining model fit for a second-order factor model (Reise, Morizot, & Hays, 2007). A second-order factor structure is appropriate when it is hypothesized that lower level (primary) factors are substantially correlated and that the higher order factor accounts for the relations between specific factors (Chen, West, & Sousa, 2006). In recent years, the inherent limitations of the second-order factor model, coupled with the clearly multidimensional nature of many psychological constructs, have researchers looking to an alternative multidimensional model known as the Bifactor Model (Reise et al., 2007) (see Fig. 5, Model A-B-C). This model can be indicated when there is strong evidence for a unidimensional model, but also evidence of multidimensionality (Reise et al., 2010). In the bifactor model, each item loads on a general factor (i.e., overall engagement), which accounts for common variance among the items, and, additionally, one specific factor (i.e., affective, behavioral, or cognitive engagement), which accounts for any unique variance above and beyond the general factor (Chen, Hayes, Carver, Laurenceau, & Zhang, 2012). One disadvantage of the bifactor model is that it is susceptible to method or substantive factors.

The bifactor model is highly relevant to psychological processes, such as engagement, that may contain both unidimensional and multidimensional latent structures. Engagement may have a holistic element as suggested by flow research while simultaneously encompassing diverse features, as suggested by prior engagement research. For a bifactor model to provide a stronger fit to the data (conceptually and empirically), the important components of the overall engagement factor need to be different from the important components of the subdimensions (e.g., different cognitive aspects are important to overall engagement than to cognitive engagement). That is, the whole must be conceptually and empirically different from the simple sum of its parts.

To facilitate assessment of engagement in activities that occurred in both school and out-of-school contexts, the Activity Engagement Survey was designed to fit on one side of a standard page size (8.5 × 11) and require only a few minutes to complete. This yielded a highly practical survey instrument for researchers and teachers, intended to be used directly after an activity without disrupting the flow of activities during a school day or informal learning settings. Because of the overall length limitation, we allotted 5–7 items per engagement dimension. After the survey was administered, we asked the Learning Activation Lab research team to judge the dimension that each item assessed. The research team was comprised of 17 researchers across different fields in the learning sciences and science learning, most of whom were not involved in the survey creation and therefore were expert judges. Consensus from the research team members that the items assessed affective, behavioral, or cognitive engagement is presented in Table 1.

3. Study 1

3.1. Method

3.1.1. Participants

The data utilized in this study is part of the ALES11 dataset. For this study, we examined data from sixth graders during school (Mean

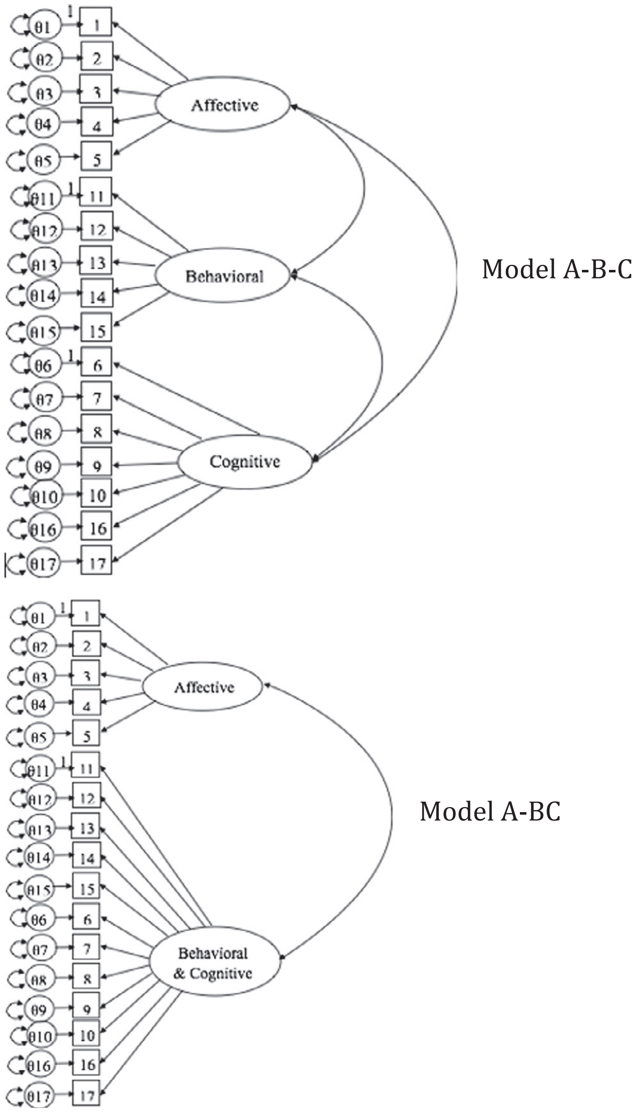

Fig. 3. Correlated Traits Model – Affective, behavioral, and cognitive engagement.

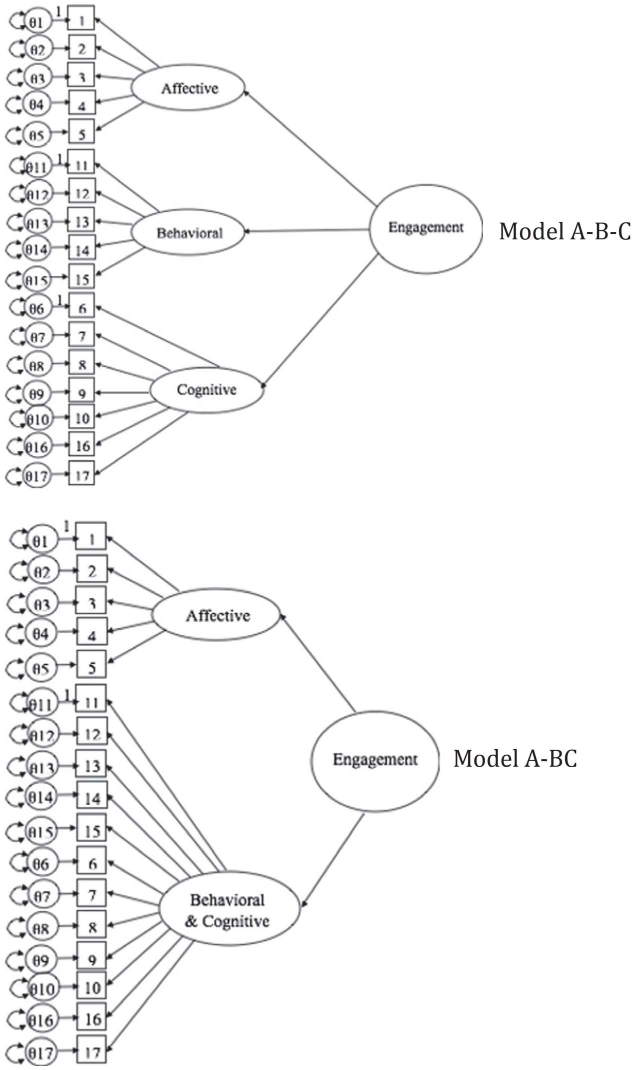

Fig. 4. Second Order Model – Engagement comprised of affective, behavioral, and cognitive components.

age = 11.7, *SD* = .99). 786 participants (59% female), coming from ten different public schools in midwest US urban schools varying widely in socio-economic level and ethnicity makeup, answered a questionnaire about their engagement for at least one of 6 different science activities. The overall sample was somewhat diverse with 29% of the students being African-American, 28% Caucasian, 2% Hispanic, 2% Asian, 1% Native American, and 1% Indian (4% did not know their race and 33% did not report their race).

3.1.2. *Description of activities by days*

Six activities in a widely-used inquiry-based middle school science curriculum were examined. Specific days in the science unit were surveyed to allow for collapsing data across similar lesson plans as well as test the consistency of structure across different activities (which might provide different affordances for different aspects of engagement) and topics (to separate topical interest from engagement). The overall curriculum consisted of 9 units taught across 5 months. The first three sampled days were part of the fourth unit, which focused on weather and water. The last three sampled days were part of the 6th unit, which focused on water and air.

The main activities for each day during the administration of the engagement survey are presented in Table 2. The main activity on Day 1 of data collection focused on comparing radiation and conduction. The Day 2 activity focused on heating sand and water. A main goal of this activity is to gather data that would be graphed during the next day's activity. Day 3 was aimed at comparing graphs through a teacher-led discussion. Day 4, occurring several weeks later, was similar to Day 1 in that it was a contrasting case activity that introduces the 6th unit, which was about the presence of water in the air (i.e., evaporation versus condensation). This contrasting case activity was carried out similarly to the activity on Day 1. Day 5 was focused on evaporation and humidity. This lesson started with a teacher-led discussion about whether there is water vapor in the air around us and, if so, whether there is a way to prove it. After the discussion, the teacher set up a condensation demonstration. Students then completed two hands-on activities in which they experienced and measured the decrease in temperature that occurs during evaporation. The lesson concluded with a discussion of condensation formation on a glass of ice water during the teacher's demonstration. Finally, Day 6 continued the evaporation and humidity activity from the previous lesson. This lesson started with a teacher-led discussion about humidity, relative humidity, and saturation. Students then completed a worksheet in which they calculated the relative humidity of air containing different amounts of water vapor. The teacher introduced transpiration and students wrote a paragraph in response to two statements about sweating and cooling. In sum, the lessons involved hands-on activities, individual conceptual

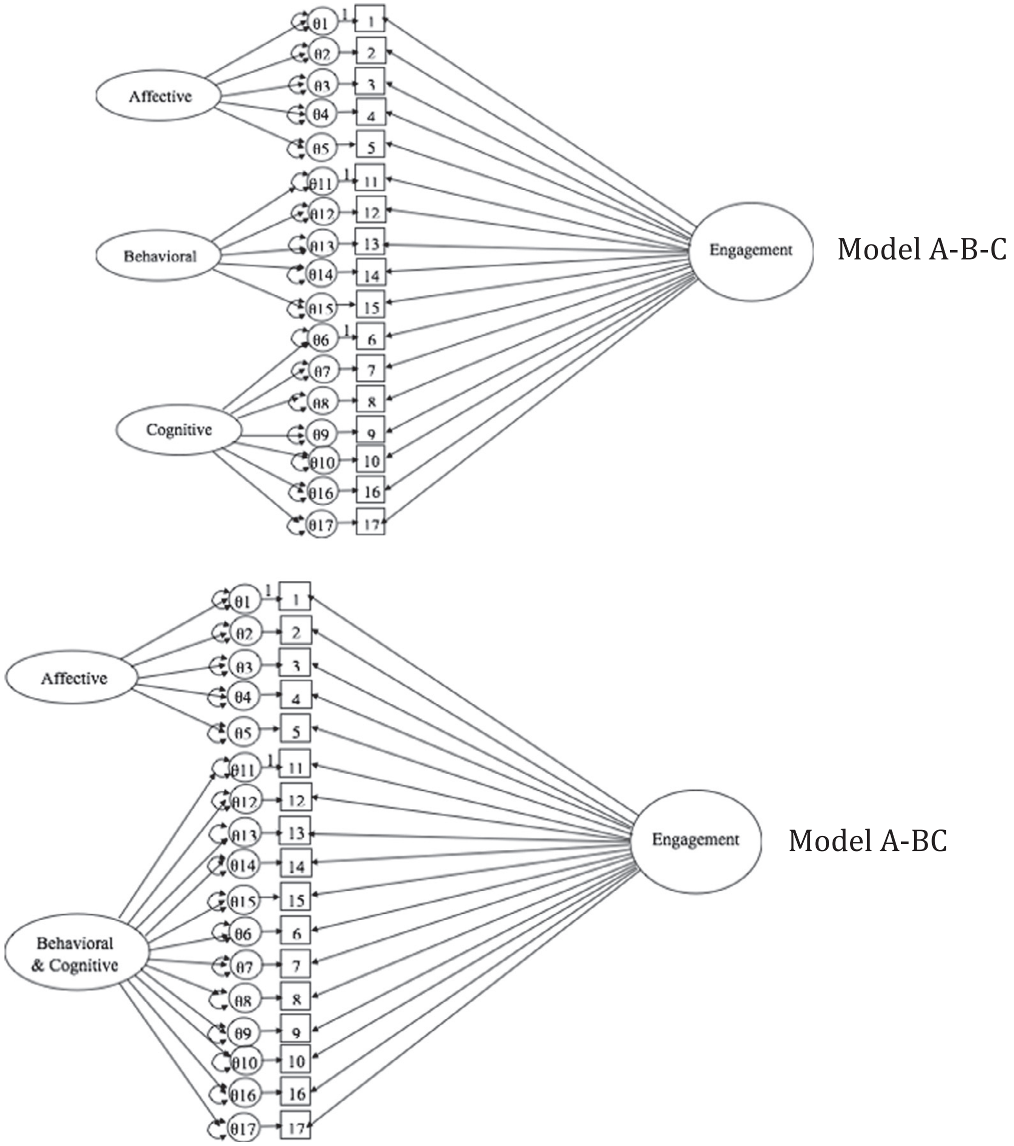

Fig. 5. Bifactor Model – This model represents a model in which items load on a overall factor and, additionally, one other specific factor.

tasks like contrasting cases, and whole class discussions.

3.1.3. Measures

3.1.3.1. Activity engagement survey. The Activity Engagement Survey was used to examine engagement across the 6 days of activities (see Table 1 for survey items). Students were asked to focus on the activity they had just completed. The first 15 items were on a 4-point Likert scale (YES! – yes – no – NO!), while items 16–18 were yes or no responses. For the emotional engagement items, we included one question for each set of emotions (valence × activation), indicating two emotions from each emotional space, in addition to boredom, which is considered a strong indicator of lack of engagement. Items 3, 4, and 5 were negative engagement emotion items and were reverse coded so that higher scores indicated more engagement. For behavioral engagement, we based the items on the BOSS (Shapiro, 1996), with the focus on behaviors that suggest involvement with the activity. For the cognitive engagement dimension, we emphasized cognitive processes such as thinking during the activity.

Reliabilities for the overall engagement scale were acceptable across the six days, ranging from $.64 < \alpha < .88$ (see Table 3). Affective and behavioral engagement dimensions also had reliabilities within the acceptable range, although cognitive engagement had lower reliabilities. We also examined reliabilities for a combined behavioral-cognitive dimension of engagement (explained below on page 36), which resulted in reliabilities within the acceptable range. In examining the test-retest for these scales, moderate-to-high correlations were found for both factor and mean scores across days (see Fig. 6). A closer examination reveals that, overall, the test-retest reliabilities for mean scores were higher than the factor scores. As will be explained later, the higher stability for the mean scores was not surprising given that the factor scores might change slightly across the days depending on the item loadings, while the mean scores are consistently a mathematical average of the items and therefore computed in an identical method across days.

3.1.3.2. Motivation. Achievement goals were measured with the same survey at the beginning of the school year (Time 1) and midway (Time 3). Both mastery goal orientations and performance-approach goal orientations were measured using three items adapted from the *Patterns of Adaptive Learning Survey* (Midgley et al., 2000). Mastery goal orientations, or a focus on developing and learning, was measured with items such as “I want to understand and know science material” ($\alpha_{T1} = .74$; $\alpha_{T3} = .85$). Performance-approach goal orientations, or the desire to appear and look smart and able was measured using 3 items such as “When I work on science, I want to appear:(4 = More skilled than everyone, 3 = More skilled than most, 2 = Just as skilled as

Table 1
Final set of survey items and research team judgments.

	% of research team rated as Affective	% of research team rated as Behavioral	% of research team rated as Cognitive	Final Engagement Factor
During today's activity				
1. I felt happy or excited	100	0	0	Affective
2. I felt relaxed or calm	94	6	0	Affective
3. **I felt frustrated or annoyed**[a]	100	0	0	Affective
4. **I felt tired or sad**[a]	100	0	0	Affective
5. **I felt bored**[a]	75	6	19	Affective
6. I was thinking during the activity	0	6	94	Cognitive
7. *I explained things to others*	0	75	25	Behavioral
8. *I tried out my ideas to see what would happen*	0	75	25	Behavioral
9. *I thought about how ideas in the activity related to other things*	0	0	100	Cognitive
10. I was paying attention during the activity	0	44	56	Cognitive
11. I was doing what I was supposed to be doing	0	100	0	Behavioral
12. I did more than was required of me	0	94	6	Behavioral
13. I worked hard on the activity	0	94	6	Behavioral
14. *I asked questions or talked with an adult*	0	88	12	Behavioral
15. *I asked questions or talked with another student*	0	88	12	Behavioral
Did you do any of these things during today's activity?				
16. I figured out something about science	0	12	88	Cognitive
17. I checked to make sure I understood what we were doing	0	56	44	Behavioral

[a] *Notes:* Indicates reverse coded item. Bold indicates items that load strongly for the affective scale. Italics indicates the items that load strongly for the behavioral-cognitive scale.

everyone else, 1 = I don't care how skilled people think I am)" points (α_{T1} = .74; α_{T3} = .74).

Self-efficacy was measured with the same survey at the beginning of the schoolyear (Time 1) and midway (Time 3). Six items (see Appendix A for all items) were used to measure self-efficacy with a sample item "I think I am pretty good at: Designing experiments." Reliabilities were high for both time points (α_{T1} = .80; α_{T3} = .86).

Because we were interested in using Structural Equation Models (SEM) to investigate reciprocal relations for motivation predicting engagement, we ran a CFA for all three scales together. Model fit for the three motivational variables was good for T1 (χ^2 = 188.78, $p < .001$; TLI = .98; CFI = .99; RMSEA = .05; SRMR = .02) and T3 (χ^2 = 140.15, $p < .001$; TLI = .99; CFI = .99; RMSEA = .05; SRMR = .01).

3.2. Data preparation and analysis plan

Exploratory factor analyses (EFA) were performed to determine whether items were behaving as expected because of the impact anomalous response patterns could have on the subsequent CFAs. Finally, we tested CFA models for each day separately. Because there were high correlations between the behavioral and cognitive dimensions of engagement consistently across all days/activities (see Fig. 6), we examined models that had separate behavioral and cognitive dimensions, as well as a combined behavioral-cognitive dimension; the theoretical interpretation of this combination is taken up in the Discussion. Comparing models that had separate and combined factors allowed a nuanced investigation of the extent to which these forms of engagement are differentiated.

3.2.1. Engagement: Exploratory factor analysis

Factor loadings for EFAs were calculated using the weighted least squares means and variances estimator in MPlus (version 6.1, Muthén & Muthén, 2010) for all original 18 items. One to five factors were extracted and examined for each day separately. Results from the series of EFAs showed that Item 18 ("I pretended to be doing the activity") was

Table 2
Description of main activity on each day.

	General description of main activity
Day 1	This is the contrasting case activity that opens Investigation 4, which is about heat transfer. In this activity, students read four scenarios involving heat transfer. They are given cards that describe radiation and conduction, and they try to figure out which card best describes what happened in each scenario. They then use the cards to answer questions about each scenario, and they complete a Venn diagram to compare radiation and conduction
Day 2	This was a hands-on activity in which students place containers of sand and water under a heat lamp and measured their temperatures every three minutes. Then they turned the lamp off and continued the three-minute readings
Day 3	A teacher led discussion accompanied by a powerpoint displaying the starting, highest, and ending temperatures facilitating student understanding that sand heats up and cools down faster than water. Teacher questions were aimed to help students connect the sand-and-water activity to what they learned about radiation and conduction in Day 1
Day 4	Focused on comparing evaporation and condensation. Students read four scenarios involving water changing state. Students are given cards that describe evaporation and condensation, and they try to figure out which card best describes what happened in each scenario. They then use the cards to answer questions about each scenario, and they complete a Venn diagram to compare evaporation and condensation
Day 5	The teacher then set up a demonstration that enabled students to observe condensation by the end of the class period. Students were given water and instructed to dampen a small area on the back of each hand. They blew on one hand to simulate wind and observed that wind makes the water dry faster and makes that hand feel cooler than the other hand. Students then used wet- and dry-bulb thermometers to measure the change in temperature that occurs during evaporation
Day 6	The main activity for this day was completion of a worksheet in which students calculated the relative humidity of air containing different amounts of water vapor. The teacher introduced transpiration and students wrote a paragraph in response to two statements about sweating and cooling

Table 3
Reliabilities (Cronbach Alpha) for overall engagement and affective, behavior, cognitive, and behavioral-cognitive dimensions.

	Number of participants	Overall	Affective	Behavioral	Cognitive	Behavioral-Cognitive
Study 1						
Day 1	596	.85	.68	.76	.64	.83
Day 2	605	.86	.73	.79	.68	.85
Day 3	569	.88	.73	.81	.68	.86
Day 4	516	.86	.71	.77	.67	.83
Day 5	588	.86	.72	.80	.71	.86
Day 6	471	.88	.75	.81	.72	.87
Mean reliability		.87	.72	.79	.68	.85
Study 2						
Dinosaur	251	.81	.54	.77	.66	.83
Engineering	253	.82	.49	.77	.65	.85
Mean reliability		.82	.52	.77	.66	.84

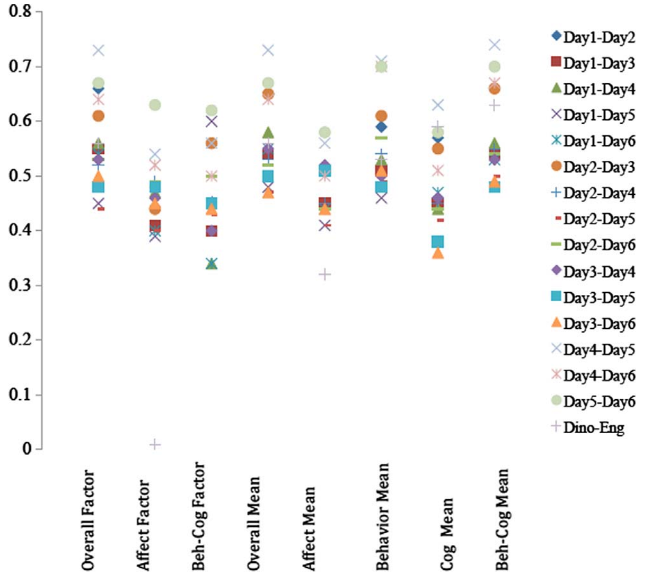

Fig. 6. Pearson correlations of engagement scores across pairs of observations for factor scores and means. *Note:* All correlations significant at the $p < .01$ level.

consistently problematic across factor solutions and days. The fact that the item did not load in the unidimensional case (1-factor solution) and inconsistently in the multidimensional cases is noteworthy because a form of this item has historically been included in many engagement surveys (Fredricks et al., 2011). It could be that this item is interpreted in different ways across participants – as one could be pretending cognitively, behaviorally, or emotionally. Some students may be answering this as “I went through the motions, but was detached in my thinking.” Others might be answering it more in line with “I seemed as though I was thinking, when really I was daydreaming.” Yet another interpretation of this item might be that “I acted as if I was excited, when really I was bored and cognitively detached.” Given the inconsistent performance, this item was dropped from further analyses.

3.2.2. Engagement: Confirmatory factor analyses

Based on the literature, and combined with the high correlations between behavioral and cognitive engagement, seven models were specified and compared. A *Unidimensional Model* (see Fig. 2) assumed that all items were influenced by the same underlying Engagement factor and not separable into component factors as measured by this instrument (Reise et al., 2010). A *Correlated Traits Model* (see Fig. 3) assumed that engagement was separable into affective, behavioral, and cognitive components, but no overall Engagement factor was influencing the items (Reise et al., 2007). We examined this model with affective, behavioral, and cognitive components separate (*Correlated Traits Model A-B-C*) and with the behavioral and cognitive components combined (*Correlated Traits Model A-BC*). We also considered whether affective, behavioral, and cognitive engagement were part of engagement by examining a *Second-Order Factor Model* (see Fig. 4). This model assumed that engagement was a higher-level factor that accounted for the correlational relationship between affective, behavioral, and cognitive engagement (Chen et al., 2006). We tested the model with affective, behavioral, and cognitive components separate (*Second-Order Factor Model A-B-C*) and with behavioral and cognitive engagement combined (*Second-Order Factor Model A-BC*). Finally, we tested the *Bifactor Model* (see Fig. 5) that assumed each item to be part of the overall engagement factor and also part of the specific dimension (Chen et al., 2012). For this model, we also tested the model with affective, behavioral, and cognitive engagement as separate components (*Bifactor Model A-B-C*) and with a combined behavioral-cognitive engagement dimension (*Bifactor Model A-BC*).

3.2.3. Criterion for comparison of models

Model fit statistics were used to compare fit for the models. MPlus provides several model fit statistics for a CFA (Muthén & Muthén, 2010). Based on Hu and Bentler (1998, 1999), we used a number of fit indices to determine the best fitting model. The *Root Mean Square Error of Approximation* (RMSEA) adjusts for model complexity, making it sensitive to the number of parameters in the model (Brown, 2006), with values of less than .06 considered a good fit (Hu & Bentler, 1999). The *Comparative Fit Index* (CFI: Bentler, 1990) and the *Tucker-Lewis Index* (TLI: Tucker & Lewis, 1973) compare the user-specified model to a baseline model, with values greater than .95 indicating good fit (Brown, 2006; Hu & Bentler, 1999).

3.2.4. Aggregate scores

In the final stage of analyses involving relationships to motivation constructs, it was important to establish whether mean scores and factor scores for each engagement aggregate would be substantially different. If simple means correlate highly with different factor scores across models, the models show little practical importance. Therefore, we created two types of scores for the affective, behavioral-cognitive, and overall engagement factors across the six days. As a first step, because we had different scales across items, we divided each response by the highest possible point value for that item. We then took an average of the resulting scores across the appropriate items for each dimension, resulting in a mean. In addition, factor scores, based on the best fitting model were calculated. The weighted least squares means and variances estimator in MPlus (version 6.1, Muthén & Muthén, 2010) was used to calculate factor scores for all participants. We then compared these two different approaches to aggregating the engagement scale items by correlating them within and between days (see Fig. 8).

Table 4
Study 1 Fit Indices for the Unidimensional, Second-Order[a] and Bifactor Models.

Model[b]	Day	Chi-square[c]	df	RMSEA	CFI	TLI
Unidimensional Model	Day 1	787.773	119	0.10	0.83	0.81
	Day 2	1358.611	119	0.13	0.78	0.75
	Day 3	1337.696	119	0.13	0.80	0.77
	Day 4	1025.534	119	0.12	0.81	0.78
	Day 5	1447.601	119	0.14	0.79	0.76
	Day 6	1320.613	119	0.15	0.78	0.74
Second-Order Model A-B-C	Day 1	584.98	116	0.08	0.88	0.86
	Day 2	1004.263	116	0.11	0.84	0.82
	Day 3	1565.26	116	0.15	0.76	0.72
	Day 4	840.057	116	0.11	0.84	0.82
	Day 5	1070.202	116	0.12	0.85	0.82
	Day 6	999.691	116	0.13	0.84	0.81
Second-Order Model A-BC	Day 1	597.434	118	0.08	0.88	0.86
	Day 2	1032.88	118	0.11	0.84	0.81
	Day 3	1024.78	118	0.12	0.85	0.83
	Day 4	833.76	118	0.11	0.85	0.82
	Day 5	1067.846	118	0.12	0.85	0.83
	Day 6	1011.337	118	0.13	0.83	0.81
Bifactor Model A-B-C	Day 1	399.544	102	0.07	0.92	0.89
	Day 2	713.615	102	0.10	0.88	0.84
	Day 3	549.517	102	0.09	0.92	0.90
	Day 4	432.84	102	0.08	0.92	0.89
	Day 5	604.453	102	0.09	0.91	0.88
	Day 6	619.43	102	0.10	0.90	0.86
Bifactor Model A-BC	Day 1	313.034	102	0.06	0.95	0.93
	Day 2	430.014	102	0.07	0.94	0.92
	Day 3	359.599	102	0.07	0.96	0.94
	Day 4	260.38	102	0.06	0.97	0.96
	Day 5	365.011	102	0.07	0.96	0.94
	Day 6	351.475	102	0.07	0.95	0.94

[a] Equal variance was specified for this model.

[b] The Correlated Traits Models did not produce factor scores for any of the days, therefore fit indices are not presented.

[c] All Chi-Square models were significant at the $p < .001$ level.

3.3. Results

3.3.1. Confirmatory factor analysis

The seven models were compared using the TLI, CFI, and RMSEA (see Table 4). Only two models produced factor scores across all days: the Unidimensional Model and the Bifactor A-BC Model (See Table 4). Both the Correlated Traits A-B-C and the A-BC Models did not produce factor scores for some days, while models in which the overall or unidimensional engagement factors were taken into account consistently produced stable results across all days. Additionally, given the high correlation between the behavioral and cognitive dimensions, it was not surprising that the three models that separate affective, behavioral, and cognitive engagement are problematic simply because they do not take into account the multi-colinearity between the behavioral and cognitive dimensions. The Second-Order Factor A-B-C Model produced factor scores for all days except Day 3 while the Second-Order Factor A-BC Model and the Bifactor A-B-C Model each produced factor scores for four of the six days. In comparing fit indices for the Unidimensional Model and the Bifactor A-BC model, we found partial support for the Multidimensional Hypothesis as the Bifactor A-BC model was the best fit across the six days. As we further elaborate in Section 5, it may be that developmentally, children in sixth grade use behaviors as indicators of their cognitions and therefore do not differentiate between behaviors and cognitions or that the learning environment was structured to have behaviors support cognitions. This model represented the affective and combined behavioral-cognitive components and the overall engagement factor in a bifactor CFA, lending support to the Consistency Hypothesis.

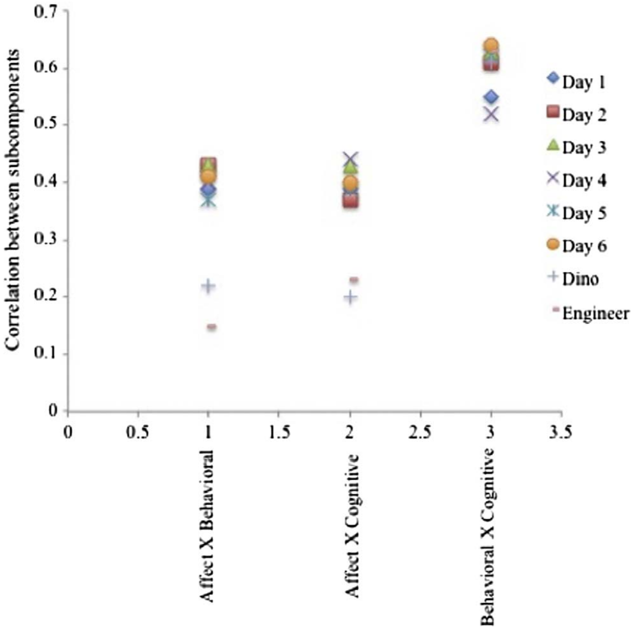

Fig. 7. Correlations between dimension means across days and activities. *Note:* All correlations significant at the $p < .01$ level except: Engineering Affect X Engineering Behavior, which was significant at the $p < .05$ level.

3.3.2. Comparison of mean and factor aggregate scores

Based on the Bifactor A-BC model, we calculated factor scores for the overall engagement, affective, and behavioral-cognitive dimensions of engagement using WLSMV estimator (Beauducel & Herzberg, 2006). While the overall structure was similar across days, there were some variations of the actual item loadings on each factor by day (factor loadings are presented in Appendix C). This resulted in slight variations in the actual factor score calculations for each day. In addition, we calculated a simple mean for each dimension. Because there were

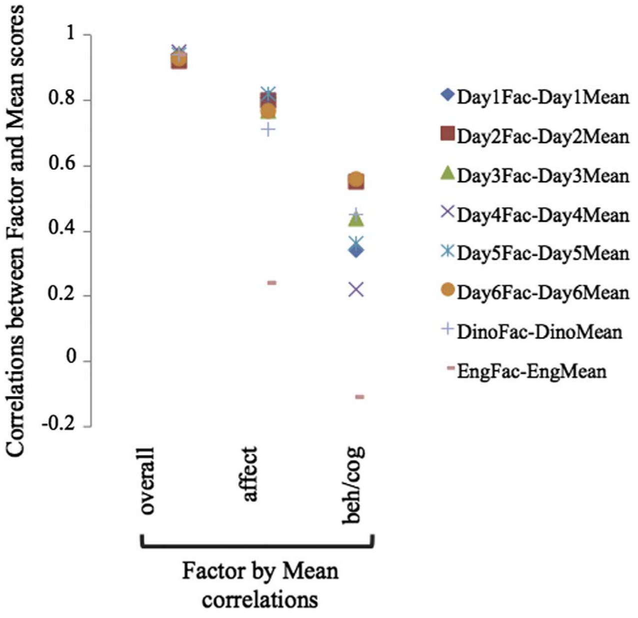

Fig. 8. Correlations between factor (Fac) and mean scores (Mean) across days and activities. *Note:* All correlations significant at the $p < .01$ level except: Dinosaur factor score and Dinosaur mean score for affect dimension and Engineering factor score with Engineering mean score for behavioral-cognitive.

different response options across the 17 items, prior to calculating the simple mean, we equated the scales by dividing by the maximum possible (items 1–15 were divided by 4). Overall, we found that the calculated mean engagement score and factor engagement score calculated from the Bifactor A-BC Model were highly correlated. The correlations ranged from .92 to .95 (see Fig. 8), suggesting that both forms of calculation provide similar information. However, correlations between the simple mean scores for the affective and behavioral-cognitive specific factors and the resulting factor scores from the estimation of the Bifactor A-BC Model were rather low (see Fig. 7). Specifically, correlations for affective engagement ranged from .77 to .82 while the correlations for behavioral-cognitive engagement were even lower, ranging from .22 to .55. The most probable reason for these low correlations between the affective and behavioral-cognitive dimensions is that the factor scores emphasize a subset of the items (discussed in greater depth in Section 3.4.4) whereas the means include all items.

3.3.3. Comparison of engagement across days

Is the consistency in the dimensional structure of engagement caused by high stability in engagement scores? In order to investigate this question, we first looked at mean differences across the days. Repeated measures general linear model and Bonferonni corrections for post-hocs were used to investigate differences between days in engagement. Overall, there were slight differences between days when comparing engagement levels within participants using repeated measures. The repeated measures effect was non-significant for both the affect and behavioral-cognitive components of engagement. Even though the overall multivariate repeated effect for the overall engagement factor scores was significant (F (5, 174) = 2.53, p = .031), the within-subject effect for Days was not (F (4.13, 735.72) = 2.063, p = .082). Thus, overall there were no differences in the level of engagement across days when taking into account the factor loading of each item when calculating the mean.

Having visited the classrooms to collect the survey measures, we were not surprised that there were not consistent engagement differences across the sampled activities when averaging across teachers. Such differences were anticipated given that the classroom dynamics varied considerably across teachers; hands-on science activities are complex balances between encouraging intellectual ownership over work but still requiring high fidelity to basic experiment details. Each teacher has a particular set of strategies for implementing a given day's activities. When looking at consistency of ratings across days through correlations in mean and factor scores (see Fig. 6), many of the correlations are only of medium levels (e.g., in the .4 to .5 range), although the last three days showed more consistent correlations.

3.3.4. Consistency and differences in components and overall engagement loadings

To understand why the bifactor model provided a better fit than the hierarchical model, we examined the item loadings on the separate components and overall engagement factor. There were consistent differences in loadings at the two levels across the six days. In particular, two affective items and six cognitive-behavioral items consistently loaded at a high level on overall engagement, while they had small, zero, and even negative loading for the separate components. Table 1 shows in bold the three items that were consistently strong for the affective factor (3, 4, and 5). These items emphasized the absence of negative emotions. Table 1 shows in italics the five items that were consistently strong for the cognitive-behavioral factor (7, 8, 9, 14, and 15). These items include meaning-making through interaction with learning material (e.g., "tried out my ideas") or through social interaction (e.g., "I asked questions or talked with…"), rather than effortful self-regulation elements found in the remaining cognitive-behavioral items. These item-specific patterns provide insight into the understanding that overall engagement is not the simple sum of its components. Across the board, overall engagement involved more elements than did the component factors.

3.3.5. Structural equation modeling: Reciprocal relations of motivation and engagement

To investigate the reciprocal relations between motivation and engagement, a structural equation model using MPlus was fit to the data using a mean factor score across all six days. Factor scores from the bifactor model estimation for each specific factor (behavioral-cognitive and affective) as well as the overall engagement factor were used. Time 3 motivation was regressed on engagement, which was regressed on Time 1 motivation (see Fig. 9). Motivation at Time 3 was regressed on Time 1 to control for Time 1 motivation, even though those direct links are not shown in the Figure. Because all of the direct links were included in the model, the model had good fit (χ^2 (6) = 44.82, $p < .001$, RMSEA = .08, SRMR = .01, CFI = .98, TLI = .91). Mastery goal orientations at the beginning of the school year were positively related to affective engagement while self-efficacy at the beginning of the school year were negatively related to affective engagement. The overall engagement factor was positively related to all forms of motivation at the end of the school year.

4. Study 2

4.1. Method

In this second study, our goal was to investigate whether the nature of engagement was similarly multidimensional in informal learning settings (Multidimensional Hypothesis), and whether it was also structurally similar across different informal activities (Consistency Hypothesis). Informal learning environments, such as museums are often quite different from the school context. Some of these differences include: children have more autonomy over their activities, there is less explicit focus on learning outcomes, and the overall novelty of the experience is higher. Such a large difference in learning context could influence the nature of engagement with activities. For this study, we used the same measure of engagement and analysis plan in a museum setting across two different types of activities often found in science museums: an interactive exhibition related to engineering and a fact-based exhibition related to dinosaurs. Although motivation levels are again measured before and after the museum visit, long-lasting changes in motivation are not expected from such a short intervention. The lack of changes from engagement to post-motivation helps to rule out 3rd variable confounds for the observed engagement to post-motivation changes in Study 1. This involved studying engagement during a much larger intervention (i.e., four months of instruction).

4.1.1. Participants

For this study, we examined data from an informal (museum) setting in a different region in the US; part of the ALES11 dataset. 253 fifth grade students from four California Bay Area schools visited the Lawrence Hall of Science museum for a field trip (46% female, Mean age = 10.4, *SD* = .74). Ethnicity varied somewhat from the previous study with most students being Hispanic (30%), followed by Caucasian students (29%), African-American students (7%), Asian students (3%), Native American students (1%), and Indian students (1%). Nine percent of students did not know their race and 20% did not report their race.

4.1.2. Description of museum exhibits

Participants visited two museum exhibits that had different levels and types of interactivity. One exhibition hall (referred to in this paper as *Engineering*) featured a variety of design challenges and other activities, including car, bridge, and parachute design and testing stations. This collection of activities has an emphasis on participation in the engineering design process to solve a variety of challenges. The other exhibition hall (referred to in this paper as *Dinosaur*) featured a traveling exhibition with animatronic dinosaurs, extensive labels, and a

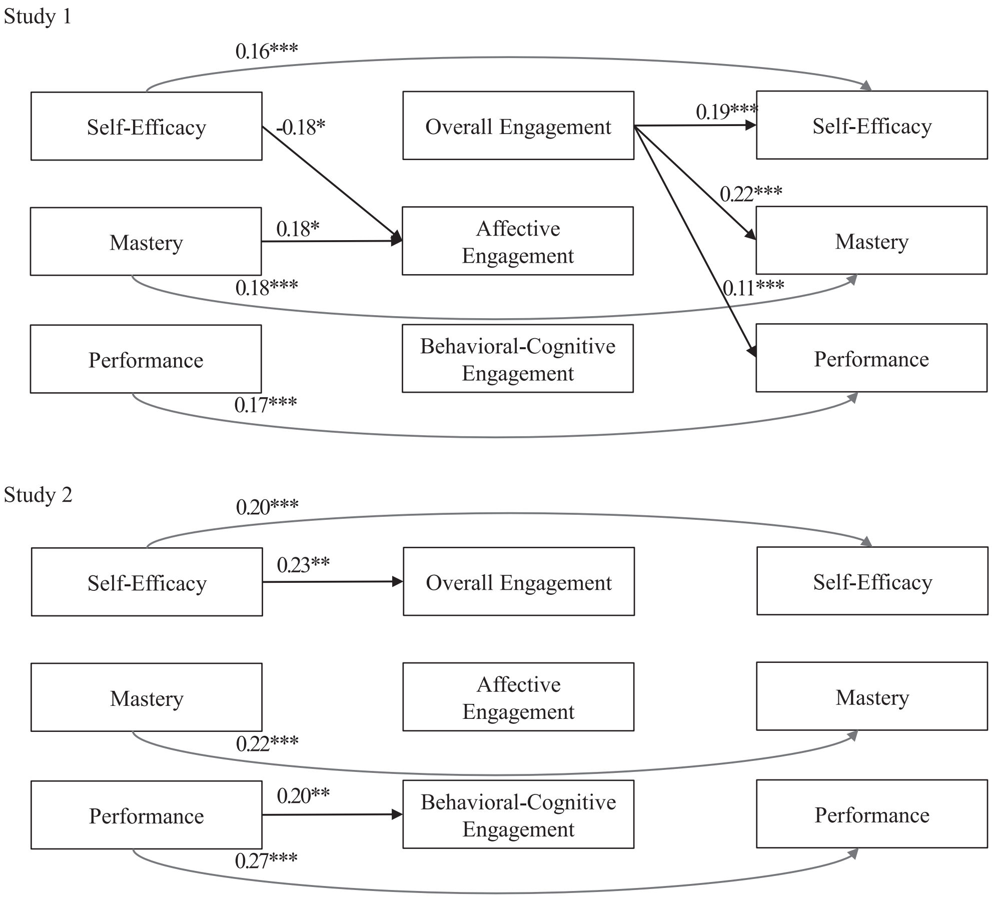

Fig. 9. For Study 1 (top) and Study 2 (bottom), structural equation models for Time 1 motivation (self-efficacy, mastery goal orientations, and performance goal orientations) predicting affective, behavioral-cognitive engagement and the overall engagement factor, which are related to Time 3 motivation (self-efficacy, mastery goal orientations, and performance goal orientations). Only significant paths are presented.

variety of fossils and other objects. This exhibit has an emphasis on learning information about a content area (dinosaurs). After visiting each exhibit hall for 30 min, students completed the same Activity Engagement Survey used in Study 1 about their level of engagement in the exhibit.

4.1.3. *Measures*

4.1.3.1. Engagement. The same Activity Engagement Survey was used as in Study 1. The survey was administered immediately following participation in each museum exhibit separately. Participants were asked to answer questions about the specific exhibition activities they had just taken part in. The reliabilities for the museum exhibits were within acceptable range, though the test-retest of these reliabilities was slightly lower than for the in-class activities. Given that the reliabilities in Study 1 for affective engagement was acceptable across six measurements and the reliability for overall engagement was high across both studies, we interpreted the Study 2 reliability levels as acceptable (Clark & Watson, 1995). The lower reliabilities for Study 2 was not surprising as the museum activities had different domains of science (engineering and palenontology) whereas the class activities were all about one domain (earth sciences), and we understand that topic plays a large role in shaping student interest (Bathgate, Schunn, & Correnti , 2014), which in turn influences engagement.

4.1.3.2. Motivation. The same *Achievement Goals Survey* was used as in Study 1. Reliabilities were acceptable-high for the mastery goals (α_{T1} = .81; α_{T3} = .88), and performance-approach goal orientations (α_{T1} = .73; α_{T3} = .84). The same self-efficacy was used as in Study 1. Reliabilities were acceptable-high for self-efficacy (α_{T1} = .80; α_{T3} = .74). Because we were interested in conducting a Structural Equation Model (SEM) to investigate reciprocal relations for motivation predicting engagement, we ran a CFA for all three scales together. Model fit for the three motivational variables was good for Time 1 (χ^2 = 139.95, p < .001; TLI = .97; CFI = .98; RMSEA = .08; SRMR = .02) and Time 3 (χ^2 = 189.65, p < .001; TLI = .93; CFI = .95; RMSEA = .09; SRMR = .06).

4.2. *Data preparation and analysis plan*

The analysis plan for this study was the same as for Study 1. We also employed EFAs prior to running the CFAs. Similar to Study 1, we found that Item 18 (I pretended…) was inconsistent across the factor structures for the two museum exhibits, so it was omitted from all model analyses in this study as well.

4.2.1. *Confirmatory factor analyses: Model testing*

The same seven models tested in Study 1 were tested separately for each museum activity (see Figs. 2–5). Model fit statistics were again compared to determine the best-fitting model.

4.2.2. *Aggregate scores*

Aggregate factor scores from the final model bifactor model and a basic mean were calculated and compared in the same way for Study 2 as in Study 1.

4.3. *Results*

4.3.1. *Confirmatory factor analysis*

As with Study 1, we found that with a different group of participants and across two exhibits in a museum setting, similar patterns were observed in the analyses, supporting the Consistency Hypothesis. Table 5 presents fit statistics for all CFA models across the two museum

Table 5
Study 2 fit indices for the unidimensional, second-order and bifactor models.

Model[a]	Day	Chi-Square[b]	df	RMSEA	CFI	TLI
Unidimensional Model	Dinosaur	362.32	119	0.09	0.84	0.82
	Engineering	328.45	119	0.08	0.87	0.85
Second-Order Model A-B-C	Dinosaur	301.77	116	0.08	0.88	0.86
	Engineering	303.79	116	0.08	0.88	0.86
Second-Order Model A-BC[c]	Dinosaur	307.04	118	0.08	0.88	0.86
	Engineering	305.31	118	0.08	0.88	0.86
Bifactor Model A-B-C	Dinosaur	180.62	102	0.06	0.95	0.93
	Engineering	Model did not produce factor scores				
Bifactor Model A-BC	Dinosaur	351.48	102	0.07	0.95	0.94
	Engineering	146.11	102	0.04	0.97	0.96

[a] The Correlated Traits Models did not produce factor scores for any of the days, therefore fit indices are not presented.

[b] All Chi-Square models were significant at the $p < .001$ level.

[c] Equal variance was specified for this model.

experiences. Second-Order Model A-BC (Fig. 3) and Bifactor Model A-BC (Fig. 4) were the only models that produced factor scores across both museum experiences. In addition to the two models that produced factor scores for both experiences, Second-Order Model A-B-C produced factor scores for the Dinosaur museum experience while Unidimensional Model also produced factor scores for the Engineering museum experience.

In comparing the model fit indices for the two models; Bifactor Model A-BC was clearly a better fit across all available indices of model fit for both museum experiences. Again, this model represented the affective and combined behavioral-cognitive components and the overall engagement factor in a bifactor CFA. Like the 6th graders from Study 1, children in 5th grade may not be adept at separating behaviors from cognitions, or these science learning environments might support coherent cognitive-behavioral interactions.

4.3.2. Comparison of mean and factor aggregate scores

Overall, we found that the calculated mean engagement score and overall engagement score calculated from the bifactor model were highly correlated, $r = .94$ (see Fig. 7). Again, correlations between the calculated mean scores for the emotional and behavioral-cognitive specific factors and the resulting factor scores from the estimation of the bifactor model were rather low. Correlations for the affective engagement factor and mean score were .24 and .71 while the correlations for the behavioral-cognitive engagement factor and mean were even lower, −.11 to .45. In both cases, the Dinosaur experience resulted in higher correlations.

4.3.3. Comparison of engagement across activities

Similar to by-day analyses within Study 1, we also investigated whether there were any differences in scores across the two museum exhibits. Overall, there were small differences between exhibits when comparing engagement levels within participants using repeated measures, mainly with the behavior-cognitive engagement factor component (F (1, 250) = 5.04, $p = .026$). Mean scores across the activities differed slightly for the overall engagement mean scores (F (1, 249) = 10.44, $p = .001$) and the cognitive (F (1, 249) = 14.80, $p < .001$) and behavioral-cognitive (F (1, 249) = 12.32, $p = .001$) mean scores, but not for affective or behavioral mean scores. Thus, this multidimensional approach was able to localize engagement differences between activities to a subdimension, even when the overall effects were small. That the main effects of activity type across all children were small is likely due to the large individual topic preferences, as suggested by the quite low correlations between engagement levels across activities.

4.3.4. Consistency and differences in components and overall engagement loadings

As in Study 1, there were clear differences between loadings on component factors and overall engagement, explaining why the bifactor model provided a better fit to the data. For affective items, once again, the absence of negative items was dominant aspect of the affective engagement scale. However, two of these items (negative emotions) had essentially zero loading for overall engagement (items 3 and 4). It may be that frustration or tiredness are not deterrents of behavioral-cognitive engagement in the highly social museum context. For behavioral-cognitive engagement, most of the same items dropped out of the component scale for both exhibits (items 10, 11, 12, 13, and 16). However, items 6 and 17 were inconsistent in that they did not drop out for the Engineering exhibit, which may relate to the difficulty of the engineering exhibit requiring more aspects to support behavioral-cognitive engagement. However, in general the same pattern was generally found that overall engagement involved more aspects than the component factors.

4.3.5. Structural equation modeling: Reciprocal relations of motivation and engagement

To investigate the reciprocal relations between motivation and engagement, a structural equation model using MPlus was fit to the data. As in Study 1, a mean across both exhibit-specific factor scores resulting from the bifactor model estimation was used, Time 3 motivation was regressed on engagement, which was regressed on Time 1 motivation (see Fig. 9). Motivation at Time 3 was regressed on Time 1 to control for motivation direct effects. This model had good fit (χ^2 (6) = 5.99, $p = .425$, RMSEA = 0, SRMR = .01, CFI = 1.00, TLI = 1.00). As seen in Fig. 9, self-efficacy at Time 1 was positively related with overall engagement while performance-approach goal orientations were positively related to behavioral-cognitive engagement. Engagement was not related to any of the motivation constructs at Time 3, as would be expected from the relatively brief nature of the museum visit.

5. Discussion

The aim of the current study was to investigate the dimensional structure of engagement and its consistency across activities and contexts. First, we were interested in investigating the multidimensional nature of engagement during a learning *activity*. To this end, we adopted a process-oriented view of engagement with a focus on the affective, behavioral, and cognitive dimensions. We examined this multifaceted nature of engagement across two different settings (school & museum) with two different groups of participants (Study 1 & Study 2) across eight different activities (six in school and two in a museum). Even with additional age, ethnic and geographical differences across settings, the analyses point to consistency in the overall nature of engagement, though there were slight contextual differences in the nuances of engagement across formal and informal learning settings at the item level. Taken together, our findings lend support to the notion that engagement is multifaceted (Multidimensionality Hypothesis) and partial support to engagement structural consistency (Consistency Hypothesis) in a particular bifactor way. Importantly, this study provides positive evidence that affect is a part of engagement – if it were not, the affect items would not load on the overall factor or on the unidimensional factor.

A second aim of the study was to investigate the reciprocal relations between motivation and engagement, to further validate this conceptualization of engagement. In formal learning contexts, positive reciprocal relations were found between motivation and engagement, though no mediation was found. Self-efficacy was negatively related and mastery goal orientations were positively related to affective engagement, and overall engagement was related to all forms of motivation measures midway through the school year. In informal learning contexts, self-efficacy and performance-approach goal orientations were positively related to overall engagement and behavioral-cognitive engagement, respectively. However, activity engagement was not related to motivation after the museum visit. This is not surprising, as it is implausible that long-lasting motivation changes would result from a short museum visit.

5.1. Situating & defining engagement

In the recent Handbook on Engagement (Christenson et al., 2012; Eccles & Wang, 2012; also see Fredricks et al., 2011), there was a charge to better define and situate student engagement. In line with the notion that research should situate the learner within specific settings (Brown, Collins, & Duguid, 1989; Schutz, Hong, Cross, & Osbon, 2006), we situated learners in specific learning activities in formal and informal learning situations (Valentine et al., 2002). We set out to investigate engagement across settings, exploring whether engagement during different learning activities situated in different learning contexts (both in and out of school) includes affective, behavioral, and cognitive facets. Thus, we had to clearly define engagement during learning, but not necessarily in school or academic settings as has been done in previous work on engagement (Carini et al., 2006; Christenson et al., 2012; Corno & Mandinach, 1983, 2004; Eccles & Wang, 2012; Finn & Voelkl, 1993; Finn et al., 1995; Fredricks et al., 2004, 2011; Gonida et al., 2007; Greene et al., 2004; Ladd & Dinella, 2009; Linnenbrink, 2007; Meece et al., 1988; Nystrand & Gamoran, 1991; Reeve & Tseng, 2011). We therefore focused on process-oriented engagement during an activity (Nystrand & Gamoran, 1991) by examining engagement in different types of activities across these two contexts.

As a first step, we considered that engagement processes are different from, though produced, by motivation. We also argued that the types of cognitive strategies used during the activity need to match the learning scaffolded by that activity. Accordingly, in contrast to prior research (Corno & Mandinach, 1983, 2004; Martin, 2008; Reeve & Tseng, 2011; Winne & Hadwin, 1989), we did not assume that elaborative self-regulated learning strategies are always preferable and indicative of higher engagement. To this end, we were interested in identifying engagement processes that are not necessarily motivational or regulatory in nature, though could result from motivation and encompass forms of self-regulated learning. Thus, in considering how engagement occurs across contexts, we adopted a multifaceted perspective (Fredricks et al., 2004; Fredricks et al., 2011) and clearly defined affective, behavioral, and cognitive engagement as a dyadic process stemming from the learner-activity interaction. Indicators that tap into the social relationships that scaffold learning, such as connectedness with teachers or peers (e.g., Appleton, 2012; Darr, 2012; Finn & Voelkl, 1993), were thought to be antecedents of engagement. Similarly, indicators that tap into intentions, value/utility, or reasons for engagement (e.g., Darr, 2012) were categorized as motivational and also omitted from our conceptualization and measure of engagement. As a result, we identified affective, behavioral, and cognitive forms of engagement that occur regardless of the specific learning strategies employed, and can be compared across learning activities and a variety of contexts. However, more research is needed to examine whether engagement, as conceptualized in the current study, mediates the relations between motivation and learning.

5.2. Multidimensional structure of engagement

In line with our Multidimensional Hypothesis, our findings consistently supported the notion that engagement is comprised of multiple facets, though somewhat differently than we hypothesized. More specifically, we found that overall engagement, affective and behavioral-cognitive engagement components, contribute to overall scores as determined by a series of factor analyses. While past work has investigated these facets of engagement (Assor et al., 2002; Carini et al., 2006; Christenson et al., 2012; Corno & Mandinach, 1983, 2004; Eccles & Wang, 2012; Finn et al., 1995; Fredricks et al., 2004, 2011; Gonida et al., 2007; Greene et al., 2004; Ladd & Dinella, 2009; Ladd et al., 2009; Meece et al., 1988; Nystrand & Gamoran, 1991), the combination of all three in one study, across activities and contexts with two different age-groups of participants, is an innovative extension of previous work and furthers our understanding and definition of engagement.

Especially noteworthy is the finding that behavioral and cognitive dimensions were highly correlated within this young population. Future research should investigate whether the high correlation between behavioral and cognitive engagement is specific to self-report measures used with younger age groups, such as in our sample of fifth and sixth graders, or whether it is the phenomenological nature of engagement. It could be that for fifth and sixth graders, it is especially difficult to self-inquire and detect the fine line between behaviors and cognitions (Reich, Oser, & Valentin, 1994; Schommer, Calvert, Gariglietti, & Bajaj, 1997).

Fifth and sixth graders might answer a question about *thinking* during an activity with a behavioral response “I was doing that.” In doing so, children might consider the act of thinking as a behavior that is done. In this sense, a fifth or sixth grader may not have the metacognition to recognize that cognitions are “performed” internally and can therefore be differentiated from more externally observable behaviors, such as gazing or trying to build things (Pintrich & Zusho, 2002). It is likely that older age groups would be better able to differentiate between behavioral and cognitive states, as the ability to reason and think becomes increasingly more sophisticated in adolescence and thereafter (Reich et al., 1994; Schommer et al., 1997). In the years that follow sixth grade, a multitude of developmental changes occur that likely facilitate the ability to distinguish between behaviors and cognitions as they pertain to learning (Larson, 2011; Pintrich & Zusho, 2002). That is, the combination of behavioral and cognitive engagement could be a result of an inability to articulate or distinguish these differences at this developmental age, rather than representing a lack of separation of these facets across all ages (Larson, 2011; Pintrich & Zusho, 2002; Reich et al., 1994; Schommer et al., 1997). Another reason for the behavioral-cognitive combination could be the science tasks themselves. The behavioral-cognitive coupling could rest in the environment as science tasks are often designed so that the behaviors support cognitions such as information acquisition and understanding.

Thus, there is utility in using our survey to investigate how behavioral and cognitive engagement, in addition to affective engagement, are related to learning outcomes and how they emerge as different constructs throughout development. While it makes sense for practitioners to consider a combined form of behavioral and cognitive engagement for evaluative purposes (especially with younger populations) to better understand engagement development, researchers could use separate scores for the components of engagement. Considering behavioral and cognitive engagement as separate dimensions could enable researchers to disentangle how development influences a learner’s ability to distinguish behavioral engagement from cognitive and affective engagement within learning activities.

Another explanation for the high correlations between the behavioral and cognitive engagement factors could be the interpretation of behaviors to indicate cognitions. The assumption that internal states can be presumed from behaviors has been long debated in psychological research and the learning sciences as “behavioral traces” (Winne & Hadwin, 1998). In contrast, Posner suggested that eye gaze does not necessarily indicate attention (Posner, 1980). For example, one could seem to be intently looking at something while actually daydreaming. In this way, behaviors and body language may not be indicative of internal states. In fact, one of the challenges in observing engagement is that cognitions are deduced based on behaviors. There is therefore value in developing a questionnaire such as that reported on in this study: self-reports may circumvent the interpretation of observable behaviors as learners directly report on their cognitions, behaviors, and emotions. Conceptually, in science activities, thinking and behaving often go in tandem. Students need to think in order to complete the tasks, and the activities facilitate thinking. Thus, for science, it might be less surprising to see such close connection between cognitive and behavioral engagement.

Interestingly, our data across both school and museum settings lend support to the Multidimensionality Hypothesis. Namely, overall engagement is comprised of affective, behavioral and cognitive components that need to be considered when measuring and conceptualizing engagement (Fredricks et al., 2004). At the same time, the sum of these engagement components may comprise a more holistic overall construct, as suggested by the bifactor model. Engagement contains both unidimensional and multidimensional latent structures encompassing diverse features whereby the whole of engagement is conceptually and empirically different from the simple sum of its parts. This multifaceted nature in a particular form was consistently observed across eight different science activities, supporting our Consistency Hypothesis as well.

5.3. *Consistency of engagement*

Our second goal was to examine the dimensional consistency of activity engagement over a variety of activities within school and museum settings. We were interested in whether the multifaceted nature of engagement changes over time and context across eight separate measurements of activities. Overall, we found that the multifaceted structure of engagement is consistent at the high-level of general structure, but somewhat variable at the item level based on context. That is, the high-level structural consistency is context-independent across science activities in schools and museums. Further, even though some factor loadings vary across activities (looking at the overall factor and the factor loadings and patterns of significance) the items show a similar trend, especially within context. The items consistently loaded in a similar way on the overall engagement and components for formal learning (Study 1). In the museum setting (Study 2), there was consistency across exhibits and the overall pattern was similar to Study 1. The most apparent difference between contexts was related to the affective items. The item related to positive deactivated emotions (relaxed/calm) had lower loading on the component, and items with negative affect (frustrated/annoyed and tired/sad) had low, zero, or negative loading on the overall engagement factor in Study 2. More work is needed to understand how, why, and whether it matters that emotions have slightly different patterns across learning contexts.

However, the findings that the items had slightly different factor loadings across activities warrant the use of more sophisticated analytic techniques to further investigate the psychometric properties of the survey. Further examination across multiple age groups could reveal that, with development of more precise recognition of internal states, individuals distinguish engagement behaviors and cognitions. More research is needed across a broader set of activities (e.g., purely child-directed activities like reading a dinosaur book at home or extended, designed out-of-school learning activities like a science camp) and other ages (both older and younger) to replicate that the multi-components of engagement is consistent. Finding further separation across dimensions at later ages would lend additional support to the Multidimensional Hypothesis of engagement, though call into question the Consistency Hypothesis across development.

Our current assessment was contextualized in science learning activities, leaving an open question of whether, and to what degree, the structure of engagement and overall student engagement varies by topic[1]. Bong (2004, 2005) found similar structures of self-efficacy and achievement goals across different topics. However, given the different sorts of activities across various subject areas (e.g., mathematics vs. visual arts vs. sports), the case with engagement could be different and more empirical investigations are needed. In addition, recent work suggests that one's preference for a course or task influences achievement processes such as motivation, self-regulation and engagement (Ben-Eliyahu, 2012; Ben-Eliyahu & Linnenbrink-Garcia, 2013, 2015; Fulmer, D'Mello, Strain, & Graesser, 2015). It may be that engagement is influenced by one's affinity towards a topic or activity. For instance, adolescents who love science might be emotionally, behaviorally, and cognitively engaged, whereas those who are indifferent to it are behaviorally and cognitively engaged but uninvolved emotionally. This could also explain the distinction between the affective and behavioral-cognitive facets of engagement. That is, affective engagement might be more fluid and individualized while behavioral and cognitive engagement are more activity-specific. However, making conceptual connections at an early stage can interfere with acquisition of correct knowledge and result in connecting or elaborating across contexts or phenomena in a way that leads to misconceptions that are later difficult to correct (Akbas & Gencturk, 2011; Posner, Strike, Hewson, & Gertzog, 1982).

6. Conclusion

The current study has both theoretical and practical implications. On a theoretical level, it is important to investigate how engagement, separate from motivation and self-regulation, functions within learning activities. We propose that measures of engagement focused on school and class attendance and conduct (e.g., Assor et al., 2002) should be precursors for on-task engagement. In this way, being physically present would function in a similar way as motivation and social support as it is thought to produce engagement. The nuanced processes captured in this study during activities have yet to be unpacked across a variety of learning settings. Furthermore, the multifaceted consistency across days, activities, contexts, age and participant groups suggest that the Activity Engagement Survey comprised for this study is quite useful. Computing both an overall engagement score and more specific affective, separate or combined behavioral and cognitive engagement scores could be done with simple means. Additionally, the structure of engagement needs to be investigated in older populations. While there seems to be a consensus that engagement in school and classroom settings are crucial for learning, most of the research on engagement has focused on antecedents to engagement such as classroom context, interest and teacher's autonomy support (Assor et al., 2002; Fredricks et al., 2004). The field is thus challenged to further examine how engagement leads to learning. The current study has set forth a survey tool that demonstrated its potential utility broadly to measure engagement across a multitude of settings and activities.

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[1] Because of this unanswered question in combination with the structure of the data collected during this study, a measurement invariant study was not undertaken. Any results from a study of this type would be difficult to interpret given the number of simultaneous comparisons required and the fact that each data set represented a different activity or a different activity and context rather than the data typically collected for an invariance study. This study illuminates convergent and divergent patterns across activities and contexts that strongly support the high level structural consistency while also revealing variability at the item level that can be the focus of future research.

Appendix A. Survey items for achievement goals and self-efficacy

Mastery goal orientations

1. I want to learn as much as possible about science.
2. I desire to fully understand and know science material.
3. It is important for me to understand science content.

Performance-approach goal orientations

1. When I work on science, I want others to think that I am:
    4 = The smartest
    3 = smarter than most of my peers
    2 = average
    1 = I don't care what others think of me
2. When I work on science, I want to appear:
    4 = More skilled than everyone
    3 = More skilled than most
    2 = Just as skilled as everyone else
    1 = I don't care how skilled people think I am
3. In science class, I want to make sure I get:
    4 = the highest grade
    3 = a high grade
    2 = just an average grade
    1 = I do not worry about my grades

Self-efficacy
I think I am pretty good at:

1. Science
2. Coming up with questions about science
3. Designing experiments
4. Finding evidence for my ideas
5. Figuring out why things happen
6. Doing experiments
7. Figuring out how to fix a science activity that didn’t work

Because there were high correlations between the behavioral and cognitive dimensions of engagement consistently across all days/activities (see Fig. 6), we examined models that had separate behavioral and cognitive dimensions, as well as a combined behavioral-cognitive dimension.

Appendix B

Table with Pearson correlations of engagement scores across pairs of observations for factors scores and means. Details of Fig. 6

	Overall factor	Affect factor	Beh-Cog factor	Overall mean	Affect mean	Behavior mean	Cognitive mean	Beh-Cog mean
Day1-Day2	.66	.48	.40	.65	.51	.59	.57	.66
Day1-Day3	.55	.41	.41	.54	.45	.51	.45	.54
Day1-Day4	.56	.47	.34	.58	.52	.53	.44	.56
Day1-Day5	.45	.39	.36	.48	.41	.46	.38	.48
Day1-Day6	.54	.40	.34	.55	.44	.48	.47	.54
Day2-Day3	.61	.44	.56	.65	.51	.61	.55	.66
Day2-Day4	.52	.49	.42	.53	.45	.54	.45	.55
Day2-Day5	.44	.42	.43	.47	.41	.49	.42	.50
Day2-Day6	.53	.49	.50	.52	.44	.57	.44	.54
Day3-Day4	.53	.46	.40	.55	.52	.50	.46	.53
Day3-Day5	.48	.48	.45	.50	.51	.48	.38	.48
Day3-Day6	.50	.49	.44	.47	.44	.51	.36	.49
Day4-Day5	.73	.54	.56	.73	.59	.71	.63	.74
Day4-Day6	.64	.52	.50	.64	.49	.70	.51	.66
Day5-Day6	.67	.63	.62	.67	.58	.70	.58	.70
Dino-Eng	.56	.01 ns	−.11 ns	.59	.32	.53	.59	.63

Note: All correlations are significant at the $p < .001$, except for affect factor for dino-eng and beh-cog factor for dino-eng, which have ns.

Appendix C

Factor loadings
Table: Factor loadings on each day and exhibit based on the Bifactor Model.
All factor loadings are significant at the p < .001, except for ˆ p < .05 and ~ = nonsignificant.

Item	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Dinosaur		Engineer	
	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog	Affect	Behav-Cog
1	.34		.31		.28		.32		.29		.14ˆ		.34		.27ˆ	
2	.21		.28		.15ˆ		.19		.25		.28		−.13ˆ		−.05~	
3	.43		.52		.68		.58		.66		.71		.77		.63	
4	.63		.74		.76		.68		.83		.79		.84		.74	
5	.66		.60		.61		.68		.63		.61		.75		.88	
6		−.07~		.16ˆ		.13ˆ		−.03~		.05~		.19ˆ		.16~		.59
7		.41		.62		.51		.42		.49		.64		.41		.70
8		.38		.51		.58		.40		.44		.52		.59		.45
9		.24		.33		.39		.16		.34		.44		.52		.48
10		−.41		−.21ˆ		−.31		−.58		−.37		−.25		−.24~		.27ˆ
11		−.35		−.30~		−.37		−.61		−.53		−.40		−.26~		.09~
12		.20~		.41		.43		.19ˆ		.34		.46		.26ˆ		.26ˆ
13		−.01~		.05~		−.01~		−.16ˆ		−.14ˆ		−.01~		.24~		.13~
14		.39		.55		.42		.41		.44		.60		.24ˆ		.61
15		.40		.70		.36		.36		.44		.65		.20~		.51
16		.01~		.18ˆ		.22ˆ		−.06ˆ		.11~		.20ˆ		.14~		.43ˆ
17		.04~		.19ˆ		−.01~		.08ˆ		.06~		.19ˆ		−.01~		.39

Item	Day 1 Overall Engagement Factor	Day 2 Overall Engagement Factor	Day 3 Overall Engagement Factor	Day 4 Overall Engagement Factor	Day 5 Overall Engagement Factor	Day 6 Overall Engagement Factor	Dinosaur Overall Engagement Factor	Engineer Overall Engagement Factor
1	.57	.66	.69	.67	.66	.75	.53	.75
2	.47	.53	.50	.48	.41	.55	.39	.55
3	.27	.32	.26	.24	.18	.29	−.03~	−.10~
4	.24	.31	.29	.30	.24	.33	.17~	−.03~
5	.46	.51	.54	.50	.50	.51	.39	.44
6	.67	.62	.70	.65	.65	.71	.58	.44
7	.62	.50	.68	.63	.67	.55	.57	.46
8	.53	.50	.54	.57	.60	.60	.47	.47
9	.57	.60	.59	.64	.63	.60	.64	.55
10	.77	.85	.82	.69	.82	.79	.79	.78
11	.70	.83	.81	.63	.70	.80	.60	.68
12	.47	.43	.46	.58	.58	.52	.54	.53
13	.77	.81	.83	.76	.79	.79	.71	.88
14	.56	.51	.53	.62	.64	.52	.64	.40
15	.51	.41	.65	.59	.56	.47	.61	.43
16	.53	.64	.52	.54	.61	.61	.62	.39ˆ
17	.65	.64	.69	.67	.73	.66	.66	.29ˆ

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