Research Article

Families Support Their Children's Success in Science Learning by Influencing Interest and Self-Efficacy

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Abstract: How is a child's successful participation in science learning shaped by their family's support? We focus on the critical time period of early adolescents, testing (i) whether the child's perception of family support is important for both choice preferences to participate in optional learning experiences and engagement during science learning, and (ii) whether the effects on choice preferences and engagement are mediated through effects on child interest and self-efficacy in science. Structural equation modeling is applied to data from two different contexts, one examining engagement during a science and technology center visit and the other examining engagement and learning during classroom instruction. Models from both datasets suggest that early adolescents' perceived family support for learning is associated with their choices for and engagement in science learning, and that these effects are mediated by effects on child interest and self-efficacy in science. Further, children's family physical resources (e.g., available learning spaces and materials) predicts their perceived family support, but is not separately connected to either interest or self-efficacy. © 2015 Wiley Periodicals, Inc. J Res Sci Teach
Keywords: family influence; science learning; interest and self-efficacy; choice and engagement

In the US, pathways toward STEM careers weaken when students avoid advanced mathematics and science high school classes (Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Maltese & Tai, 2011). Choices to enroll and engage during such classes depend upon student motivational beliefs developed during early adolescence through school and home experiences (Simpkins, Davis-Kean, & Eccles, 2006).

Students' motivation to learn science often declines around the transition to middle school (Vedder-Weiss & Fortus, 2011, 2012). As noted by Vedder-Weiss and Fortus (2012), research has primarily investigated the role of classroom environments in producing this decline. Lee and Shute (2010) called for research exploring the role of factors related to the family (e.g., parental education, parents' involvement) in fostering children's motivation, learning behaviors, and achievement.

The larger issue of environment factors, motivation, and learning outcomes involves two distinct strands of prior research. First, there is the relationship between individuals' motivational beliefs (e.g., interest, self-efficacy, values) and their learning behaviors and achievement (Baram-Tsabari & Yarden, 2009; Koballa & Glym, 2007; Pintrich, 2003; Schunk, Pintrich, & Meece, 2008), examined primarily by motivation and science education researchers. Second, there is the

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large body of studies on the influences of children's family on their academic engagement, or achievement (see, Cheung & Pomerantz, 2012; Fan, Williams, & Wolters, 2012; Grolnick & Slowiaczek, 1994; Hill & Taylor, 2004; Pomerantz, Moorman, & Litwack, 2007; Raftery, Grolnick, & Flamm, 2012; Urdan, Solek, & Schoenfelder, 2007; Fortus & Vedder-Weiss, 2014; Wentzel, 1998, 1999), produced by researchers in the fields of educational and developmental psychology.

In recent years, some research has combined the two strands, exploring whether the effects of family background on students' academic engagement and achievement are mediated through effects on motivational beliefs (Friedel, Cortina, Turner, & Midgley, 2007; Gonida, Voulala, & Kiosseoglou, 2009; Vedder-Weiss & Fortus, 2013). For example, Gonida et al. (2009) found that early adolescents' perceptions of their parents' goals influenced classroom engagement (not specific to science) because of effects on student general achievement goal orientations. Within science education, Vedder-Weiss and Fortus (2013) found that early adolescents' perceived parent, peer, school, and teacher goal orientations influenced their in- and out-of-school engagement via effects on their own goal orientations.

However, this one prior study connecting family factors to motivation and learning in a science context (Vedder-Weiss & Fortus, 2013) was preliminary in that it only has one family-related variable, one mediating motivational variable, and one outcome variable. It is likely that a broader look is required. First, family influence on children's achievement motivation and learning behaviors may also be connected to parents' actions (e.g., engaging in children's learning activities) and material resources (e.g., providing study space at home), rather than just parental beliefs. Second, as detailed in the subsequent section, motivation is multi-faceted. Other than goal orientations, students' self-efficacy and interest play an important role in learning behaviors and achievement, and the family environment might influence these motivational factors. Third, motivational factors can influence both decisions to engage in optional learning experiences and the ways of engagement with learning experiences. Each can influence overall learning outcomes and each may be driven by different motivational factors. Based on these, the current study examined: (i) parental factors other than parental goal orientations; (ii) the roles of influential motivational beliefs other than just goal orientations; and (iii) effects on both choice preferences and engagement.

Theoretical Framework

Past research suggests an empirical relationship between parental involvement and child motivation to learn in school. However, what are the theoretical underpinnings for this relationship? From a developmental psychology perspective, child-parent relationships function as a key context for all psychological development, including the development of academic motivation and achievement (Pomerantz, Cheung, & Qin, 2012).

There are two theoretical traditions in educational and developmental psychology that frame the relationship between parental involvement and children's motivation (Pomerantz et al., 2012). First, according to attachment theory (Bowlby, 1969, 1973), when children are securely attached to their parents in the early years, they will be better able to explore their environment and are more cognitively capable. A secure attachment to parents allows the child to develop an internal model of the self that is worthy of love and important to parents. Feeling special and important to parents has been found to activate learner behaviors such as effort, persistence, as well as to stimulate positive emotions such as interest and enthusiasm (Furrer & Skinner, 2003). Viewing oneself as worthy of love may also develop one's perception of competence in exploring the world (e.g., high self-efficacy in learning science).

Second, research on self-determination theory (Furrer & Skinner, 2003; Grolnick, Deci, & Ryan, 1997; Pomerantz et al., 2012) suggests that parental involvement influences children's academic learning by enhancing children's sense of relatedness to their parents. In self-determination theory (Deci & Ryan, 2000), relatedness is one of three basic psychological needs; when basic needs are met in a learning process, learners' intrinsic motivation to learn will be enhanced. In general, feelings of relatedness to others is fundamental to human functioning, and for most human beings, their relationships with parents and other family members are their first experience with relatedness (Furrer & Skinner, 2003; Pomerantz et al., 2012). Past research suggests that students' feeling of relatedness to their parents may play a role in linking parental involvement to children's academic motivation and achievement (Furrer & Skinner, 2003).

Choice Preferences and Engagement–Motivational Outcomes

Motivational researchers distinguish motivational beliefs (e.g., self-efficacy) and motivated behaviors (e.g., choices, engagement; Schunk et al., 2008; Ainley, 2012). We focus on two kinds of motivated behaviors that are highlighted in social cognitive theory (Bandura, 2001): proactively making academic choices and actively engaging during learning. Both are thought to be important in terms of leading to high learning achievement.

In daily life, children are given a diverse array of choices in- or out-of-school that can involve science content or other (non-science) content: taking optional science courses, participating in after-school science or art clubs, reading books about science or history, experimenting at home with science kits or perhaps cooking or woodwork. Choice availability, peers, and adults also influence what ultimate choices are made, but children do influence these choices, especially as they get older. The child's role in the decision making can be described as their *choice preference.* Together all the small choices can cumulate to have a large influence on later knowledge and skills in science (Katz & Assor, 2007; Patall, 2013). We define science choice preference as the extent to which children prefer a science-related choice when given both science-related and non-science related alternative options (i.e., a psychological tendency towards a topical choice; Sha, Schunn, & Bathgate, in press).

Engagement, broadly conceptualized as one's involvement, focus, participation, and persistence on a task, is also thought to be important to learning (Carini, Kuh, & Klein, 2006; Fredricks, Blumenfeld, & Paris, 2004; Fredricks et al., 2011). Engagement involves behavioral, cognitive, and emotional components. In our conceptualization, behavioral engagement refers to whether students are behaviorally active in the learning activity. Some previous research on behavioral engagement in school examined student attendance and conduct (Fredricks et al., 2011), which are important prerequisites to task engagement. Without being physically present, engagement cannot occur. However, students' behaviors can also vary in important learning-oriented ways while present in class, such as reading aloud, raising a hand, and talking to the teacher or a peer about the materials.

Cognitive engagement refers to the quantity or quality of cognitive processing as indicators of engagement. Some studies consider participation to be an indicator of cognitive engagement, while other studies take a more process-oriented approach and differentiate levels of cognitive processes such as elaboration or re-organization (Fredricks et al., 2011). But learners paying attention and thinking about the activity might not necessarily be employing deeper cognitive processing in the form of elaboration, and some activities that require thinking and analyzing might not require re-organization. Therefore, we focused on more generally applicable productive cognitive acts for science learning: whether participants were concentrating, thinking about the activity, explaining things, and paying attention.

Emotional engagement refers to the learner's emotional reactions while learning including happiness, boredom, anxiety, and so on. Common measures of emotional engagement in learning contexts have focused on broader positive and negative reactions to academics, school, peers, and teachers (Pekrun, 2006; Pekrun & Linnenbrink-Garcia, 2012). Research suggests positive emotions about a class (e.g., enjoyment, hope, & pride) lead to higher levels of academic performance (Linnenbrink, 2007; Pekrun, Elliot, & Maier, 2009), while negative emotions can lead to lower academic performance (Linnenbrink, 2007; Pekrun et al., 2009).

If choice preferences and engagement are key motivated behaviors that produce improved science learning outcomes, what motivational beliefs produce these motivated behaviors? Research on this topic is still rare in science education.

Interest and Self-Efficacy in Science

Motivational beliefs are generally conceptualized as multi-faceted (Schunk et al., 2008), and motivational theories frequently emphasizes two kinds of beliefs: (i) people's subjective perceptions of their competences in doing a task well, called *self-efficacy beliefs* (Bandura, 1986; Schunk & Usher, 2012); and (ii) their intrinsic enjoyment or *interest* in the task or broader learning domain (Hidi & Renninger, 2006). We briefly review general conceptualizations of interest and self-efficacy, prior work on what supports their development, and research on their role in student learning and achievement in science.

In science education, interest has long been recognized as a central concept (Krapp & Prenzel, 2011). Interest is a motivational construct that refers to the liking and enjoyment from engagement in tasks as well as the desire to acquire knowledge (Hidi & Renninger, 2006). Research investigating interest in academics has defined interest as a predisposition to reengage with interesting activities, and that it has several critical components (Hidi & Renninger, 2006; Renninger & Hidi, 2011). First, interest is composed of both affective (positive emotions) and cognitive aspects (desire to learn and curiosity). Second, interest is content-specific, such as interest in science as opposed to interest in sports or history. Third, interest can be *situational* or *individual* (Hidi & Renninger, 2006). The former refers to a transient psychological state and emotional reaction triggered by environmental stimuli; the latter refers to a relatively enduring predisposition to reengage particular activities. Situational interest is already captured within our cognitive and emotional engagement construct described above. Because we are focused on understanding the effects of family factors on general choices and engagement during science learning (i.e., tendencies across diverse environments), it is the relatively enduring individual interest construct that is most relevant here.

In general motivational research, interest has been linked to students' learning behaviors and achievement by its influences on choice for and engagement during learning activities (Hidi & Renninger, 2006; Hidi & Ainley, 2008). In science education, Alexander, Johnson, and Kelley (2012) found that children's self-reported early science interests were predictors of their later participation in informal science learning (e.g., attending a science museum).

A number of factors have been found to influence interest development, including certain kinds of texts and science topics (Baram-Tsabari & Yarden, 2005, 2009), and certain kinds of activities (Palmer, 2009; Swarat, Ortony, & Revelle, 2012). However, the connection of family influence to science interest has received relatively little prior investigation and is a focus in the current study.

The second motivational variable in the current study is self-efficacy. Self-efficacy beliefs are "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Educational and psychological research has revealed that self-efficacy is often an important predictor of task choice, level of effort, and persistence (Durik, Vida, & Eccles, 2006; Linnenbrink & Pintrich, 2003; Schunk et al., 2008; Zimmerman, 2000). Further, self-efficacy has been found in various domains to be influenced by teachers, peers, and parents (Schunk et al., 2008). Although effects of self-efficacy on choices, engagement, and achievement are also evident in science (Liu, Hsieh, Cho, & Schallert, 2006; Sawtelle, Brewe, & Kramer, 2012; Zeldin, Britner, & Pajares, 2008), little is known yet about how early adolescents' science self-efficacy works together with interest in science to produce motivated behaviors (e.g., choice and engagement). Further, little is known about home factors that influence self-efficacy in science.

Family Influences on Children's Academic Motivation and Behaviors

Most research on the influence of families on children's development and academic achievement (e.g., Fan & Williams, 2010; Fan et al., 2012; Grolnick & Slowiaczek, 1994; Pomerantz, Cheung, & Qin, 2007; Wentzel, 1998, 1999) adopted a multidimensional construct of *parental involvement*: "parents' interactions with schools and with children to promote academic success" (Hill et al., 2004, p. 1491). Parental involvement can be both school-based and home-based. School-based parental involvement includes all activities in which parents participate through school, e.g., volunteering at school, participating in school governance, and communicating with teachers and other personnel. Home-based parental involvement involves diverse activities outside of school (Pomerantz et al., 2007), e.g., creating a place for children to study, helping children complete homework, course selection, taking their children to visit the library, museum or historic sites, and so on.

Both school-based and home-based parental involvement can be classified into three categories: behavioral, personal, and cognitive/intellectual (Grolnick & Slowiaczek, 1994). Behavioral involvement refers to parents' physical presences in academic activities in school or at home, such as parent-teacher contact, assisting with homework, course selection, and so on. Personal involvement refers to parents' attitudes, values, and expectations about education, future goals, and children themselves that may be conveyed to their children in their interactions. Cognitive/intellectual involvement refers to providing enrichment such as exposing one's children to education-related activities (e.g., visiting science museums).

In science education, Alexander et al.'s longitudinal study (2012) suggests that children's interest development largely relies on a parent's ability to answer science-related questions at home. But additional research is needed to examine broader connections of various forms of family support for science learning to child science interest and self-efficacy.

The multidimensional nature of parental involvement complicates its relationship with their children's academic performance and achievement in terms of strength and direction (Fan et al., 2012). Recent comprehensive reviews (Hill & Tyson, 2009; Pomerantz et al., 2007; Raftery et al., 2012) concluded that the association between parental involvement and children's engagement and achievement is positive in many cases, but, the findings of this positive relationship were not always consistent across various dimensions, and locations (school-based vs. home-based). According to Hill and Tyson's meta-analysis (2009), parental personal involvement such as communication with their children of their expectations for achievement and value for education, and behavioral involvement, such as discussing learning strategies with children, have the strongest positive relation with achievement in middle school. School-based involvement (e.g., participating in school events) is positively associated, but less strongly, with achievement. Also, they found that the effect of parents' helping with homework on achievement is mixed. Hill and Tyson (2009) supposed that the negative relation between helping with homework may be due to a number of factors such as parents' hindrance of students' autonomy or to extreme parental pressure. In other words, the associations between parental involvement and achievement are indirect, this suggests that helping with homework influences children's achievement via something else (e.g., their psychological outcomes of parental involvement) and overall the associations between parental involvement and achievement are indirect. This raises the question, what are mechanisms through which parental involvement influences their children's academic performance and achievement?

Pomerantz et al. (2007) proposed two mechanisms by which parents' involvement influences children in academic learning. One is through enhancing knowledge acquisition and improving cognitive and metacognitive skills. The other is through providing a variety of motivational resources that foster learning behaviors and achievement. Based on Grolnick and Slowiaczek's influential work (1994) connecting parental involvement with children's school performance through psychological processes (e.g., self-efficacy), Pomerantz et al. (2007) argued for two kinds of motivational development that result from parental involvement. First, parents' involvement conveys value of schooling to children that could be internalized as intrinsic motivation (e.g., interest). Second, in the interaction with children, parents demonstrate study strategies that may lead children to view themselves as competent in intellectual activities at school. There has been some support for this theory in studies of mathematics and English in high school (Fan & Williams, 2010), and in general academic performance in college (Weiser & Riggio, 2010). But this theory regarding interest and self-efficacy as the key mediators of effects on achievement has not been tested in science. Further, more research is required to determine which kinds of home involvement are most important in science (e.g., providing physical resources vs. providing psychological support).

The Current Study

We present structural equation modeling (SEM) analyses applied to data taken from two very different learning contexts to explore the extent to which middle school students' perceived family support influence choice preferences, engagement, and achievement in science through effects on interest and self-efficacy in science learning. In the hypothetical model (see Figure 1), the solid lines represent the central relationships to be tested in the SEM models, and the dotted lines represent the possible alternative relationships. As reviewed above, most of the previous studies focused on the direct relation between parental involvement and academic achievement. But, our emphasis is placed on unpacking these effects in terms of motivational beliefs (interest and

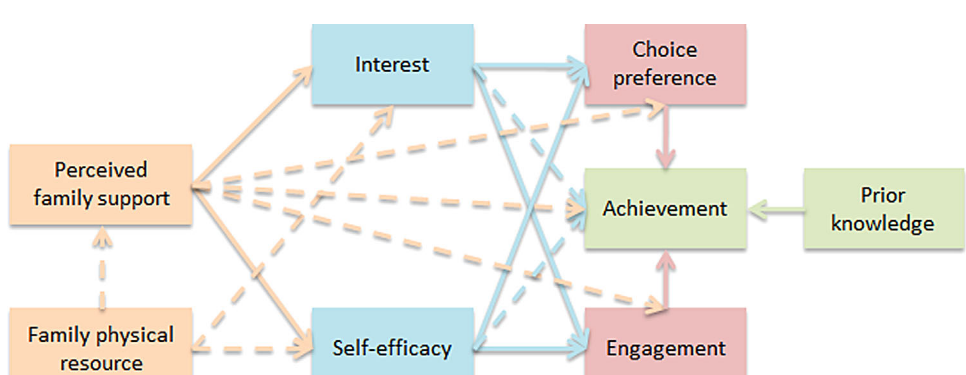

Figure 1. A hypothetical pathway from family support to motivation, learning behaviors, and achievement.

self-efficacy). Overall, the theoretical model can be viewed as embodying two specific research questions that need to be tested:

1. Are the effects of family support on science learning outcomes explained by effects on interest and self-efficacy?
2. Are these relationships robust across different science learning contexts?

As noted earlier, science learning happens both in and out of school contexts. Therefore, it is important to understand whether the effects of perceived family support similarly influence learning in both in school and out-of-school contexts.

As a final note, the present study also examines age and ethnicity effects on the structure of the examined model. Hill and Tyson's review (2009) pointed out that except for African Americans, few studies on parental involvement in middle school included other sizable ethnic groups such as Latinos and Asian American. Indeed, Fan et al.'s recent study (2012) did find ethnic differences between African Americans and Latinos. Similarly, many studies in science education research have revealed a pervasive gender effect on students' attitude toward science and science learning (Britner, 2008; Patrick, Mantzicopoulos, & Samarapungavan, 2009; Simpkins et al., 2006). These gender differences in academic motivation typically begin to emerge in the middle school years (Meece & Painter, 2008).

Overall, the current study contributes to theory by: (i) clarifying which aspects of home environments are most critical to motivational development in science; (ii) testing the mechanisms by which home environments influence student performance in school and in other science learning contexts; and (iii) testing the extent to which motivational outcomes in and out of school science learning in early adolescence is specifically driven by science interest and self-efficacy. These theoretical contributions are also relevant to science educators and family members in that they suggest which motivational factors are important to influence at this age and provides insights into how such factors can be influenced. The practical implications are taken up in greater detail in the general discussion.

Methods

In order to test the existence and generalizability of the hypothetical path (shown in Figure 1) across different contexts, two cohorts of students were selected to be different on many dimensions such as grade, regional culture, and ethnic composition (see Table 1 below). First, Cohort 1 was from the Pittsburgh area, a historically blue-collar, industrial-focused urban region in the Eastern US; Cohort 2 was from the Bay Area, a highly diverse, technology-focused urban region in the Western US. Participants from the Pittsburgh area were 6th graders, and those from the Bay Area were 5th graders. The Pittsburgh dataset focused on engagement in school and learning outcomes from school engagement. The Bay Area dataset focused on engagement in a science and technology center visit. In short, the study design was not created to provide a clean test of age or region, but instead to provide a strong generalization test of the theoretical path across substantially different contexts.

Participants and Procedure

For the Pittsburgh cohort, 702 6th grade students from ten public schools in the Pittsburgh area participated. For the Bay Area cohort, 284 5th grade students from four schools participated. These schools were recruited to represent a broad range of student ability levels and home socio-economic status, and the schools were participating in a larger longitudinal study of motivational factors in science learning. As shown in Table 1, the majority in the Pittsburgh cohort was

Table 1
Age, gender, and ethnicity information provided by the two participant cohorts

	Pittsburgh cohort Mean age = 12.0 (SD = 0.5)	Bay Area cohort Mean age = 10.5 (SD = 0.5)
Gender		
Boy	305 (51.3%)	135 (51.9%)
Girl	290 (48.7%)	125 (48.1%)
Ethnic information		
White	261 (47.9%)	73 (32.6%)
Asian	15 (2.8%)	8 (3.6%)
African American	246 (45.1%)	25 (11.2%)
Hispanic	19(3.5%)	111 (49.6%)
Native American	4 (0.7%)	7 (3.1%)

Caucasian and African Americans, while the majority in the Bay Area cohort was Hispanic and Caucasian.

The students in Pittsburgh completed the surveys through a mix of paper-and-pencil and online computer administration, when available. Empirical research has repeatedly revealed that online and paper methods of measurement are essentially invariant (Bates & Cox, 2008; Davidov & Depner, 2011), with only minor differences found when people self report highly sensitive information (e.g., sexual risk-taking) (Kays, Gathercoal, & Buhrow, 2012). Five variables (Family physical resource, perceived family support, self-efficacy, interest, and prior knowledge) were measured in September and early October (based on classroom availability). Choice preference was measured in February—purposely at a later point in time to capture enduring motivational outcomes rather than just short-lived effects.

Engagement at a task level was measured across four different days distributed across late October/November (depending upon when a particular fixed set of activities took place within a given teacher's rate of progress in the unit). The goal was to hold learning content constant across classrooms but also sample a diverse range of activity types and content difficulty. All ten schools were teaching the same 5-month-long unit on weather and climate from Full Option Science System (FOSS, http://www.lhsfoss.org/), a widely used, hands-on curriculum developed by the Lawrence Hall of Science. The main activity on Day 1 of data collection focused on comparing radiation and conduction. The Day 2 activity was focused on the relatively easy task of heating sand and water. On this day, students only gathered data. Day 3 was aimed at comparing graphs through a teacher-led discussion. Day 4 was similar to Day 1 in that it was a contrasting case, this time focused on comparing evaporation and condensation. The pre-test and post-test on learning content were respectively administrated in early September and in the following January. Students completed the instruments using assigned pseudonyms to allow for connection of responses across instruments but provide a sense of anonymity.

The students in the Bay Area were given an initial survey at the beginning of 5th grade that included measures of family physical resources, perceived family support, self-efficacy, and interest. The students came from schools using different curricula. Therefore, rather than focusing on engagement during scale-based activities, students were bused to a science and technology center (approximately a month after the initial survey) to provide shared engagement opportunities for the study, and also to examine effects of interest and self-efficacy on engagement during out-of-school science learning. The same activity engagement survey used in the Pittsburgh cohort was administered immediately following visits to each of two different science exhibits: the Engineering Exhibit Hall (Engineering) and the Dinosaurs Exhibit Hall (Dino). The Engineering Exhibit Hall (Engineering) includes a variety of design challenges and other activities such as car, bridge, and parachute design and testing stations. The Dinosaurs Exhibit Hall (Dino) includes animatronic dinosaurs, extensive labels, and a variety of fossils and other objects. Choice preferences were measured a few weeks after the museum visit. Because a single visit to a museum is unlikely to produce large learning outcomes, there was no measurement of learning achievement in this dataset.

Measures

As part of a larger project (http://activationlab.org), new scales were developed and used in this study. While many related scales already exist, they are often developed for studying motivational factors outside of science, focusing exclusively on in-school contexts (e.g., MSLQ; Duncan & McKeachie, 2005; Pintrich, Smith, Garcia, & McKeachie, 1993) or normed for older populations (e.g., SMQ; Glynn et al., 2009, 2011). Our study required scales that captured interest, self-efficacy, etc. in science for both in and out-of-school contexts, and was understandable by 5th and 6th graders from diverse backgrounds.

To validate the new instruments, seven 6th grade students from diverse backgrounds were asked to describe in one-on-one interviews how they interpreted each survey item and why they made a particular choice on the item. For instance, for a participant who selected YES! on the self-efficacy item, "I feel I can do a good job when I work on science activities," her explanation of why she selected YES! was, "Yeah, usually the assignment—like usually I get it. So I'm able to like, like do a good job on it because I understand it." Only items that were generally interpreted as intended were included in the deployed surveys.

Due to the age of the students, we desired to utilize a scale that minimized both the complexity and amount of reading. Therefore, several instruments used a four-point scale (YES!-yes-no-NO!). In pilot work with the instruments, children found the "YES!-yes-no-NO!" scale easier to use than the more traditional "strongly agree-strongly disagree" response options. Finally, Item Response Theory (IRT) analysis verified that there were approximately equal distances between the responses options along a unified metric for each scale, suggesting it was appropriate to exclude a neutral middling value (e.g., "maybe").

Perceived family support is measured as a mean score across 3 three-point Likert scale items (2 = Always, 1 = Sometimes, 0 = Never), indicating the extent of support the students received from their family for science learning. The three items were as follows: (i) Someone in my family takes me to places where I can learn new things, (ii) Someone in my family knows enough about science to answer my questions about science, and (iii) Someone in my family is interested in teaching me things.

Family physical resources was measured as a mean score across 3 three-point Likert scale items (2 = Always, 1 = Sometimes, 0 = Never), indicating degree of physical resource a student has from her family. The three items asked about the availability of the following in the home: (i) Calculator, (ii) Dictionary, and (iii) Study area. The particular items were based on prior literature regarding differentiating factors (i.e., are not universally available) and are relevant to science learning. These resources may be taken by children as indicators of support for science learning.

Self-efficacy was measured as a mean score across 6 four-point (4 = YES! 3 = yes, 2 = no, 1 = NO!) Likert scale items. Our measurement of this construct is not only subject specific, but also specific to critical aspects of science (e.g., I think I am pretty good at: Coming up with questions about science) rather than simply asking the degree of general confidence in learning science. That is, the students were asked about common tasks they are often asked to complete at this age in formal and informal science settings.

Interest was computed as a mean score across 4 four-point Likert scale items (e.g., "When I work on science at school, I: enjoy it - don't enjoy it", 4 = YES! 3 = yes, 2 = no, 1 = NO!). The four items were intended to not only cover a wide range of possible interest-related psychological states while learning science in school, but also includes affective rather than simply cognitive elements of interest, as suggested by theories of interest. That is, rather than simply asking if they are interested in or like science, the items included related psychological states like happy, amazed, curious, excited as elements of the interest construct.

Choice preference was computed across 4 four-alternative forced choice items, that provided the students immediate and future choices between experiences involving science and those involving other topics (e.g., math, history, art). The goal of the scale was to determine the relative degree of preference for science learning opportunities across school, home, and other out-of-school contexts. The first item asks about making a choice of classes in the future (i.e., next year), which allows students to choose more than one option. The remaining three items invite the students to make only one immediate choice of an activity either in school (e.g., science experiment) or out of school (e.g., science museum, doing science at home). A score of 1 is given for a selection of a science-related item, otherwise, a score of 0 is given (See Sha, Schunn, and Bathgate (in press) for detailed information on the design and validation of this scale).

The *engagement* survey consists of 17 Likert items measuring students' affective-behavioral-cognitive engagement. A four-point Likert scale (YES!-yes-no-NO!) was used and all reversed coded items were recoded prior to analyses. Sample items include: "I worked hard during the activity" and "I tried out my ideas to see what would happen." Many prior measures of engagement ask about science at a general level (e.g. "In general, when I do science. . .") and were intended to assess a more stable level of interest outside of a particular learning activity. By contrast, our measure of engagement was intentionally tied to a particular learning activity on a given day (e.g. "During today's activity. . ."), to provide a clear distinction between interest (a general level) and engagement (the result at particular moments in time of interest levels, self-efficacy levels and situational characteristics). Assessing across multiple time points allowed us to generate a sense of a child's average engagement in their science class or museum visit, rather than measuring their engagement in a single activity. Previous validation work on this engagement scale shows the scale structure to be stable across multiple time points and contexts, as well as supports the scale producing an overall engagement assessment rather than only separate assessments of behavioral, cognitive, and affective engagement (Ben-Eliyahu et al., in review). As such, a mean score for engagement was calculated across the four days (for the Pittsburgh dataset) or across the two museum exhibits (for the Bay Area dataset).

Achievement. The participants completed a knowledge pre-test during the first week of class. The assessment was developed to assess the weather and climate big ideas found in the curriculum unit, and consisted of 24 multiple-choice questions (e.g., What is the primary energy source that drives all weather events, including precipitation, hurricanes, and tornadoes? – the Sun, the Moon, Earth's gravity, or Earth's rotation). The same assessment was given as a post-test five months later, except that 3 items are excluded from the post-test because not all the teachers covered the content of those 3 items. Both pre-test scores and post-test are the proportion of correct answers, and the post-test score is called *Achievement*.

Two 2-factor Confirmatory factor analysis (CFA) models with 1) the two family-related variables and 2) the two motivational variables justify the homogeneity of the above four predictors is psychometrically acceptable (the thresholds: CFI > .90, RMSEA < .08) (Brown, 2006) (see Table 2). The Cronbach's alpha values of all the variables are shown on Table 3.

Table 2
Fit indices of the two 2-factor CFA models

	Pittsburgh Cohort		Bay Area Cohort	
	Family variables	Motivational variables	Family variables	Motivational variables
CFI	0.99	0.99	0.99	0.99
RMSEA	0.06	0.06	0.05	0.05

Results

Basic Statistics

Data screening was done prior to all subsequent analyses to identify outliers. There were no univariate outliers in either predictors or outcomes, defined as cases with absolute z-scores >3.08 (Tabachnick & Fidell, 2007). A few multivariate outliers were identified and removed at the .001 significance level for Mahalanobis distance. Table 3 presents means, standard deviations, Skewness, and Kurtosis of each measure from the two cohorts; all of the variables are approximately normally, although the Skewness and Kurtisis of interest is slightly above 1. On average, a majority of fifth and sixth graders reported high scores on most variables involved, as is common at this age.

Pearson correlations were computed between the predictor variables (see Table 4). While many were statistically significant, they were moderate in size (the largest correlation was 0.45, and most are below 0.30), indicating an acceptable level of multicollinearity of these measures for the subsequent multivariate analyses (Tabachnick & Fidell, 2007).

Table 3
Descriptive statistics of each variable from the two cohorts

	N	M	SD	Skewness	Kurtosis	Alpha
The Pittsburgh Cohort						
Time 1 measures						
Family physical R	565	1.48	.53	−.50	.24	0.62
Perceived family S	559	3.19	.66	−.61	−.24	0.69
Interest	566	3.33	.65	−1.04	.87	0.80
Self-efficacy	576	3.00	.69	−.47	.33	0.80
Pretest	647	9.75	4.09	.18	−.16	0.72
Time 2 measures						
Choice preference	576	1.55	1.34	.51	−.94	0.79
Engagement (mean)	615	.76	.12	−.53	.38	0.86
Achievement	643	12.74	4.21	−.34	−.37	0.78
The Bay Area						
Family physical R	231	1.35	.55	−.55	−.56	0.62
Perceived family S	232	3.48	.47	−.60	−.51	0.60
Interest	211	3.41	.61	−1.07	.41	0.84
Self-efficacy	220	3.15	.58	−.44	−.25	0.80
Choice preference	233	1.69	1.42	.38	−1.20	0.73
Engagement	220	.84	.10	−.75	.38	0.72

Table 4
Zero-order Pearson correlations between the variables from the two cohorts

	PR	PS	IN	SE	PT	CP	EG
Pittsburgh							
Time 1 measures							
Physical R (PR)							
Perceived FS (PS)	.40**						
Interest (IN)	.12**	.15**					
Self-efficacy (SE)	.17**	.31**	.45**				
Pre-test (PT)	.11*	.08	.10*	.06			
Time 2 measures							
Choice P (CP)	.06	.13**	.29**	.25**	.13**		
Engagement (EG)	.21**	.33**	.33**	.34**	.12**	.20**	
Achievement (AC)	.12**	.03	.14**	.10*	.53**	.17**	.07
The Bay Area							
Family R (PR)							
Perceived FS (PS)	.30**						
Interest (IN)	.15*	.21**					
Self-efficacy (SE)	.10	.35**	.37**				
Choice P (CP)	.00	−.02	.25**	.12			
Engagement (EG)	.26**	.42**	.24**	.43**	.03		

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

Are the Effects of Family Support on in School and Out-of-School Science Learning Outcomes Explained by Effects on Interest and Self-Efficacy?

The Pittsburgh Cohort. Table 4 reveals that most of the correlations between the predictor and outcome measures are statistically significant, suggesting that analysis of independent contributions are needed. A series of SEM models was run in AMOS 19 (http://www-03.ibm.com/software/products/us/en/spss-amos/) in a stepwise manner to test the conceptual model shown in Figure 1. In each step, any non-significant regression weights (i.e., β values) were removed from the model until that all of the remaining connections had significant regression weights (i.e., $p < 0.05$). The most parsimonious model (shown in Figure 2) has fit indices indicating that the overall model fit is acceptable according to commonly used thresholds (CFI > 0.90, RMSEA < 0.08; Brown, 2006). Other two fit indices, i.e., IFI ($>.90$, Incremental Fit Index), and TLI ($>.90$, Tucker Lewis index) also indicate an acceptable model. In addition, since χ^2 is sensitive to sample size, it recommended to use the ratio of χ^2 to degrees of freedom (with the threshold of ratio <2) rather than the χ^2 p-value (Kline, 2011).

In Figure 2, the large β (.61) indicates that the family physical resource a student received (an objective measurement of aspects of the family background relating to academic learning) is strongly associated with his/her perception of family support (a subjective measurement of family background). It should be noted that no direct paths were found from the family physical resource to interest, self-efficacy, engagement, and achievement, although Table 4 shows that the zero-order correlations between them are statistically significant. The strong links of individuals' perceived family support to their interest, self-efficacy, and engagement suggest that the influences of family physical resource on those variables are mediated by their connection to perceived family support.

In the model, children's perceived family support was significantly associated with engagement in classroom science learning mediated via connections through interest and self-

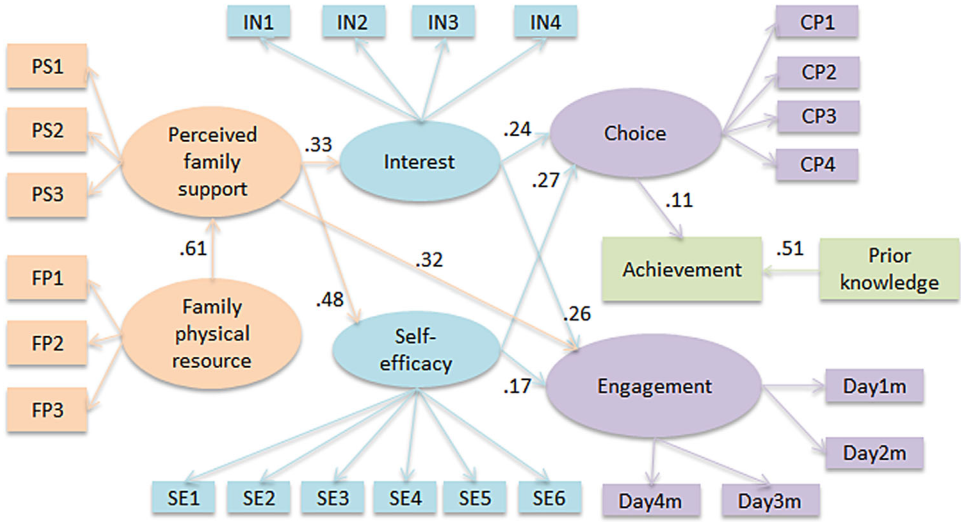

Figure 2. A final SEM model of a path from family support to perceived family support, choice, engagement, and achievement ($\chi^2 = 503.20$, df = 291, /df = 1.73, IFI = .94, TLI = .93, CFI = .94, RMSEA = .03).

efficacy. But there was also a significant direct connection to engagement, perhaps mediated through other motivational variables not captured here (e.g., extrinsic value of science).

As shown in Table 4, there is a significant zero-order correlation between perceived family support and choice preference ($r = .13$, $p < .01$). However, the direct connections disappear when other factors are taken into account in this SEM model and instead the relationship is fully captured by the mediated connection through interest and self-efficacy.

Turning to the last layer of the model, the association between choice preference and learning achievement is statistically significant ($\beta = .11$, $p < .05$) even when controlling for prior knowledge. Thus, perceived family support appears to be associated with higher classroom learning in that perceived family support is associated with high interest and self-efficacy, which in turn is associated with choice preferences, which in turn is associated with learning outcomes (presumably by diverse optional science learning activities that the choice preferences enabled). Interestingly, there is no path to learning outcomes via engagement, in either zero-order correlations or in the SEM. It may be that test performance was more driven by homework completion and test preparation activities (which may be partially measured by choice preferences) than by in-class engagement. Alternatively, it may be that cognitive engagement in-class included off-topic or misconception-building cognitive activities (i.e., in this inquiry science context, it may be that students were cognitively engaged with the wrong content).

The Bay Area Cohort. Figure 3 shows (i) a significant link between the family physical resource and perceived family support; (ii) much weaker links of family physical resource than perceived family support to interest, self-efficacy, and engagement, suggesting a mediating role of the latter construct as found in the Pittsburgh cohort; and (iii) both family physical resources and perceived family support have no significant direct links to choice preferences.

A stepwise series of SEM models was run in AMOS 19 to test the conceptual model shown in Figure 1. The most parsimonious model (shown in Figure 3) has fit indices indicating that the overall model fit is acceptable. The best fitting model replicates the main findings from the

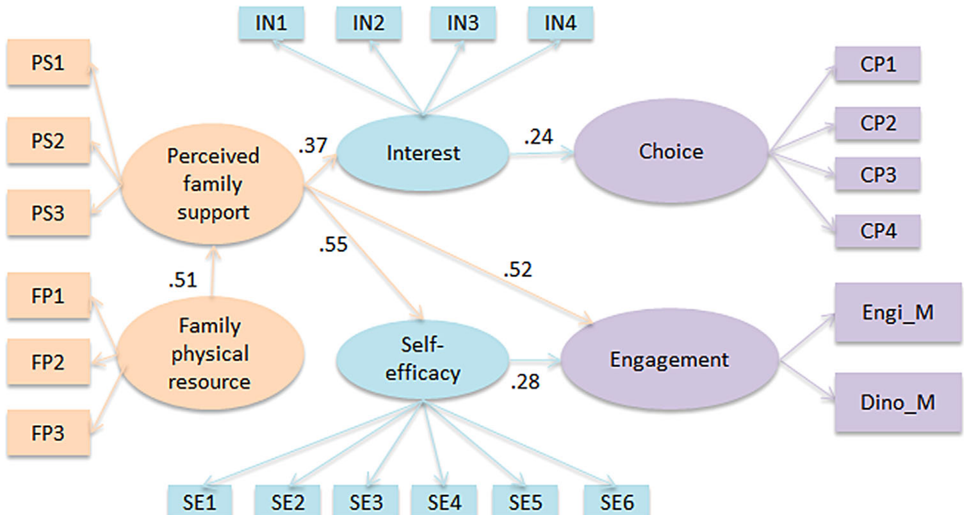

Figure 3. A final SEM model of a path from family support to choice, engagement, and achievement in Bay Area ($\chi^2 = 243.40$, df = 203, /df = 1.20, IFI = .97, TLI = .96, CFI = .97, RMSEA = .03).

Pittsburgh cohort: (i) individuals' family physical resource is associated with perceived family support and there is no direct connection of physical resources with interest, self-efficacy, choice, and engagement; (ii) as predicted, perceived family support is significantly associated with interest as self-efficacy, (iii) this association is greater with self-efficacy than with interest; (iv) perceived family support is directly associated with engagement levels, indicating some other mediating variable is missing; (v) interest is significantly associated with choice; and (vi) self-efficacy is significantly associated with engagement.

Unlike the overall data findings in the Pittsburgh cohort, there is no significant relationship between interest and engagement, or between self-efficacy and choice. These missing connections may reflect lower power from the smaller dataset, differences in the context for engagement, or differences in the populations being studied. Therefore we turn to possible effects of population differences.

Are These Relationships Robust Across Different Learners (Age, Ethnicity) ?

To explore the robustness of the findings and also the extent to which the findings hold across different groups vs. being driven by particular subgroups, we conducted the same analyses on the Pittsburgh cohort's subsets by age and ethnicity (subsets within the Bay Area cohort were too small for reliable SEM analysis). Children at different ages may depend differentially on family support, and different cultural subgroups may also depend differentially on family support, particularly with respect to engagement in science, that has gender and ethnicity-related stereotypes. There were 221 children whose ages were less than 12, 204 of them whose ages were above 12, 257 children categorized themselves as White or Asian, and 215 of them categorized themselves as other ethnical groups traditionally underrepresented in science such as Africa American, Hispanic/Latino/Mexican.

The overall SEM model was run separately for each of the binary subgroups. The fit indices are shown in Table 5 reveal that the SEM model shown in Figure 1 is generally acceptable across different age groups and ethnical groups.

Table 5
Comparison of fit indices of the SEM models in different groups of students

	Chi-square	df	CFI	RMSEA
All students ($N=702$)	503.20	291	0.94	0.03
Age ≤12 ($N=221$)	413.89	291	0.91	0.04
Age >12 ($N=204$)	374.60	291	0.93	0.04
White/Asian ($N=257$)	444.98	291	0.92	0.05
Others ($N=215$)	354.89	291	0.93	0.03

Table 6 provides the β values in the model overall and for each subgroup. Pathways whose beta values are insignificant statistically ($p > 0.05$) are not present on Figure 2. Overall, the paths from family physical resource to perceived family support, and from perceived family support to interest, self-efficacy, and engagement were the most robust and stable part of the model across subgroups. The full set of links was significant only in the group of White/Asian students. Also, in this ethnic subgroup, the importance of choice preference for promoting learning achievement is much stronger than in the full dataset ($\beta = .26, p < .01$).

Discussion

Students in middle school and high school tend to follow pathways away from careers in STEM as a result of failing to choose optional STEM experiences, low engagement in STEM courses, as well as poor academic achievement in these areas. The current study applied SEM methods to test the central hypothesis: the paths from middle school students' perceived family support of learning to choices for, engagement within, and achievement in science learning are mediated by the effects on science interest and self-efficacy beliefs. The current study provides three important contributions to research in both motivation and science education. First, it deepens our knowledge about the associations between particular motivational factors and their motivated learning behaviors in science for children at this critical age. Second, the study brings together research on formal science learning (i.e., school-based) and research on informal science learning (e.g., home and museum contexts) to reveal important commonalities to what drives how students engage and why they make choices in and out of schools. Third, the SEM models reveal the degree to which children's perceptions of family support for science learning are associated to motivated learning behaviors and achievement in science learning (i.e., through particular motivational factors).

Table 6
Comparison between obtained the beta values of the relationships among the latent variables

	PR > PS	PS > IN	PS > SE	PS > EG	IN > CP	IN > EG	SE > CP	SE > EG	CP > AC
All	.61**	.33**	.48**	.32**	.24**	.26**	.27**	.17**	.11*
Age ≤12	.72**	.25**	.40**	.42**	.21*	$p=.10$	.47**	$p=.32$	.15*
Age >12	.63**	.48**	.52**	.29*	.44**	.44**	$p=.89$	$p=.37$	.18*
White/Asian	.66**	.36**	.47**	.30**	.19*	.27**	.37**	.19*	.26**
Others	.58**	.23*	.44**	.36**	p=.78	$p=.12$	.37**	$p=.18$	$p=.44$

PR, Family physical resource; PS, Perceived family support; IN, Interest; SE, Self-efficacy; CP, Choice preference; EG, Engagement; AC, achievement.
$*p < .05$, $**p < .01$.

Complexity in the Links From Science Interest and Self-Efficacy to Choice and Engagement

The overall tested model (shown in Figure 1) replicates established links of interest and self-efficacy to their choice preferences and engagement. This replication is non-trivial: although each of those four links has supporting research literature, the amount of research is small at this critical age group, in science with diverse populations, or looking at both interest and self-efficacy together. The obtained models (shown in Figures 2 and 3) found significant connections between the two motivational variables (interest and self-efficacy) and the two outcomes of motivation (choice and engagement). For example, interest as a motivational variable refers to the liking and enjoyment from engagement in tasks as well as the desire to acquire knowledge (Hidi & Renninger, 2006). Science choice preference, as a behavioral outcome of motivation, refers to the extent to which children prefer a science-related choice when given both science-related and non-science related alternative options (i.e., a psychological tendency towards a topical choice; Sha et al., in press). These theoretically distinct constructs reflect different aspects of children's motivation in science. Our tested model provides a useful framework for researchers and educators in science education to understand the complex relations between children's motivational beliefs and motivational behaviors in science learning.

In the motivation literature, interest is defined as both cognitive and affect-oriented (Hidi & Ainley, 2008), whereas self-efficacy is primarily cognitive (Schunk et al., 2008). The findings from the two cohorts/contexts (see Figures 2 and 3) suggest that for the early adolescents: (i) the cognitive motivational variable of self-efficacy more consistently shows associations with science engagement; and (ii) the mixed cognitive/affective motivational variable of interest shows more consistent associations with science choice preferences. These findings illustrate the complexity of the relationships between people's motivational beliefs and achievement behaviors that may not have been adequately revealed in past research. For example, many existing studies emphasized the association between self-efficacy and choice of task (Durik et al., 2006; Linnenbrink & Pintrich, 2003; Schunk et al., 2008; Zimmerman, 2000). Some variation of that relationship emerges when both self-efficacy and interest are treated as competing predictors. In this case, interest has a closer association with choice preference than self-efficacy. Although this does not necessarily mean that the well-established relation between self-efficacy and choice disappears, this finding at least illustrates the diversity and complexity of that relationship depending on the way in which it is assessed.

Thus, the above findings have implications for science educators and parents seeking to increase student choice preferences that ultimately have an important effect on overall student learning. Educators should attach more importance to the affective side of motivation—the pleasure of science phenomena and explanations—because this aspect will drive student choices. Similarly, educators and parents should not simply force children to engage in teacher or parents' designated activities whereby some increment of scientific knowledge may be obtained at the cost of impairing student interest.

Finer-grained analyses on the data from the Pittsburgh cohort further identified age moderation effects on the relationship between interest and self-efficacy in predicting choice and engagement. For students at the age of 12 and younger, both interest and self-efficacy were associated with choice, but neither was associated with engagement. However, for students older than 12, interest was associated with choice preferences and engagement, but there was no predictive role for self-efficacy. These age-related changes may reflect a shift to interest-driven participation with age. However, older and younger children within a given grade often have other differences than age. Further research is needed to replicate these patterns. At the very least, this study has identified patterns of variation across groups; we can no longer assume that interest and self-efficacy matter equally for all groups. A number of studies examined how different motivational constructs grow or decline over time (e.g., Friedel, Cortina, Turner, & Midgley, 2010; MacCallum & Pressick-Kilborn, 2011; Turner & Patrick, 2008), but more studies are needed that examine how the relationships among constructs change over time.

Similar analyses for ethnicity revealed that the motivational factors were less predictive of motivational outcomes for minorities traditionally underrepresented in science than for students from ethnicities well represented in science. Again, the mechanisms behind this moderation effect are not yet clear. It could be that stereotype threat or other forms of pressure related to perceptions of who should participate in science are driving this moderation. Alternatively, it could be that differences in perceived value of science knowledge and careers are acting as moderators. No matter what the exact mechanisms are behind this ethnicity effects, however, these finding suggest, similar to the case of age effects, additional research should study the effects of ethnicity on the motivation to outcome relationships, rather than only studying the role of ethnicity on the development of motivational beliefs (e.g., Beghetto, 2007; Pintrich, 2003).

The Critical Role of Perceived Family Support in Developing Science Interest and Self-Efficacy

The current study examined two ways in which families can support science learning: creating an environment in which children feel their learning is being supported, and providing physical resources that can be used in science learning. The SEM models were quite consistent across datasets, ethnicities, and age groups in finding a differential role of the two factors. The family physical resource construct in both datasets and all age and ethnicity subgroups was a strong predictor for children's perception of family support of learning ($\beta = .51$ or larger in all cases), but it was not directly associated with interest, self-efficacy, choice, or engagement. That is, the family's physical resources (e.g., calculator, dictionary, learning space) appear to just be a kind of material support for creating perceptions of learning support rather than directly supporting the development of motivation and learning processes themselves. By contrast, perceived support for science learning was consistently associated with both interest and self-efficacy, as well as directly to engagement.

These results suggest that simply providing material support is not sufficient for effectively fostering children's motivation because physical resource does not necessarily mean that the family members are willing or able to help children solve difficulties in science learning. This finding has a strategic implication for family members (including parents) regarding what they should do to foster their children's motivation to learn science. Of course, more research is needed to further differentiate various roles played by various family members (i.e., parents vs. elder brothers, sisters, grandparents, or siblings) in fostering children's science learning and achievement.

The physical resource is "cold", lacking affective interaction between human beings. But, motivation is "hot" (Pintrich, Marx, & Boyle, 1993), involving enthusiasm and passion. Fostering "hot" motivation likely needs "hot" interactions between parents and children. The importance of emotional interactions for development is consistent with attachment theory and self-determination theory (c.f.: Pomerantz et al., 2012).

Even so, providing children with the necessary physical resource in homes also appears to be important, because it does exert some impact on motivation and learning indirectly through its effect on the development of children's perception of family support. But from a cognitive view, it is people's perceptions of the physical environment as being an indicator of support that may matter more than the physical environment itself (Brunning, Schraw, Norby, & Ronning, 2010).

This is analogous to the frequent result that found people's confidence in their capabilities of doing a task well (i.e., self-efficacy) is a stronger predictor of their academic behaviors than their actual capabilities.

It is also interesting to note that perceived family support was consistently a stronger predictor of self-efficacy than of interest across locations, ages, and ethnicities. The general predictiveness for both motivational variables is consistent with arguments made elsewhere (e.g., Furrer & Skinner, 2003; Pomerantz et al., 2012) that family involvement in children's learning at home may strengthen their feelings of relatedness to the family members, which in turn strengthen their perceptions of being capable and their interest to explore the environment. That is, learning occurs within the learner's social-cultural environment (Ben-Eliyahu & Bernacki, 2015). What is novel to the literature here is that the perceived family support in science appears to exert a greater impact on children's self-efficacy in science than on interest to learn science. According to social cognitive theory (Bandura, 1997; Schunk et al., 2008), social persuasion is a source of one's self-efficacy, which refers to others' (e.g., teachers, parents) evaluative feedback and judgments about one's academic performance. This suggests that interpersonal relationships are key to the development of self-efficacy. Interest research reveals that the interestingness of learning material and task is a significant influence on the development of learners' academic interest. It is primarily determined by such factors as novelty, surprise, and ease of comprehension (Palmer, 2009; Schunk et al., 2008). Family support may influence ease of comprehension, but may have less of an effect on novelty or surprise. Of course, since we lack the details about how the family members actually interacted with the students, the present study is not able to provide mechanisms behind the observed differential predictiveness for interest versus self-efficacy.

It is also worth noting that the models from the two cohorts revealed a strong direct link from perceived family support of learning to engagement during learning, both in classroom instruction and museum exhibit interactions. This is particularly remarkable given that perceived family support refers to support from individuals (i.e., family members) not directly within the classrooms or the museum visit being studied. These findings suggest that interactions with family members in science learning (e.g., "Someone in my family is interested in teaching me things") are more broadly important. This finding provides a piece of empirical evidence bridging the measures in two settings of learning (school vs. family), suggesting that children's learning experiences in their families be not only associated with their motivational beliefs (e.g., interest, self-efficacy) in the context of school education (where the two motivational variables were measured, e.g., "When I work on science at school, I: enjoy it-don't enjoy it"), but also associated with their learning behaviors in school (e.g., classroom engagement).

Key Implications for Family and School Practices and Limitations

From a research perspective, the present study reveals the path from parental support to the choices and engagement of students in and out of school learning contexts: that is, what are the critical constructs that explain the relationship? Past studies unpacking mechanisms of important effects are rare. For example, Vedder-Weiss and Fortus' study (2013) uncovered the way in which early adolescents' perceived parent, peer, school, and teacher goal orientations influenced their in- and out-of-school engagement via effects on their own goal orientations. The present study expands on those findings by exploring how family physical resources and children's perceived family support are associated with their choice for and engagement in science learning. In other words, this finding enriches our knowledge about the complex relations between children's familial factors (actual and perceived), motivation, and academic behaviors by including more variables from both predictor side (two family-related variables) and outcome side (two behavior-related variables).

From an educator perspective, understanding the mechanisms is useful for guiding interventions. For example, if an educator surveys their students and discovers that interest or self-efficacy is low, they could explore increasing parental involvement in science learning (e.g., by providing particular homework assistance roles). Such an intervention is suggested by the model tested in the present study, but is not likely where an educator would initially turn to address student motivational issues. Alternatively, if an educator discovers that parental involvement in science learning is low in a context and not responding to interventions (e.g., perhaps communications with parents is not robust in that setting), then the educator can anticipate motivational problems that require other compensatory interventions.

From the perspective of parents and other important family members (e.g., grandparents or older siblings), the findings of the present study suggest approaches to more broadly assisting science learning (i.e., supporting later choices and engagement rather than simply directly support particular home or tests). When they wish to have children willingly choose after school science-related activities science, for instance, family members should not only foster children's science self-efficacy belief, as many existing studies have suggested, but also take action to inspire and maintain their interest. Further, the current findings suggest it is important to not only provide their children with material/physical support (e.g., study area, computer), but more importantly, families should be willing to cognitively and affectively engage in their children's learning activities at home (e.g., able to and willing to teach their children). An encouraging implication for the families that may lack physical resources (e.g., low SES families) is that it is still feasible for their children to have high motivation to learn science, and attain satisfactory achievement as long as the children explicitly perceive support of learning from their family members. A remaining issue for parents, therefore, is how to establish a family atmosphere (a child's psychological environment) under which their supports can be perceived by their children explicitly.

It is important to note a few limitations of the current study. First, no learning data was obtained from informal learning opportunities. Second, the obtained data was fundamentally correlational in nature. Although predictor data was obtained at earlier time points than outcome data and regression analyses were implemented to tease apart various confounded relationships, not all third variable explanations have been ruled out. Follow-up research exploring interventions or more broadly addressing other possible confounded variables is needed to address this limitation. Third, the obtained effects may have been more robust if the reliability coefficient of the family physical resource variable ($\alpha = 0.62$) had been higher, although that value is psychometrically acceptable given the use of a 3-item instrument. More items could be added to that scale in future research, since measure reliability is heavily influenced by the number of items (Kline, 2011). Finally, towards further integration of research on formal learning and informal learning, more empirical studies in science education are needed to explore how family members should play a role in fostering children's motivation and achievement in formal learning through their involvement in informal learning.

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