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SCIENCE LEARNING IN EVERYDAY LIFE

Science Interests in Preschool Boys and Girls: Relations to Later Self-Concept and Science Achievement

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ABSTRACT: Although young children display various types of interests, little is known regarding the potential impact of these interests on subsequent learning and development. Of particular importance is the question of whether or not children's early interests are instrumental in their later academic achievement. The current study fills this gap in the interest literature by longitudinally investigating the relationship between 116 children's early science interests and their subsequent self-concepts and science-related academic achievement, with particular emphasis placed on gender. The intensity and content of children's science interests between the ages of 4 and 6 (i.e., preschool interests) and between the ages of 6 and 8 (i.e., elementary school interests) were used as predictors of age 8 self-concept and science achievement. Boys displayed higher overall levels of science interests than girls, though interest was not related to boys' self-concepts. Girls' early intense science interests were related to higher science self-concepts at age 8. In addition, early interests predicted science achievement in girls but not in boys. In conclusion, it appears that early science interest may be a critical supporting factor for girls in fostering positive self-concepts and higher science achievement scores. © 2013 Wiley Periodicals, Inc. *Sci Ed* **97:**574–593, 2013

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INTRODUCTION

During the past two decades researchers have paid particular attention to interest as an important construct for understanding the processes and outcomes of learning and development. Interests assert profound influences on children's preferences, attention span, depth of engagement, and persistence, impacting academic learning, acquisition of motor skills, identity development, and overall well being (Chen & Darst, 2002; Harackiewicz & Hulleman, 2010; Hidi, 1990; Hidi & Ainley, 2002; Hoffmann, Krapp, Renninger, & Baumert, 1998; Hunter & Csikszentmihalyi, 2003; Krapp, 2002; Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005; Silvia, 2006). Despite the recent profusion of interest research, most investigators have tended to focus on adolescents (e.g., Krapp, 2000; Rathunde & Csikszentmihalyi, 1993; Tai, Liu, Maltese, & Fan, 2006) and adults (e.g., Reeve & Hakel, 2000), with little attention given to interests manifested by young children (but see Renninger, 1990, 1992, 2000; Renninger & Wozniak, 1985 for noteworthy exceptions). Researchers have also tended to focus on how "current" interests affect academic learning and motivation (e.g., Murphy & Alexander, 2002).

The current study fills a gap in the interest literature by investigating longitudinally the relation between early science interests and elementary school aged children's subsequent self-concepts and science achievement, with particular emphasis placed on potential gender differences. This link between early science interests and subsequent self-concepts and achievement may be especially important for females given their typical underrepresentation in science-related careers as adults in the United States and other countries (Ceci, Williams, & Barnett, 2009; Organisation for Economic Co-operation and Development [OECD], 2008) and a general concern over the stagnant (and even slight decrease) in the number of students pursuing degrees in science, technology, mathematics and engineering fields in the United States (Hill, Corbett, & St. Rose, 2010; National Science Foundation, 2013).

To frame this investigation, we first consider the literature documenting the prevalence and types of interests in childhood. We then consider how such interests might be related to both children's self-concepts and academic achievement, particularly in domains related to science. Finally, we conclude this section by hypothesizing why the interrelationships among these constructs may differ for boys and girls.

Interests in Childhood

Previous investigations have shown that parents frequently recognize specific interests expressed by preschool children (e.g., Hidi & Ainley, 2002; Krapp & Fink, 1992; Renninger, 1992). For example, both DeLoache, Simcock, and Macari (2007) and Johnson, Alexander, Spencer, Leibham, and Neitzel (2004) report that preschool-aged children discuss their object(s) of interest frequently, ask numerous questions, and spend a significant amount of time engaged with their domains of interest. A sustained interest in an activity or topic leads to increased persistence, positive affective engagement, and the tendency to direct attention to the object/event of interest over and above other choices (Hidi, 2000; Hidi & Renninger, 2006). For children with sustained involvement in a particular topic or domain, interest is both a psychological state and an ongoing individual predisposition to engage with particular content; it has moved beyond interest tied to a situation and has become a relatively enduring disposition termed an *emerging individual interest* (Renninger, 1989, 2000; Hidi & Renninger, 2006; Schiefele, 2009).

Renninger (1992, 2000) demonstrated that age 4 is the approximate age at which a well-developed individual interest can be identified because it is at this age when children display the attention and memory capabilities to both sustain a focused interest for a period of time and to retain knowledge about the object of interest. More importantly, Renninger (1992) claimed that at this point interest actually *leads* development by exerting powerful and pervasive effects on cognitive development. Preschooler's interests impact what stimuli are selectively attended to and for how long, as well as the specific information that is encoded and subsequently available to be retrieved. Interest during the preschool period impacts the types of play in which children engage (e.g., investigative play vs. social play; Neitzel, Alexander, & Johnson, 2008) and the types of actions they employ during play (e.g., problem solving, pretend). These cognitive activities and patterns may have long-term influences as they lay the foundation for future learning. In fact, Krapp and Fink (1992) suggest that the patterns of children's actions established within their interest domains remain somewhat stable as children make the transition from home to the school environment.

Transitioning from preschool to elementary school brings changes in both time available for interest development and topics considered interesting. When children are in preschool, they have fewer constraints placed on their developing interests than they do later when they transition to more formal curricular and extracurricular schedules (Follings-Albers & Hartinger, 1998; Renninger, 1990). Thus, preschoolers have more opportunities than older children to self-select their play materials, engage in particular play styles, and plan their activities. As they enter formal schooling, children must adhere to the schedules and assignments set forth by the classroom context and they have less available time for unstructured play in the home. School brings other changes in interests as well. Some children's interests may not align well with academic content and may change accordingly as school becomes more important in the child's life and new topics of potential interest are introduced (Hidi & Harackiewicz, 2000).

Gender differences in children's interests have been well documented. Unfortunately, a few studies have addressed the development of science interests in young children; existing research has focused primarily on older children (i.e., 4th–12th grade; Baram–Tsabari, Sethi, Bry, & Yarden, 2006; Buccheri, Gurber, & Bruhwiler, 2011; Cleaves, 2005; Folling-Albers & Hartinger, 1998; Jones, Howe, & Rua, 2000; Lindahl, 2007; Moller & Serbin, 1996; Schiefele, 2001; Tai et al., 2006; Weinraub, Clemens, Sachloff, Ethridge, Gracely, & Myers, 1984). Research does suggest that by the time they are in middle school, boys and girls have had different science experiences, with boys having more exposure to microscopes, physics experiments, and batteries and girls having more exposure to planting, gardening, and caring for animals (Jones et al., 2000). By the time they are in kindergarten, boys have read more science-related books (or have had parents/teachers read these books to them) than girls have (Mantzicopoulos & Patrick, 2010). Interests in science also vary across gender with older elementary and middle school boys expressing more interest in X-rays and technology and girls expressing more interest in health, animals, and biology (Baram-Tsabari & Yarden, 2005; Baram-Tsabari et al., 2006; Dawson, 2000; Farenga & Joyce, 1999). Stability of science interests also differs across gender, with girls becoming decreasingly interested in science as they transition from middle to high school (George, 2006), though this is not universally the case (see Stark & Gray, 1999 for data from Scotland suggesting that girls' interest in biological topics stays high throughout high school).

To be clear, children's interests do not develop in a vacuum. They get triggered within the various microsystems in which children interact, (Alexander, Johnson, & Leibham, in press; Bronfenbrenner, 1986, 1995), making parents (and teachers) important partners in the triggering and maintenance of young children's interests. Parents first notice a child's burgeoning interest through the child's preferences to engage in particular activities and the positive affect displayed while so engaged. Parents then provide support for interest maintenance, ultimately helping the interest to evolve from a situational interest to a more personal, individual interest (Hidi & Renninger, 2006). Parents act as regulators of exposure to information (Alexander et al., in press; Holden, 2010). They exert control over how much time the child can allocate to the interest, they answer curiosity questions, and provide various activities to support a child's growing interest. This coregulation model includes the beliefs and attitudes of parents toward a focus area and the resources and cultural capital necessary to support the interest (i.e., Portes, 1998).

Children's Self-Concepts

During early childhood, children begin to develop an understanding of their attributes, abilities, and values. This sense of who they are characterizes their developing self-concepts. The term self-concept is often used interchangeably with self-esteem and sometimes self-efficacy. Although these terms are related to each other (e.g., self-concept may contribute to self-esteem and self-efficacy), they do have distinct characteristics. Self-concept is a multidimensional concept that reflects one's perceptions of relative competence in various domains including social, cognitive, and physical activities. Self-concept is not as tied to a particular task as self-efficacy is, nor is it as global as self-esteem. For example, it is possible for a child to have a positive math self-concept (i.e., he/she feels very capable at math) but still have low self-efficacy for a recently learned ability to divide fractions. It is also possible for someone to have a negative math self-concept (i.e., he/she lacks confidence in math skills) but to still retain high self-esteem through a belief that one is a worthy person. Although children's initial self-concepts are frequently very concrete and prone to be overly positive, they ultimately become more realistic, abstract, and multidimensional over time, beginning around age 8 (Harter, 1998; Marsh, Craven, & Debus, 1991; Marsh, Ellis, & Craven, 2002). Research by Chafel (1987, 2003) has suggested that children implicitly construct self-concepts through everyday interactions during play and in other social settings.

Children's self-concepts have important developmental and educational implications. Children who view themselves as academically competent, physically attractive, and socially accepted may have higher self-esteem than those children who view themselves as incompetent, unattractive, or unpopular (Harter, 1990a, 1990b). Additionally, children's self-concepts may also be related to their preference for challenging activities, desire for mastery, and overall persistence and motivation (Hay, Ashman, & Van Kraayenoord, 1998; Wigfield & Karpathian, 1991). Finally, children's academic self-concepts may be related to their subsequent educational attainment. Guay, Larose, and Boivin (2004) discovered that children who perceive themselves as academically competent reached a higher level of educational attainment in young adulthood than did those children with lower academic self-concepts. This difference persisted even after academic achievement, family structure, and socioeconomic status were controlled.

It seems reasonable to hypothesize that children's interests may be related to the development and possible enhancement of their self-concepts, though an exact model of the relations, particularly for children, is not currently available in the literature. It is likely that preschool children's early interests and developing self-concepts mutually influence each other by affording children opportunities to assess their strengths, weaknesses, and desired activities while developing and refining skills (Hannover, 1998). In one of the few studies to examine the link between self-concept and interest, Marsh et al. (2005) discovered that middle school students' math self-concept was significantly related to subsequent math interest, but math interest had little relation to subsequent math self-concept. Beyond this, little is known about the links between interest and self-concept, particularly in science domains and among young children.

Gender differences in academic self-concept have been addressed in numerous studies (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Fredricks & Eccles, 2002; Marsh, 1989; Murphy & Whitelegg, 2006; Nagy et al., 2010; Watt, 2004). Results have consistently revealed that boys tend to display more positive self-concepts in math than girls. Girls, on the other hand, tend to display more positive self-concepts in reading than boys. However, few studies have addressed gender differences in science self-concept. Not surprisingly, the few studies to address this issue did find that boys display more positive self-concepts in science than girls (Hannover & Kessels, 2004; Watt, 2004), though this tends to be more true in the United States than in other countries (OECD, 2007).

Children's Academic Achievement

Various studies have demonstrated that interest in a subject matter is positively related to academic achievement (Harackiewicz, Durik, Barron, Linnenbrink–Garcia, & Tauer, 2008; Harackiewicz & Hulleman, 2010; Schiefele, Krapp, & Winteler, 1992). Interest promotes task engagement and knowledge-seeking behaviors, and these behaviors, in turn, affect academic achievement by stimulating knowledge growth, problem solving, and persistence (Krapp, 1999, Krapp, Hidi, & Renninger, 1992; Renninger, 1992). However, a majority of the studies currently available in the field have focused on older students and the role of current subject matter interest. As such, little is known about the influence of children's early interests on their subsequent academic achievement. Our study is the first we are aware of to relate early childhood interests to later outcomes, such as self-concept and academic achievement.

Research findings regarding gender influences on academic achievement have been mixed, with some researchers claiming that differences do exist (e.g., Owens, Smothers, & Love, 2003) and other researchers claiming that the differences are minimal (e.g., Beal, 1994; Klein, 2004). When differences between genders do obtain, their directionality and intensity are similar to those found in the interest literature (e.g., Hyde, Fennema, & Lamon, 1990). In the United States, boys begin outperforming girls on science achievement tests in middle school and this difference becomes more pronounced through the teenage years (Jones, Mullis, Raizen, Weiss, & Weston, 1992; Muller, Stage, & Kinzie, 2001). More recent research has suggested that there are minimal gender differences in science ability and the underrepresentation of women in science careers (particularly those in the physical sciences) is due more to societal attitudes, socialization processes, and the value placed on these careers than individual aptitude (Eccles, 2007; Haworth, Dale, & Plomin, 2009). The 2009 Program for International Student Assessment (PISA) results suggest that women are making significant strides toward equal representation in the career areas of *living systems/biological sciences* and less progress in the areas of *physical systems* and *earth and space systems* (OECD, 2010).

Overview of Current Design

This study both extends previous literature and contributes to research investigating the ongoing gender discrepancy in science-related careers (Ceci et al., 2009; Hyde, 2005; Pinker, 2005; Spelke, 2005) by evaluating and assessing factors that could be associated with children's early scientific competency, as these likely set a trajectory for later science involvement. Using a longitudinal design, this study examined the relations between preschool interests in science and later self-concept and academic achievement in science exhibited at age 8 years.

METHOD

Participants

The initial sample of children who participated in this study was part of an ongoing prospective longitudinal study focused on the development of interests ($n = 215$, 90 girls and 125 boys). Beginning at age 4 (between 4.0 and 4.6; $M = 4.2$), the children were followed for 4 years. Parents were informed at the outset that we were interested in exploring the types of play interests developed by preschool boys and girls, but were told neither about the objective of exploring the long-term consequences of early interests nor of the present study's specific focus on science-related interests. At the time of enrollment, no child had been diagnosed with a receptive language disorder or a learning disability.

Characteristics of Original Sample. The majority (77%) of the original sample was recruited throughout an urban metropolitan region of the midwestern United States, whereas the remainder was recruited through a small college community within the same state. Parents filled out a demographic questionnaire indicating that the majority of the sample was Caucasian (86%), with 6% African American, 3% biracial, and a very small percentage of Asian American children. These percentages are roughly representative of the 2000 U.S. census population in the state. The median income of participating families was in the range of $55,000–$65,000 (a middle to slightly upper-middle–class sample), and the average level of education for both mothers and fathers was 16 years (a college education).

Characteristics of Current Subsample. Participants in the present study included 121 children (69 boys, 52 girls) who were chosen because they were enrolled in the third grade (or on summer break immediately following the third grade). The remainder of the original sample was born after the kindergarten cutoff date and had not yet entered third grade. Five of the subsample children did not complete all of the tasks at age 8 and were removed from subsequent analyses. As a result, the final sample included 116 children (66 boys, 50 girls). Children were 8 years old ($M = 8.4$, $SD = 0.27$, range = 7.9–9.1) when self-concept, reading achievement, and science achievement were measured. This sample was reflective of the original sample in that the majority of the children were Caucasian ($n = 111$), with the remaining children of African American and Asian ethnicity. Eighty-nine of the children lived in an urban metropolitan area, and 27 of the children resided in a midwestern college town.

Measures

Interest measures were continuously collected beginning at age 4 as part of a longitudinal study. The data on self-concept, science, and reading achievement for the present study were collected during one session at age 8. For more details about the interest data collection process, please see Johnson et al., 2004; Leibham, Alexander, Johnson, Neitzel, and Reis-Henrie, 2005; and Alexander, Johnson, Leibham, and Kelley, 2008.

Interests Related to Science. Between the ages of 4 and 6, children's early interests were tracked through bimonthly telephone or email contacts with parents. At each contact, parents were asked multiple questions concerning the child's preferred play activities and interests. We used three key questions to define children's early interests: (1) What does your child prefer to do during free play time?; (2) If your child had 1 hour to do anything, what would he/she prefer to do?; and (3) Does your child seem to have a focused interest (and what is it in)? Science interest credit was given for topics related to life science and nature (e.g., dinosaurs, horses), earth science (e.g., rocks, space), mechanics (e.g., cars), or technology (e.g., computers). When the domain related to the interest was ambiguous, the child's reported activities within the domain were evaluated. For example, a child interested in cars who was engaged only in racing his cars around a track would *not* be credited with a mechanical science interest, whereas a child interested in cars who read extensively about different kinds of cars or about how cars worked or who collected car models in addition to his car racing *would* receive mechanical science interest credit. If the child expressed an interest in how "computers" worked, science-oriented technology interest credit was given. If the child simply used the computer to engage in games or learning activities, science credit was not given.

Between the ages of 6 and 8, parental contacts were reduced from bimonthly to quarterly contacts to reduce burden on parents. Consequently, a total of eight parental reports were collected during the last 2 years of the study. Proportions of children's science interests across the eight contacts were computed to create an index of "recent" interests in science. Having a measure of recent science interest allowed us to examine whether preschool or recent interests had a stronger effect on science achievement and self-concept at age 8.

A single author coded all parent-reported child interests as science-relevant or not. A second author recoded the interests for 20% of the sample. Raw agreement between the two coders was 97%, and the few disagreements were resolved through discussion.

Science Achievement. We used 22 items from publicly available national comparative studies to create our science achievement measure. Twenty of these items came from the International Association for the Evaluation of Educational Achievement's Third International Mathematics and Science Study (Trends in International Mathematics and Science Study [TIMSS], 2003), and the remaining two items came from the National Assessment of Education Progress ([NAEP], 2000). Eleven items assessed the domain of life science understanding, whereas 11 items assessed the domain of physical science understanding. Details regarding each item (item content, type of information required, and difficulty level as determined by TIMSS) are included in Table 1. Of the 22 items included in the current study, 20 used a multiple-choice format. One item had four possible responses (1 point each), and the remaining item was a free-response format that required children to generate their own answers. 1 point was given for generating at least one relevant response with a possible 2 points. Thus a total of 26 points were available. Because there were slightly different numbers of points available to be earned for the life and physical science–related items, we created an equally weighted composite score by adding the proportion of points earned in each domain of science.

Because the majority of children were in third grade, we chose items from the range of difficulty for third graders nationally. Both third- and fourth-grade national passing percentages for the items chosen are included in Table 1 as a reference.

Science Self-Concept. Marsh (1990) designed the self-concept scale that was used in this study (*Self-Descriptive Questionnaire-I,* SDQ-I). This measure is grounded in the Marsh and Shavelson (1985) multidimensional self-concept model. It was originally intended for children in Grades 4–6 (ages 8–12), and it is suitable for children as young as Grade 2. The original measure included 76 items that assessed four areas of nonacademic self-concept (physical abilities, physical appearance, peer relations, and parent relations), three areas of academic self-concept (general school, reading, and mathematics), and one area

TABLE 1
TIMSS Science Achievement Items

Item	Domain	Performance Expectation	Percentage of Passing[a]	
			Grade 4	Grade 3
Watering can	Physical	Complex	21	15
Floating wood	Physical	Complex	34	30
Energy source	Physical	Simple	35	29
Travels faster	Physical	Complex	41	31
Solar energy	Physical	Simple	44	35
Magnets	Physical	Complex	50	41
Makes own light	Physical	Simple	52	46
Human energy	Physical	Simple	52	45
Decomposition	Physical	Complex	54	46
Rock (NAEP, 2000)	Physical	Complex	-	-
Reflectors (NAEP, 2000)	Physical	Simple	-	-
Seeds in moisture	Life	Complex	41	31
Protection	Life	Complex	42	29
Pollen/offspring	Life	Complex	55	50
Water/bones/fish	Life	Simple	59	48
Birds differ insects	Life	Simple	60	51
Type of body (outside skeleton; backbone; hair/inside skeleton; scaly inside skeleton)	Life	Simple	62	52
Bean growth	Life	Simple	69	60
Birds foot	Life	Simple	71	61
Living things	Life	Complex	74	63
Stages of frog growth	Life	Simple	83	71
Caterpillar stages	Life	Complex	85	82

[a]The percentage of students who answered each item correctly was used to determine the difficulty level.

of general self-concept. The internal consistency reliability estimates for the eight original SDQ-I scales and total scores were between 0.80 and 0.99. Exploratory factor analyses identified and confirmed eight distinctive factors, and while researchers have found it difficult to identify psychometrically strong measures of self-perception for young children, this instrument is one of the few that has been noted for its strong psychometric properties and is viewed as a reliable and valid instrument for research purposes (Byrne, 1996).

A science-related self-concept scale was created specifically for this study. This scale was similar to both the original math and reading scales, but the term "science" was used in place of "reading" or "math." For example, the item "Work in reading is easy for me" was modified to "Work in science is easy for me." This modified scale also included fewer items than the original scales (i.e., seven items instead of nine items). Questions were answered on a 4-point Likert-type scale ranging from *not true* (1) to *a tiny bit true* (2) to *more than a tiny bit true* (3) to *very true* (4). This same scale had been used on previous measures with the children and was familiar to them. The Chronbach's alpha for the science scale was .90 in the present study, consistent with those reported for the original scales. The correlation between the science achievement measure (see above) and the SDQ science scale was $r = .17$, $p < .07$, suggesting that the scale works similarly to the previously created SDQ scales.

Reading Achievement. Given that reading is often a mechanism for acquiring more information about an interest, and that it may even be the pathway through which fluent readers sustain their interests, reading achievement was used as a covariate in several analyses. To assess children's reading achievement level, we chose the Wide Range Achievement Test (WRAT3; Wilkinson, 1993). The reading subtest consists of 42 words ranging from simple one-syllable to more difficult multisyllable words. Children were instructed to pronounce each word before progressing to the next word. If they mispronounced a word they were asked to repeat that word. If they mispronounced it again, they were told to go on to the next word. The assessment was discontinued if they missed eight consecutive words. The measurement of reading achievement using the WRAT3 is reliable as indicated by a test coefficient alpha of .88 and is normed for use with ages 6–16. The WRAT3 yields a standardized score with a mean of 100 and a standard deviation of 15.

Identifying Children With Individual Interests. For some analyses reported below, we were particularly interested in the effects of having a significant amount of experience in a science-related interest area. To capture this, children were classified as having an *individual interest* in science if parents reported an interest in a science-related domain during at least 15% of the contacts. Although 15% of contacts is a somewhat arbitrary cutoff, it represents the median number of months of science-related interests reported in this study. This classification of domain involvement reflects Krapp's (2002) proposal that interest develops along a continuum of intensity (situational interest → stabilized situational interest → individual interest). We propose that children who exhibit higher proportions (>0.15) of interest in science are likely in the midst of developing an *individual interest*.

Procedure

At the beginning of the longitudinal study, children and their parents visited one of our research laboratories located either on an urban university campus (77% of the sample) or in a rural university town after being recruited through flyers at pediatrician and activity centers or through listservs. Children completed an initial battery of cognitive tests (receptive language, working memory, etc.) not referenced in this study. As noted earlier, parents provided information on children's interests and play activities on a regular basis. This corpus of data was used to calculate measures of children's long-term interest in the science domain.

At age 8, children completed another laboratory visit at either of the two university campuses. Each visit took approximately 50 minutes. Children completed the science achievement measure followed by the self-concept questionnaire and finally the reading achievement measure. Additional tasks were administered between measure administrations and are not considered in the present study. Each participating child received a small gift.

RESULTS

We first consider descriptive information related to boys' and girls' interests, both early (ages 4–6) and current (ages 6–8). Next, we present analyses examining self-concept differences between genders and the relations between self-concept and interest. Finally, we present multiple regression analyses examining the relations among self-concept, interest, and science achievement. Table 2 provides means and standard deviation for the science interest measures as well as other descriptive statistics. Table 3 provides a correlation matrix for all variables in the study.

TABLE 2
Descriptive Statistics for Variables in the Current Study

	Girls		Boys	
Measure	*M*	*SD*	*M*	*SD*
Ages 4–6 proportion of science interests	0.13	0.23	0.44	0.37*
Ages 6–8 proportion of science interests	0.13	0.27	0.29	0.36**
SDQ Science (max 4.0)	3.30	0.64	3.16	0.75
TIMSS achievement (max 2.0)	1.31	0.24	1.34	0.29
WRAT reading	114.30	13.83	115.73	13.36

**$p < .01$.
**$p < .001$.

TABLE 3
Bivariate Correlations Among Science Self-Concept, Science Achievement, and Reading Achievement

Measure	WRAT Reading	TIMSS Achievement	SDQ Science	Ages 4–6 Proportion of Science Interests	Ages 6–8 Proportion of Science Interests
WRAT reading		.336**	.055	.027	− .016
TIMSS achievement			.165	.188*	.000
SDQ science				.093	− .083
Ages 4–6 proportion of science interests					.558**
Ages 6–8 proportion of science interests					

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

Children's Interests

To assess the effects of gender and examine the relative stability of science interests over time, a 2 (gender) × 2 (age: 4–6 years and 6–8 years) repeated measures analysis of variance (ANOVA) on proportion of contacts with science interests revealed a significant effect of gender, $F(1,114) = 16.97$, $p < .001$, $\eta_p{}^2 = .13$, a significant effect of time, $F(1,114) = 11.56$, $p < .001$, $\eta_p{}^2 = .09$, and a time × gender interaction, $F(1,114) = 13.88$, $p < .001$, $\eta_p{}^2 = .11$. Follow-up of one-way repeated-measures ANOVAs on the interaction revealed that the proportion of contacts in which girls were reported to be interested in science did not change significantly over time, $F(1,49) = 0.04$, *ns*. The proportion of contacts in which boys were reported interested in science did drop significantly after school began, $F(1,65) = 32.81$, $p < .001$, $\eta_p{}^2 = .34$. Parents reported that girls were interested in science during approximately 13% of the contacts over the 4 years, with the rate of science interests remaining very steady between the early preschool years (ages 4–6) and early elementary school years (ages 6–8). Parents of boys reported interests that were classified as science related far more frequently during both time points, though with a much larger drop off in interest reports after school began than for girls (44% of contacts from ages 4 to 6; 29% of contacts from ages 6 to 8).

TABLE 4
Descriptive Statistics for Children with More Intense and Less Intense Interests by Gender

	Individual Interests			Less developed Interests		
Measure	*n*	*M*	*SD*	*n*	*M*	*SD*
Girls self-concept	14	3.67	0.31	36	3.15	0.68**
Boys self-concept	46	3.12	0.74	20	3.24	0.80
Girls science achievement	14	19.36	3.34	36	17.11	2.55*
Boys science achievement	46	17.83	3.77	20	18.15	3.53

Note: $t(48) > 2.56$.
*$p < .05$.
**$p < .01$.
Levene's correction reported when appropriate.

The content areas of early science interests reflected a range of content domains. Preschool boys' interests tended to fall into the mechanical (cars, trains) and dinosaur categories. Girls, on the other hand, expressed more varied science interests. Of the 14 girls with at least 15% of contacts over the 4 years related to science, three consistently exhibited interests aligned with the natural world (e.g., worms, flowers, frogs); one was interested in weather phenomena; three were interested in dinosaurs. The remaining eight girls were interested in various animals (e.g., birds, insects, dogs), and these interests often intersected with pretend themes involving caring or nurturing, in contrast to the more aggressive "fighting" pretense exhibited by boys.

Self-Concept

As can be seen in Table 2, boys and girls did not differ in their overall science self-concept, $t(114) = 1.05$, *ns*. To explore this further, a 2 (gender) × 2 (intensity of early interest, described below) ANOVA was conducted to evaluate the hypothesis that children with early individual interests in science (interests prevalent at least 15% of the time between ages 4 and 6) would rate themselves higher in science self-concept at age 8 than would children with lower levels of early preschool interest (interests prevalent less than 15% of the time between ages 4 and 6). Table 4 presents relevant means and standard deviations for these variables.

The 2 (gender) × 2 (intensity of interest) ANOVA on SDQ self-concept scores revealed no significant main effects for gender, $F(1{,}112) = 2.56$, *ns* or early interest intensity, $F(112) = 1.92$, *ns*. There was, however, a gender × early interest intensity interaction, $F(1{,}112) = 4.69$, $p < .05$. $\eta_p^2 = .04$. Univariate follow-up analyses by early intensity level revealed no significant differences between males and females on self-concept for those low in interest intensity, $F(1{,}54) = 0.16$, *ns*. Results indicated a significant difference between male and female SDQ scores for those children high in early interest intensity, $F(1{,}58) = 7.06$, $p < .01$, $\eta_p^2 = .11$, with girls' ratings significantly higher than boys (3.55 vs. 3.12). Thus, girls with early (age 4–6) more intense individual interests in science rated themselves at age 8 as higher on the science self-concept scale ($M = 3.55$) than equally interested boys. These results suggest that, for girls, having significant early science interests relates to later self-concept in science. Boys' self-concept ratings are unrelated to their early science interests. The pattern was similar but nonsignificant when examining the relations between current interests (ages 6–8) and self-concept at age 8.

TABLE 5
Coefficients for Regression Predicting Science Achievement, Girls Only

Measure	β	t	p
Constant		1.03	.31
WRAT reading achievement	.38	2.98	.005*
Science self-concept	.16	1.26	.213
Preschool science interests	.29	2.23	.031*

*$p < .05$.

Science Achievement

As can be seen in Table 2, there are no overall differences in science achievement due to gender, $t(114) = -0.72$, ns. Given earlier literature suggesting differences in life versus physical science achievement by gender, we conducted a 2 (gender) × 2 (science domain: life vs. physical science) repeated measures ANOVA on proportion of correct science achievement test answers. Results indicated no significant effect of gender, $F(1,114) = 0.52$, ns. There was, however, a significant main effect of science domain, $F(1,114) = 334.09$, $p < .001$, $\eta_p^2 = .75$ and a significant gender × science domain interaction, $F(1,114) = 20.36$, $p < .001$, $\eta_p^2 = .15$. To examine the interaction more closely, univariate-repeated measures ANOVAs were conducted. There were differences in proportion of items answered correctly in the two science subdomains (life science and physical science) for both genders; boys $F(1,65) = 120.12$, $p < .001$, $\eta_p^2 = .65$ and girls, $F(1,49) = 205.10$, $p < .001$, $\eta_p^2 = .81$. Girls answered a higher proportion of the life science items correctly ($M = 0.83$) than boys ($M = 0.78$), $t(114) = 2.40$, $p < .02$. For physical science items, boys answered a higher proportion of the items correctly ($M = 0.56$) than girls ($M = 0.47$), $t(114) = 2.54$, $p < .02$.

To test the differential relations between self-concept, science interest, and TIMSS achievement scores, we used multiple regression. Current science self-concept and early preschool (age 4–6) science interests were used as predictors of overall TIMSS scores with WRAT reading scores entered as a covariate, separately for each gender. For girls, the overall model was significant, $F(4,46) = 4.98$, $p < .01$ with an adjusted $R^2 = .20$. Both the reading achievement measure, $\beta = .38$, $p < .01$, and early science interests, $\beta = .29$, $p = .03$, were significant predictors of science achievement at age 8. This suggests that reading achievement is an appropriate covariate for the model. Using Baron and Kenney's (1986) recommendations, we tested the mediating effects of self-concept on the relation between early interests and science achievement. In other words, does the relation between interest and science achievement differ for individuals with different levels of interest (an interaction)? We also tested the moderating effects of self-concept on the relation between early interests and science achievement. In other words, does the inclusion of the self-concept variable actually explain away any previous relation between interest and science achievement? No evidence of a moderating or a mediating relation was found, as all relations were nonsignificant. Simply put, the link between early interests and subsequent science achievement was not altered by the child's self-concept. Table 5 provides model details. We ran a similar model for girls substituting current science interests for early interests. The model was still significant, $F(3, 46) = 3.08$, $p < .05$ with an adjusted $R^2 = .11$, but reading achievement was the only significant predictor of science achievement at age 8, $\beta = .34$, $p < .05$. These findings suggest that *early* preschool science interests are related to later science achievement for girls.

TABLE 6
Coefficients for Regression Predicting Science Achievement, Boys Only

Measure	β	t	p
Constant		1.06	.29
WRAT reading achievement	.34	2.85	.006*
Science self-concept	.11	0.93	.355
Preschool science interests	.01	0.05	.962

*$p < .05$.

For boys, the overall model with current self-concept along with early science interests was also significant, $F(3, 62) = 3.26$, $p < .05$ with an adjusted $R^2 = .09$ (see Table 6 for a summary of the model). The only significant predictor was the reading achievement score, $\beta = .34, p < .01$. A model with current science interests was also significant, $F(3,62) = 3.30$, $p < .05$ with an adjusted $R^2 = .09$. Reading achievement was, however, the only significant predictor again, $\beta = .34$, $p < .01$. These findings suggest that neither preschool (age 4–6) nor current (age 6–8) science interests are related to boys' age 8 science achievement scores. Similar analyses were run for subtest scores (physical science and life science) separately by gender. Patterns of relations between variables were similar, but because of restricted variance, none of the predictors of the subtest scores for either gender were significant at the 0.05 level.

DISCUSSION

The goal of the present study was to explore the potential relations between children's preschool interests and their self-concepts and science achievement at age 8. Our results suggest that boys had higher levels of reported interest in science than girls—in both preschool and early elementary school. These differences did not, interestingly, translate to higher levels of self-concepts in science at age 8. In addition, we found no overall gender differences in science achievement between boys and girls. Subtest scores, however, revealed that boys did better on physical science questions and girls performed better on life science questions.

Patterns of interrelations among the variables did differ by gender. Girls' early science interests were related to higher self-concepts in science at age 8. Girls' early preschool interests in science were also related to science achievement at age 8. These findings suggest that early interest-driven experiences may be particularly important to support girls' science learning.

On the other hand, we found it interesting that there were no significant gender differences on the science self-concept scale. These findings are promising in that girls do not appear to be lagging in their assessments of their abilities in what might be considered as male-stereotyped domains. Furthermore, these results contradict Farenga and Joyce's (1999) finding that girls have little desire to learn about science. The girls in the current study rated themselves relatively high in science self-concept. Given that the majority of the girls in this study came from middle-class families, their desired motivation for science may be related to their socioeconomic status. It may be that many middle to upper socioeconomic class status families have fostered a value of science within their daughters, and they may have had the resources to provide their daughters with more science exposure and science-related opportunities (e.g., museums) than families with lower socioeconomic circumstances.

The current study found no evidence in support of gender differences in children's overall science achievement at age 8 (Hyde et al., 1990; Jones et al., 1992). There were no significant differences between girls' and boys' science or reading achievement scores. At least among the middle-class children studied here, boys did not outperform girls on standardized measures of science and girls did not outperform boys on standardized measures of reading. It is important to note that the sample in this United States–based study may not be entirely representative of the samples typically used in large-scale studies (e.g., the Progress in International Reading Literacy Study) examining gender differences in achievement. The majority of the children in this study came from middle-class homes where English was the predominant language spoken and the average level of parental educational attainment was 16 years (i.e., a college degree). Consequently, it is likely that many of these children had been exposed to both enriching literacy and science environments (e.g., numerous books in the homes, trips to museums and zoos). Subtest scores did reveal a difference in the domains of science best understood and likely enjoyed. But overall science and reading achievement remained comparable across genders. These results are promising in that they suggest that at least in this sample, girls and boys are achieving at equal levels in two important academic domains.

Self-Concept

Early interest-related experiences appear to be related to subsequent self-concepts in science for girls. As such, the current study provides evidence that children's early individual interests may be powerful factors in shaping their subsequent self-concepts. Our results do not suggest, however, that the effects of early interests on science achievement depend on or support achievement only through high levels of self-concept. In fact, our data did not suggest an overall correlation between self-concept ratings in science and science achievement at age 8. Instead, our data suggest that early interests (and likely the activities related to those interests) relate to later science achievement for girls but not boys. Below, we speculate on possible mechanisms that might drive this relation.

How Might Early Interests Influence Later Science Achievement?

A series of research studies in the past decade have begun to shed light on the role early interests and parent-supported opportunities might play in later behavior. Shaffer (2006) argues that the activities in which children participate change their ways of thinking about or justifying actions or claims—in other words, their epistemology. Because epistemology is domain specific, in order for one to think like a scientist, one needs to participate in science-related activities. Early interest-related experiences may change one's view of what's important in a problem or may change what evidence one examines during problem solving. Early and ongoing exposure to these kinds of conversations around a topic of interest may facilitate changes in what children pay attention to in class, what they read with voracity, and how they justify their decisions.

At this point, epistemological changes based on early exposure to domains of interest have not been examined, but research by Neitzel et al. (2008) provides some evidence that these claims are reasonable. Children's interests were followed a year before they attended kindergarten. Then, during kindergarten, their behaviors in classes (more than 100 different classrooms) were observed. In particular, the kinds of questions children asked and the kinds of questions children answered were of interest. Neitzel et al. found that children whose early interests were based on factual information (which is true for most preschool-relevant science-oriented domains, such as dinosaurs) were most likely to answer elaboration or factual questions when asked by the teacher and also to ask questions requesting additional factual information from the teacher. In contrast, children whose early interest areas aligned with the arts were most likely to answer questions asking for a connection or association from the teacher and were least likely to ask questions about evaluation criteria. Finally, children whose early interests were in the social domain were most likely to ask questions related to social interactions and norms as well as to answer connection or association questions from the teacher. In other words, early interests seem to be tied to the kinds of information children pay attention to and pursue in the classroom, regardless of the content of the information.

Given the very young age of the children when the present study began, parental support seems critical. This support likely happens during the day-to-day activities in the home and community. Parents and children share many activities during the preschool years. This shared history allows scaffolding of behaviors (and possibly epistemologies) and information to happen frequently and often without planning (see Crowley's similar discussion of "islands of expertise"; Crowley & Jacobs, 2002). Research has shown that parents seem sensitive to the need to respond to their child's curiosity questions (although they do not always provide correct information; Crowley et al., 2001). Parents also engage their child in supportive conversations around their child's interest (Callanan & Oakes, 1992; Callanan & Jipson, 2001; Chouinard, 2007). Consequently, it is reasonable to speculate that parents offer appropriate support for their young child based on their knowledge of their shared activity history driven to some extent by the child's interest. Such support seems critically important for young children's further interest development.

Finally, it is important to consider the role that cultural capital, including the activities that families engage in as well as the parenting practices children are exposed to, plays in children's interests and, subsequently, their academic achievement. Certainly, parents' educational attainment, occupational status, and income directly and indirectly affect the experiences children have. For example, parents who have high levels of educational attainment and sufficient income are likely to provide children with ample literacy-rich activities and out-of-home informal learning experiences in contexts such as museums and zoos. These children, in turn, are more likely than children who are not exposed to such activities to develop interests in reading and/or science. Given the opportunities that these children have to develop reading and language skills, they have an educational advantage and may be more inclined to achieve at higher levels simply because they begin school with more advanced literacy skills and/or awareness of some conceptual information. This variation in academic achievement has been supported by Roksa and Potter (2011), who found that students from middle-class backgrounds performed better in reading and math than did children from working-class backgrounds. Furthermore, children from middle-class backgrounds were more likely to be exposed to cultural activities such as theater and museum visits than were children from working-class backgrounds. Clearly, trips to theaters and museums give children more opportunities to be exposed to various interests, such as music- or science-related topics such as dinosaurs. Although interests are likely to foster learning and achievement, it is impossible to ignore the role that cultural capital plays in academic achievement.

Limitations

The findings of this study may have been restricted by the following limitations. First, the sample within this study was somewhat narrow in that children were primarily Caucasian and from middle- to upper-middle–class families. Future research should address this issue by obtaining a more diverse sample. Children's early interests may not be as important for their development if other contextual factors (e.g., socioeconomic status) are overriding influences. For example, gender differences in the factors that predict science achievement may not extend to families that are more socioeconomically vulnerable.

A second limitation may be our reliance on parents' reporting of their children's interests. We were concerned that children would not be able to provide valid responses about interests early in childhood because young children often have difficulty with self-assessments related to psychological traits (Harter, 1988). On the other hand, parental reports of their children's interests are likely filtered by their own expectations (Martin, 1999). This filtering may result in an unintentionally distorted characterization of their child's interests. Although these concerns cannot be completely allayed with our current data, relying on parent report and self-report about interests is common, and often retrospective (e.g., DeLoache et al., 2007; Ericsson & Crutcher, 1990). Our parent reports were not retrospective, and our characterization of children's interest profiles was based on a compilation of repeated reports over time. In addition, our questions were not specifically biased toward science interests, but rather addressed play interests more generally.

In sum, owing to the importance of science for the advancement of technology and global economic competitiveness, it is essential that researchers critically evaluate and assess the range of factors that could be associated with children's scientific competency. The present study identified early science interests as a critical contributor to later self-concept and achievement in science, particularly for girls. Cultivating young children's interest in science may help them to engage more positively with science texts and experiences later on in elementary school, setting a trajectory of science-related involvement over time.

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