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Exploring Girls' Science Affinities Through an Informal Science Education Program

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Abstract This study examines science interests, efficacy, attitudes, and identity—referred to as affinities, in the context of an informal science outreach program for girls. A mixed methods design was used to explore girls' science affinities before, during, and after participation in a cohort-based summer science camp. Multivariate analysis of survey data revealed that girls' science affinities varied as a function of the joint relationship between family background and number of years in the program, with girls from more affluent families predicted to increase affinities over time and girls from lower income families to experience initial gains in affinities that diminish over time. Qualitative examination of girls' perspectives on gender and science efficacy, attitudes toward science, and elements of science identities revealed a complex interplay of gendered stereotypes of science and girls' personal desires to prove themselves knowledgeable and competent scientists. Implications for the best practice in fostering science engagement and identities in middle school-aged girls are discussed.

Keywords Informal science education · Gender and STEM · Gender · Mixed methods · Motivation · Identity · Self-efficacy

Science, technology, engineering, and mathematics (STEM) careers typically provide higher than average salaries and social prestige (National Science Board 2008b), and are a possible path to improving lives, yet women remain underrepresented in these fields (Hill et al. 2010) The underrepresentation persists despite data that demonstrates that girls have all but closed the STEM achievement gap on standardized tests and exceed boys in grades received and the total number of science credits earned in high school (Nord et al. 2011). Women now also

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outnumber men in college enrollment (Dorius and Firebaugh 2010; United States Census Bureau 2011a) and in degrees earned (United States Census Bureau 2011b). The overall increase of women in higher education, however, has not led to the equal inclusion of women in the STEM careers (Corbett and Hill 2015; Kelly 1981; Saraga and Griffiths 1981; UNESCO Institute for Statistics 2014; Xu 2008). Women currently remain under 50% of the corporate workforce and under 30% of tenure track faculty in all STEM disciplines. The employment trend for women in the STEM workforce has been largely flat in the twenty-first century (Hill et al. 2010; U.S. Department of Labor and Bureau of Labor Statistics 2014).

In addition to their underrepresentation in the STEM workforce, women also experience higher attrition from STEM careers than both their male counterparts and women pursuing careers in non-STEM disciplines (Hewlett et al. 2008; Simard et al. 2008). In the corporate workplace, 52% of women leave STEM careers as opposed 17% of men (Hewlett et al. 2008; Simard et al. 2008). Moreover, in disciplines where women start out with nearly equal representation (biology, physical sciences, and mathematics), the drop in women in academic postgraduate traineeships and industry careers is even more precipitous (see Fig. 1). The drop is most dramatic in disciplines where women were above or near parity with men in undergraduate study (biological sciences, mathematics, physical sciences). Women in STEM also experience higher rates of out of field employment. Among women who earned engineering degrees between 1985 and 2003, 25% worked in a field unrelated to engineering, while only 10% of males who earned engineering degrees in the same time frame worked outside of their field (Hewlett et al. 2008).

In light of the differential attrition, the path to STEM careers is often discussed in the literature as a pipeline that disproportionately leaks girls and women from the earliest stages all the way to the top (Alper 1993). The first leak begins with the development of STEM attitudes and identities (Beilock et al. 2010; Cvencek et al. 2011; Dweck 2008; Mattern and Schau 2002; Robinson and Lubienski 2011). In the K-8 setting, research demonstrates that young children internalize gendered stereotypes about mathematics and science competence (Cvencek et al. 2011), that science careers are viewed by girls as inconsistent with emerging feminine identities (Archer et al. 2012; Archer et al. 2013), and that girls are pushed away from STEM identities in the classroom (Brickhouse et al. 2000; Calabrese Barton and Brickhouse 2006; Carlone et al. 2015; Tan et al. 2013). By high school, interest in college science majors is lower among girls than that of boys and girls with interest in science careers tend to be more focused on people-oriented disciplines or using science as a means of entering a health

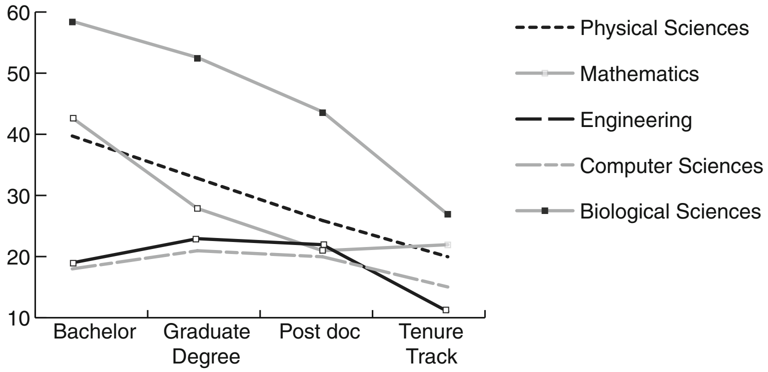

Fig. 1 Women holding STEM degrees/positions as percentage of total

profession (Kitts 2009; Miller et al. 2006). The High School Transcript Study (Nord et al. 2011) also reveals that girls are completing only 80% as many credits in physics as boys.

At the postsecondary level, 40% of men graduate with STEM degrees, while only 29% of women do (National Student Clearing House Research Center 2015). Gender disparities fluctuate heavily by discipline. In the biological sciences, women earn 58% of bachelor's degrees, however in mathematics (43%), engineering (19%), computer science (18%), and the physical sciences (40%), women are not in the majority of degree earners. Women's advantage in the biological sciences also disappears at higher STEM career levels as many of those graduates go on the careers in the medical professions (see Fig. 1).[1] Overall, women leave STEM majors at higher rates than their male peers (Chen and Soldner 2013; Griffith 2010; Hill et al. 2010).

The above primarily references circumstances in the USA, however, international data shows that only 20% of nations have achieved parity in STEM careers as defined by women representing between 45 and 55% of STEM job holders (UNESCO Institute for Statistics 2014). Globally, women represent 28% of STEM job holders. The STEM representation of women in the USA is thus fairly typical of Western European and other North American nations (19–50% with most nations around 30%). The regions of the world with the highest representation of women in STEM are Latin America (44%) and Central Asia (47%), but with a great deal of variation between nations within regions (UNESCO Institute for Statistics 2014).

The aforementioned data show that, generally, girls experience less interest and have more negative attitudes and intentions toward STEM than boys, and that women leave STEM studies and careers disproportionately compared to men following high school (National Science Board 2010b, 2014a, b; National Science Foundation 2008, 2011; UNESCO Institute for Statistics 2014). The lower affinity toward science and the steady and consistent loss of women from the STEM pipeline persist despite decreasing achievement gaps on standardized tests and increases in girls STEM achievements in high school (Bayer Corporation 2010; Hill et al. 2010). In an attempt to understand this phenomenon, researchers have examined a variety of environmental deficit hypotheses, including inequitable access to science education and experience (Walford 1981), biased curriculum and pedagogy (Spear 1987; Zohar and Bronshtein 2005), and the nature and culture of science (Gilbert 2001). More recently, it has been proposed that in addition to factors external to the individual, girls and women do not receive the same psychosocial development support necessary to build a persistent interest in STEM (Blickenstaff 2005; Brotman and Moore 2008). The possible disparity in the development of girls' identification with science provided the impetus for this study. In the following, the perceptions and experiences of participants attending an informal science outreach program built around theories of identity and self-efficacy are examined in order to gain further insight into the development of middle school girls' science affinities.

STEM and Science

The term STEM varies in connotation depending on context and has become somewhat ubiquitous in meaning. Often, the term is used as a simple shortcut to reference a set of

[1] While careers in medicine heavily employ the tools and knowledge of the STEM domains, they are not traditionally included in the umbrella of STEM (Gonzalez and Kuenzi 2012; National Science Foundation 2016). Furthermore, inclusion of these careers, where women are better represented, masks the persistent gender disparities in STEM (National Science Foundation and Directorate for Social 2017). Seems like something is missing after Social

disciplines that are perceived as conceptually similar in their approach to describing, understanding, and utilizing phenomena in the natural world. STEM is also often used in reference to the educational pipeline for careers that employ the tools, terminology, and methods of the included disciplines (National Science Board 2010a). When employed with respect to P-20 education, the term "STEM education" contains within it the idea of an integrative, cross-disciplinary approach to teaching that incorporates project-based learning activities (Sanders 2009). For the purpose of this paper, the term *science* is used to refer to the processes and methods of scientific inquiry and STEM is used to refer to the broader suite of domains/disciplines that employ these methods.

Historical Context

Research into the mechanisms underlying gender disparities in STEM has evolved over time. Early research focused on deficit theories of girls' access to and academic preparation for STEM careers. Studies in this vein examined science textbooks, female science role models, and mathematics and science achievement among girls. Textbooks were found to depict girls as objects of science rather than subjects actively engage in scientific pursuits, if they were depicted at all (Walford 1981). Suitable female science role models were scarce in education and popular culture (Evans and Whigham 1995), and girls' performance on standardized mathematics and science tests was poor (Blickenstaff 2005; Brotman and Moore 2008; Hill et al. 2010). Suggested interventions based on the deficit research perspective proposed addressing gender disparities in STEM by providing improved access to science education and on raising girls' achievement in mathematics and science.

Later, thinking on gender disparities in STEM shifted to critically examining curriculum and pedagogy that was biased in that it failed to consider girls lived experiences and ways of learning (Brotman and Moore 2008; Kelly 1981; Spear 1987; Zohar and Bronshtein 2005). Research in this area focused on addressing teaching practices that fostered gendered notions of STEM by developing gender inclusive or gender neutral curriculum (Harding 1991), on examining teachers attitudes and ways of teaching that hindered inclusion of girls in STEM (Zohar and Bronshtein 2005), and in emphasizing *depth* over *breadth* in STEM learning (Tai and Sadler 2001).

Attention next turned to reforming the culture of science. Researchers in this area employed feminist critiques of scientific culture such as standpoint theory (Harding 1991), situated knowledge (Haraway 1991), and feminist empiricism (Longino 1990). Researchers argued that STEM fields, like other disciplines, are socially constructed and subject to the values, perspectives, and biases of the inherently masculine, upper middle class, heteronormative worldview of science (Gilbert 2001). From this perspective, the path to increasing gender diversity in STEM would require identifying and challenging the inherent assumptions of science culture and confronting the sources of disparities.

More recently, research on gender disparities in STEM has included efforts to understand science learner motivation, particularly science identity formation. Identity research shifts focus from generalizations about gender experiences in STEM to focus more on differences *within* the genders, and how individual girls experience and construct ideas about science and scientists (Brickhouse 2001; Brickhouse et al. 2000; Gonsalves et al. 2013; Tan et al. 2013). Studies in STEM identity examine the many facets of identity (gender, race/ethnicity, social class, vocation) and how girls often struggle to build identities as scientists (Brickhouse et al. 2000; Griffith 2010).

Conceptual Framework

The conceptual framework that guides the current research on the science affinities of middle school girls is grounded in the psychosocial stages of development theorized by Erik Erikson (1968) and the self-efficacy theory of Albert Bandura (1997b). Combined with informal science education techniques (Bell et al. 2009) and research on expectancy-value theory and gender in career choices (Eccles 1987; Eccles et al. 1984; Eccles and Wigfield 2002), these foundational theories have been operationalized into concrete psychosocial supports for use in practical outreach settings designed to understand the pathways underlying the development of positive science affinities and retain girls in STEM education and careers.

Identity Formation Erikson's theory of identity development (1977) explored social development in youth and adults. Among youth, Erikson theorized the key stage of development as *identity* vs. *role confusion* or identity formation. The pre-teen ages associated today with middle school are the time in which identity formation begins (Erikson 1968). Identity formation is concurrent with the time when children have been observed to begin to lose interest in formal science. Archer and colleagues observed that children were confident and positive toward science until about the age of ten (Archer et al. 2010; Archer et al. 2013), the onset of adolescent identity development. Later, many children grow disillusioned with formal science, turning their attention to other pursuits (Archer et al. 2010). Regardless of age, girls and women lose interest in STEM at a disproportionally larger rate than males (Bayer Corporation 2010; Hill et al. 2010). One explanation for the disparate attrition of girls and women from science thus stems from the lack of a strong science identity formation (Brotman and Moore 2008).

Identity formation is described as a cyclical process. Individuals process and integrate both negative and positive feedbacks received from social messages. Through the integration process, the individual develops a sense of self and belonging to groups with which the individual identifies. External feedback from role models (peers, family, mentors, and other authority figures) plays an important role in the psychosocial process (Files et al. 2008; Kanter 1977). Two crucial elements of identity formation include gaining experience around the target identity and receiving feedback from role models (Erikson 1968; Gennep 1909).

Although girls have closed achievement gaps in formal STEM education, research on science learning in schools shows that they are not receiving identity-building experience of the same quality and quantity as their male peers (Burkam et al. 1997; Jovanovic and King 1998; L. Parker and Rennie 2002). In the classroom, girls are less likely to engage in self-directed, exploratory, hands-on experiences that help build expertise (Fouad and Guillen 2006; Jovanovic and King 1998), despite the differential importance these activities can have for girls instead, girls typically take notes, manage activities, and work to keep male peers "on task" during laboratory activities in school. While the management skills girls gain in these setting are valuable, they are not associated with the kinds of experience that build interest and confidence (Alper 1993). Management and oversight of activities is a more general skill set, not specific to scientific exploration. Identity development is a product of the direct experiences with the specific tasks and roles implicit in the target identity. Direct manipulation of equipment, trial and error, and the act of *playing scientist* are the foundational activities for developing an identity as a scientist (Fouad and Guillen 2006; Hazari and Potvin 2005).

Feedback serves two crucial roles in identity formation: reinforcement and social control (Côté and Levine 2002). The social acceptance implicit in confirmatory feedback helps individuals integrate and refine target identities. Feedback is also a means of social control of identity (Kerpelman et al. 1997) while negative feedback serves to deny integration of identities not considered socially acceptable. Implicit association research shows that implicitly held negative stereotypes about girls' and women's competence and appropriateness for education and careers in mathematics and science persist in 70% of the worldwide population (Nosek et al. 2002a, b). The lack of female STEM role models to provide identity building feedback and examples, and the negative social messages about women and STEM present a barrier to the development of women's science identities (Buck et al. 2008; Horn 1997; Riegle-Crumb and Moore 2013).

Self-efficacy is the set of beliefs an individual holds with regard to her ability to perform a task within a given domain (Bandura 1977). Self-efficacy is dynamic, specific, and context dependent (Hazari et al. 2010). The individual forms beliefs about ability based on three primary sources: *personal mastery* experiences, *vicarious learning* experiences, and *social persuasion* experiences (Bandura 1997b).

Mastery experiences are derive from successful completion of tasks. Past experience with tasks the same as or similar to the task at hand provides evidence of potential for mastery and increases efficacy. Past failures, or perceived failures, at the same or similar tasks will undermine self-efficacy. Failure or perceived failure has a more powerful impact on efficacy than success (Bandura 1997b). Personal mastery experiences have traditionally been considered the most important component of self-efficacy; however, context can play a role in determining the relative effect of the different components of self-efficacy (Pajares 1997).

Vicarious learning experiences come from individuals observing others, particularly others they think of as similar to themselves perform a task. Observing others perform tasks successfully is a predictor of self-efficacy (Bandura 1997b; Zeldin and Pajares 2000). In STEM domains, some researchers have found that vicarious learning is a more powerful predictor of self-efficacy in women than in men (Zeldin and Pajares 2000). Opportunity to share learning through inquiry-based classes has also been identified as a source of vicarious learning (Sawtelle et al. 2013). Context also likely plays a role in determining what constitutes a *similar* individual. Stereotypes about science and gender are well-established (Nosek et al. 2002b; Nosek et al. 2009; Steinke et al. 2007). For these reasons, girls and women may not view males successfully engaging in science activities as similar enough for vicarious self-efficacy.

Feedback received from peers, mentors, and through social messages about the individuals' capabilities around a task is called social persuasion (Bandura 1997b). Positive social persuasion experiences are most effective for individuals who have already built some positive self-efficacy around a task (Bandura 1997b). Social persuasion, in the form of social and cultural messages, plays a role in discouraging women from building efficacy in areas outside traditionally acceptable roles (Hackett and Betz 1989).

Self-efficacy is not merely a person's belief in her ability to complete a task. It is also a predictor of persistence and effort which in turn predicts success (Bandura 1997b; Hazari et al. 2010). Women's career choices have been shown to be influenced by self-efficacy while self-efficacy is influenced by gendered career perceptions (Betz and Hackett 1981). Gender has been shown to be a significant predictor of self-efficacy even beyond mastery, vicarious learning, and social persuasion, with women experiencing lower average self-efficacy in STEM disciplines (Matsui et al. 1990). Though there is evidence that girls' attitudes toward science are improving, they are still not persisting in science as would be expected given their early achievement (Glass et al. 2013).

Expectancy-value theory posits that students' motivation for learning will be predicted by two beliefs: expectancy for success and subjective task value. In simple terms, if a student believes she can successfully complete a task and views the task as useful to her in either the present or the future, she will be more motivated to pursue the task and will demonstrate higher achievement than if these beliefs are absent (Eccles 1987). In a landmark paper, Eccles examined how gender role expectations, through the lens of expectancy-value, perpetuated disparities in gendered occupations (Eccles 1987). She found that the combination of the devaluation of traditionally female roles and tasks and women's low expectations for success in male-dominated areas helped to perpetuate gender disparities. Though this work was published 30 years ago, the conditions she describes are still prevalent. Research on implicit bias shows that STEM disciplines are still heavily associated with men (Nosek et al. 2002b; Nosek et al. 2009). Research on early science identities likewise shows that girls' experience difficulty reconciling gender identities with STEM identities (Archer et al. 2012; Archer et al. 2017).

As Eccles proposed in her early work, in order for girls to develop strong expectancy-value for STEM education and careers, they will need to perceive attainments in STEM as both achievable and relevant. Numerous interventions have shown that it is possible to shift student expectancy-value by helping students to connect learning to potential present and future uses, by increasing their confidence, and/or by reducing the perceived cost of learning (Eccles and Wigfield 2002; Harackiewicz et al. 2012; Hulleman and Harackiewicz 2009). Interventions targeting a science identity should then provide context for the usefulness of science in girls' lives, help build confidence (best achieved through experience as outlined previously), and help reconcile potential conflicts between identities (e.g., gender and STEM).

Study Purpose and Significance

While a large literature on gender disparities in STEM currently exists, there is little extant research on girls' science identity development and informal general science interventions designed to promote middle school-aged girls interest in science. Studies that have examined this age group with an eye toward STEM tend to focus on school-related activities (Haussler and Hoffman 2002; Laursen et al. 2007; Parker 2000), programs that target specific disciplines or careers (Colvin et al. 2013; Haussler and Hoffman 2002; Hyun 2014), and pre-college preparatory programs (Merolla and Serpe 2013; Swail and Perna 2002; Wigfield and Eccles 2000). Much of the literature uses high-achieving or talented and gifted students as study subjects (Lubinksi and Benbow 2006; Shoffner and Newson 2001; Stake and Mares 2001) although more recent studies have sought to understand how the intersection of race/ethnicity and gender informs women and girls' STEM choices (Jayaratne et al. 2003; Riegle-Crumb and King 2010). In contrast, this study examined the experiences and perspectives of girls from a mixture of academic and achievement backgrounds who either expressed a personal interest in science and/or had a parent or guardian who wished to support an appreciation of science in their child.

In the current study, the application of a mixed methods research design enabled exploration of how girls participating in an informal science program built on motivational theories perceive and exhibit their science affinities. The theory of action underlying the program was that by providing middle school girls with identity, self-efficacy, and expectancy-value-building experiences around science in an informal setting, program participants will improve both their current affinity toward science and their longer term persistence in STEM education and STEM careers. It should be noted however that the goals of informal STEM education are not focused on particular learning outcomes. Instead, informal STEM emphasizes hands-on experience with scientific processes, learning to apply scientific concepts, participating directly in scientific practice, and most importantly, that participants come to identify as science learners (Bell et al. 2009). These goals map well onto identity (role experience, confidence building) and self-efficacy (mastery, vicarious, and social persuasion) theories. Proximal outcomes of interest were thus three science affinity components: science efficacy, attitudes toward science, and science identities. We were also interested in eliciting middle school girls' ideas about their attitudes, ability, and interest in and identification with science.

Method

The core manifestations of science identity formation, referred to here as science affinities (i.e., science efficacy, attitudes toward science, and identifying as a scientist), were the focus of the investigation. Pre- and post-intervention survey data, administrative records, and qualitative data from focus group and individual interviews with participants were used to predict and describe individual differences in girls' science identity formation.

Sample

The study sample was drawn from participants in the 2014 session of an informal science outreach intervention, hereafter referred to as the Intervention Program. Each summer, the Intervention Program provides three cohort-based camps to 60 middle school-aged girls. Twenty girls entering the sixth grade participate in the Discovery camp, 20 girls entering the seventh grade participate in the Forensics camp, and 20 girls entering the eighth grade participate in the Engineering and Computer Science camp (camp descriptions are provided below). Participants were recruited from local elementary and middle schools, home school networks, youth serving nonprofits, and word of mouth in the community. Most participants are recruited during their fifth grade year with the expectation that they will stay with the program for the full 3 years. However, a few participants are recruited following the sixth and seventh grade years to replace those who drop out of the program. In 2014, 58 middle school girls attended the Intervention Program summer camps. Of these, 31 returned from the 2013 camps and 27 were new participants (including a new sixth grade cohort). Fifty-five of the 58 girls (95%) agreed to participate in the research, but only 51 of 55 (93%) completed both the pre camp and post camp survey.

Program participants were 83% non-Latino White (n = 42), 14% Latino (n = 7), 4% Asian-American (n = 5), 2% African-American (n = 4), and 2% other (n = 2). Participants were permitted to select multiple racial and ethnic identities; 8 of the 51 participants identified as multi-racial/multi-ethnic, hence the greater than 100% total for racial/ethnic demographics. Approximately 63% of participants (n = 32) received a need-based scholarship in the year the data was collected. The percentage of program participants receiving a need-based scholarship was higher than the percentage of students that were eligible for a free or reduced-price lunch during the academic year in the county where the Intervention Program is located (55%; United States Census Bureau 2014).

The Intervention Program

The Intervention Program is a cohort-based, university-run, science outreach program targeting middle school girls. The goal of the program is to encourage more young girls to pursue STEM education and careers. The Intervention Program provides outreach activities and summer camps built on the principles of identity formation utilizing relatable near-peer mentors, positive reinforcement, and hands-on, student-centered activities. The cohort-based science camps run for 2 weeks during the summer. Participants typically range in age from 11 to 14 and attend various local schools. Each cohort consists of approximately 20 girls who matriculate through the program together.

Girls are recruited during the fifth grade academic year just when the downturn in science attitudes and confidence typically begins (Dweck 2006; Good et al. 2008; Halpern et al. 2007; Rabenberg 2013; Stake 2006). In the summer following the fifth grade, participants attend the Discovery Camp, a survey of activities from physics, chemistry, biology, geology, psychology, human physiology, and engineering with an emphasis on data collection and scientific inquiry. They return the following summer prior to entering the seventh grade to attend the Forensic Investigation camp, which covers activities related to both crime scene investigation and forensic research, culminating in a mystery scenario the girls solve in small teams. Emphasis in this camp is placed on data analysis and scientific storytelling. In the final summer prior to eighth grade, participants attend the Computer Science and Engineering camp where they learn to program Arduino microcontrollers (Banzi et al. 2016) and build fully functional pinball tables with integrated electronic and mechanical components. All three camps run concurrently for 4 days in the first week and 5 days in the second week for 7 h/day in July.

The goal of the Intervention Program is to facilitate girls' identity formation and self-efficacy through hands-on experiences and feedback from peers and relatable mentors. Girls with developed science identities are expected to be more likely to pursue STEM education and future STEM careers. Research in identity and career persistence indicates that many women who leave careers such as engineering do so in part because they have not developed identities as professional practitioners of their chosen field of work (Brainard and Carlin 1998; Glass et al. 2013). Developing strong, early science identities is hypothesized to be a precursor to developing future professional identities (Tai et al. 2006), yet extant research on the long-term persistence of early science identities is limited. Anecdotal evidence however suggests that early interventions can be effective in engaging girls' interest in science, and female STEM practitioners often identify an early positive learning experience such as a passionate teacher or a special program that sparked their interest in a particular STEM field (Dukeshire 2014; Ride 2012).

Curriculum Curriculum goals and rigor increase with each year of camp. Discovery camp curriculum is largely episodic, covering a range of topics, though data collection remains a theme in the majority of activities. Activities in the Forensic Investigation camp follow the theme of data collection and analysis, with a focus on using deductive reasoning to eliminate possible explanations for each crime scenario. The Engineering and Computer Science camp is the most rigorous, with each activity providing a new skill or tool necessary for the pinball machine construction. A full list of camp activities is provided in the online supplemental materials.

In addition to curriculum-based science activities, instructors also prepare a host of group-based games with science themes. Games are used to provide a break between activities, fill gaps in the schedule if an activity is canceled or takes less time than expected, and to help students release pent-up energy. Instructors are encouraged to use games to help students refocus and relax if they become disengaged or show signs of stress from a challenging activity.

At the end of camp, girls present their favorite activities, crime scenes, or pinball machines in small groups to an audience comprised of fellow campers, instructors, and parents. Though learning outcomes are not the focus of the intervention program, the girls consistently display mastery of new terminology, scientific concepts, and skills during these presentations.

Instructors Intervention Program instructors are primarily drawn from students (graduate and undergraduate) at the university that hosts the program. Each camp has two paid lead instructors who are responsible for setting the schedule of activities, assembling supply lists, and directing other instructors. Volunteer instructors assist the lead instructors, direct activities, develop curriculum for camp activities, and work with small groups of campers on projects. Each camp typically has six to eight volunteer instructors, mostly undergraduate students. Camp alumni also return as assistant instructors. Assistants perform a range of duties from helping with the coordination and organization of supplies to escorting campers around campus, role playing parts in the forensics mysteries, and assisting with instruction. Additionally, five former participants returned as junior assistants in 2014. The junior assistants helped with setting up activities, ran errands, and assisted younger campers with activities.

Instructor Training Instructors are trained in basic pedagogy of science outreach, introduced to major learning theories, and the camp theory of action. Instructors attend a series of trainings prior to camp, including an introduction to science outreach and pedagogy, learning theories, and brain-based learning. Workshops are taught by the program director and experienced Intervention Program instructors. Each training session is conducted over a 2-h period. A fourth workshop provides time for lead instructors to meet with their assistant instructors, test curriculum, and set schedules in consultation with the program directors. Group leaders also meet with the program director several times during the weeks prior to camp to discuss curriculum specifics. Detailed descriptions of each training can be found in the online supplemental materials.

Research Design

A mixed methods research design was employed to investigate the science affinities of the Intervention Program participants. The Intervention Program participants were administered pretest measures on the first day of camp in order to capture their pre-existing affinities toward science. Posttests of the same measures were administered again 4 weeks later via an online Qualtrics survey. Paper surveys were sent by mail to participants who did not respond to the online survey (n = 19). Paper surveys were returned between August 2014 and January 2015. Ninety-three percent of the participants (n = 51) completed the pre and post camp surveys. Qualitative data were collected using focus groups during the summer camp and through interviews of selected participants later in the summer and fall.

Instruments and Measures

The quantitative outcomes of interest were scores on three science affinity measures: science efficacy, science attitudes, and science identities. Qualitative measures included instructional observations, a focus group interview protocol, and an interview protocol. The survey instrument and interview protocols are available in the online supplemental materials.

Science Efficacy Participants' science efficacy was measured using two scales from the work of Eccles et al. (1984). The first scale measured self-concept of ability (e.g., how good at science are you; compared to most of your other school subjects, how good are you at science). The second was a scale of student task value (e.g., how important is it that you learn science; how important do you think science will be to you in the future). Each scale consisted of three items on a 5-point scale ranging from "not at all important" to "very important." Cronbach's alphas for the self-concept of ability scale have ranged from .80 to .95 (Else-Quest et al. 2013). Cronbach's alpha for the scale of task value was reported as .81 (Else-Quest et al. 2013). Both scales have been utilized many times since their initial development and validation. The scale has been used primarily with middle- and high school-aged students to measure gender and race differences in science and mathematics attitudes and perceptions (Eccles et al. 1984; Else-Quest et al. 2013; Fredricks and Eccles 2002).

Science Attitudes Participants' science attitudes were measured using the Attitudes Toward Science in School Assessment (Germann 1988). This instrument measures students' attitudes toward science with particular emphasis on studying science in schools. Original respondents were the seventh and eighth grade students. The developer reported an alpha value of .94 in the validation sample. The ATSSA scale consists of 14 items (e.g., science is fun; I would like to learn more about science) arranged on a 5-point scale ("strongly disagree" to "strongly agree").

Science Identity The item measuring science identity, "I think of myself as a scientist," was adopted from a pilot study conducted in the summer of 2013. The pilot study included an activity where camp participants ranked their interest in possible disciplines (STEM and non-STEM) for future study before and after camp. Participants also completed a brief survey (developed by the author) about their interest in science careers before and after camp. Focus groups of 5–8 participants were also conducted during the 2013 camp. Responses to survey of science career interest and transcripts from the focus groups were used to develop additional items for the science identity scale. Three items that represent the major components of identity: experience, confidence and competence, and feedback were included (I have had enough experience to know that I can be good at science; I am confident in my science skills; I receive feedback from people important to me that says I can be good at science). All items were represented on a 5-point scale ("strongly disagree" to "strongly agree").

Predictors of science affinity outcomes were years in the Intervention Program and scholarship status. Years in program and scholarship status were obtained from administrative data. Participants who joined the program in later years (7th and 8th grade) were counted as active for the number of years they participated, not the level of camp they attended. Program years had two levels, first program year (59% of the sample) or more than 1 year of participation (41%). The second predictor, scholarship status, also had two levels (scholarship or no scholarship). Scholarships were provided to students from economically disadvantaged families and served as socio-economic status proxy. Sixty-three percent of participants received a scholarship.

Observations Observations were conducted by the lead researcher and three research assistants for 23 of the 40 unique camp activities. Researchers completed an implementation fidelity rubric and took observational notes on camp activities placing an emphasis on observations of the three science affinities. These observations were coded and used to develop research memos. The rubric can be found in the online supplemental materials.

Focus Group Interview Protocol The lead researcher used an interview protocol with 11 questions and associated probes. The questions covered ideas and attitudes participants have about science and scientists, science identities, science experiences, and perceptions of gender and science. One final question addressed participant suggestions for improving the camp. The protocol was meant to help elicit conversation between the girls about their common and divergent ideas about science and scientists, their experiences with science, and their experiences as girls in science. The lead researcher omitted questions that seemed irrelevant or repetitious given girls' earlier conversations. New questions were posed by the researcher and sometimes by the girls as interesting lines of inquiry emerged.

Individual Interview Protocol The interview protocol included 20 questions divided into four thematic sections: past, present, and possible future science opportunities, science identities, ideas about science and scientists, and gender and science. Each question included 1–4 probes to be used depending on girls' responses. The lead researcher omitted or added questions as appropriate based on girls' responses and the emergence of interesting themes in the girls' responses.

Analytic Procedures

Quantitative and qualitative data analyses were performed on the responses provided by the Intervention Program camp participants and researcher observations during camp.

Quantitative Data Analysis

Descriptive and inferential statistical methods were applied to the quantitative data. A series of paired samples t tests were first conducted to determine if the mean scale scores on each of the three science affinity measures changed from the pre to post camp condition.

A 2×2 factorial multivariate analysis of variance (MANOVA) was then performed with the change in science efficacy, science attitude, and science identity scores as dependent variables and program years and scholarship status as predictor variables. The outcome variables for the MANOVA analysis were calculated by subtracting the pre camp response from the post camp response. The multivariate analysis was designed to align with the target of the intervention (i.e., the development of science affinity components) and to examine the change in the affinity for science among participants from more or less advantaged backgrounds and with a longer or shorter summer camp participation history.

Qualitative Analysis of Science Affinities

Coding and the subsequent qualitative analyses were performed using NVivo for Mac. Observations, focus group transcripts, and individual interview transcripts were coded using a simultaneous descriptive approach with sub-codes and provisional codes (Saldaña 2013). An iterative approach was taken to coding. First, a sample of each source type (interview, focus group, researcher observations) was coded using a preliminary codebook developed during the analysis of the 2013 pilot data (Todd 2013). New codes were added as ideas emerged that did not fit the existing codes. Following the initial round of coding, the emergent codes were organized into hierarchies according to theoretical framework. This codebook was used in coding the remaining documents and additional codes were added as necessary. After all the documents were coded, matrix queries were run to examine the frequencies of codes and search for codes with high overlap. Some codes were then combined for a final number of 46 non-attribute codes. The qualitative data analysis presented here includes the major themes emerging from conversations with girls as they relate to the science affinities for efficacy, attitudes, and identity.

Results

Quantitative Results

Paired sample *t* tests revealed that post camp science affinity means were uniformly higher than the pre camp means (see Table 1), but the differences were not statistically significant. Effect size estimates of the pre-post change ranged from zero to a quarter of a standard deviation.

Results of the factorial MANOVA demonstrated that the joint relationship between scholarship status and years in the Intervention Program was related to the weighted multivariate combination of science affinity measures, $\Lambda = .85$, $F\ (3, 45) = 2.71$, $p = .05$, $\eta^2 = .15$. Examination of the standardized discriminant function coefficients (SDFC) used to weight the multivariate composite revealed that science identity change (SDFC = .54) and science efficacy change (SDFC = .52) provided the largest independent contributions to the formation of the function that discriminated the groups. Science attitude change (SDFC = .21) contributed less to the function. Inspection of the structure coefficients indicated that the observed measures had relatively strong correlations with the multivariate composite, identity change ($r = .84$), efficacy change ($r = .78$), and attitude change ($r = .70$). Computation of the parallel discriminant ratio coefficients (DRC) revealed that identity change (DRC = .54 * .84 = .45) and efficacy change (DRC = .52 * .78 = .41) were relatively more important in distinguishing the groups than attitude change (DRC = .21 * .70 = .15).

Multivariate simple effects tests revealed that two of four cell centroid comparisons were statistically significant. Within the no scholarship group, participants who were in their second or third year of summer camp ($M = .70$, SD = 1.04) had greater change than first year participants ($M = -.13$, SD = 1.09), $p < .05$. The magnitude of the cell centroid difference was approximately three-quarters of a standard deviation (Hedges' $g = .74$). In addition, no scholarship students in their second or third year in camp also differed from second or third year scholarship students ($M = -.58$, SD = .82), $p < .05$ (Hedges' $g = 1.39$). Figure 2 presents the joint relationship between scholarship status and years in the Intervention Program on the

Table 1 Descriptive statistics and *t* test results for science affinity outcomes

	Pre camp		Post camp		95% CI for mean difference	Cohen's *d*	Cronbach's alpha (pre/post)
	M	SD	M	SD			
Science efficacy	25.43	3.47	25.58	3.56	− 0.63, 0.93	.04	.85/.85
Attitudes toward science	53.81	10.28	54.87	8.71	− 0.78, 2.90	.25	.96/.97
Science identity	15.14	2.89	15.78	2.63	− 0.10, 1.37	.23	.81/.77

$N = 51$

weighted multivariate combination of science affinity measures. As can be seen in the figure, while first year scholarship and second or third year no scholarship participants had a decline in composite outcomes over the summer, veteran no scholarship participants had an increase in their composite science affinity scores. Alpha was adjusted for the number of simple effects tests conducted per factor (i.e., .05/2 = .025) to maintain the probability of type I error at .05.

Qualitative Results

In the remainder of this manuscript, the terms "IP girls," "campers," and "participants" shall be used to describe the study participants. The term "girls" is intended to refer to girls more generally as they are described in the literature about gender and science. Results of the qualitative analyses are presented by science affinity component. Each component analysis uses data from observations, focus groups, and individual interviews.

In focus groups and interviews, IP girls' responses to questions around efficacy gravitated toward discussion of the role of gender in science. If girls feel that their gender undermines their chances of succeeding in science, then they will also likely have lower efficacy (Ahlqvist et al. 2013; Cundiff et al. 2013). Four themes emerged from IP girls' conversations about gender equity in STEM: women's contributions to STEM, perceived interest in STEM by gender, the role of female friends in supporting STEM interest, and the need to prove oneself.

IP girls were clearly aware that women are in the minority in science. They also recognize that messages about traditional gender roles are not consistent with science identities (feedback, social persuasion). Discovery campers associated the lack of women in science with traditional gender roles such as childcare and housework. The IP girls touched on how historic roles flow forward into the present. They connected these traditional roles to a lack of role models in the present. Many participants in the focus group discussions and individual interviews expressed the belief that while girls currently have opportunity and freedom, girls are less likely to envision themselves as scientists in the absence of a strong history of female involvement in science. This is consistent with expectancy-value theory and research on

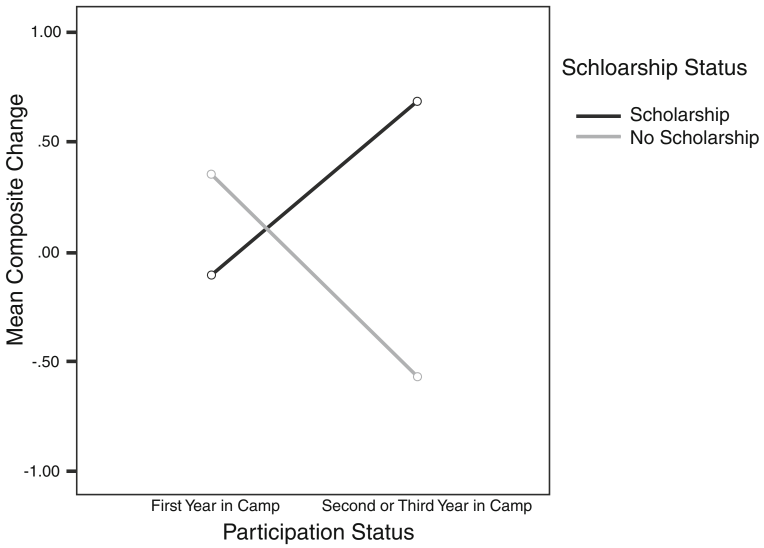

Fig. 2 Mean composite change as a function of scholarship and participation status

gendered stereotypes about science and scientists (Eccles et al. 1984; Eccles and Blumenfeld 1985; Eccles and Wigfield 1995).

Girls' lack of interest in science is often cited by teachers, parents, and commentators in the debate over gender disparities in STEM (Nosek et al. 2009). The interviewed campers were split in their views about which gender is more interested in science: girls (6), boys (2), and both equally (3). Six IP girls qualified their observations by citing a lack of social interaction outside their gender, enforced participation in coursework, or simply not having enough experience to say for certain, whether one gendered favored science more than the other.

IP girls who were already highly engaged with science prior to camp and had a circle of friends who shared their interest all cited girls as being more interested in science. IP girls without a circle of friends engaged in science were more likely to say that interest in science was gender neutral or more present in boys; these IP girls also expressed the perception that regardless of interest, boys were more likely to be acknowledged for their science skills (achievable expectancy-value). This struggle for recognition is a common theme in research on gender disparities in STEM (Bayer Corporation 2010; Hill et al. 2010).

Some IP girls conflated interest in science with studious behavior in class, attributing boys' tendency to "mess around" as a sign of disinterest. However, the behaviors described as messing around, playing with scientific samples and instruments instead of taking notes, are the types of behaviors associated with interest and identity formation (Fouad and Guillen 2006). IP girls' who critiqued boys for their lack of focus in the classroom described their own behaviors as more interested by virtue of being on task and following instructions. They described the actions of an "interested" student as involving note-taking, completing assignments, and paying attention to teacher direction. Handling equipment and carrying out hands-on activities did not factor into these girls' assessment of interest in the classroom, even though the vast majority of IP girls cite a strong preference for hands-on science activities over the "worksheet" approach to science they often encountered in school. Classically, in the classroom laboratory, girls manage activities and take on passive roles like note-taking and observing while boys manipulate equipment, often "messing around" in the process. What IP girls may be identifying as markers of interest, studious behavior, does not often translate into lasting science identities (Burkam et al. 1997; Fouad and Smith 1996; Jovanovic and King 1998). One camper summed this phenomenon by stating, "More girls *like* science, but more boys *do* science."

All of the IP girls who participated in an interview and most of the IP girls who spoke during the focus groups expressed a strong interest in science. Some were very positive toward their experiences with science and optimistic about future science education opportunities. Other IP girls were more pessimistic about their future science education and expressed frustration with their past experiences. A key difference between these groups was the presence of female friends engaged in science (feedback, social persuasion). IP girls with strong friendship circles around science were overwhelmingly positive and viewed gender-barriers as surmountable. They often expressed a desire to be female science trailblazers and help other girls who would follow. Girls without friends were by no means so certain of how long their interest in science would sustain in the face of gendered obstacles.

All of the girls interviewed were asked if they would be comfortable working in a job with few or no other women around. Nine of the IP girls expressed no concern about working in male-dominated environments, one said she would not like working without other women around, and one said that she would feel more comfortable working with other women, but that their absence would not preclude a science career choice. Most IP girls responded to the question without hesitation, and then immediately followed up with a statement similar to this one by Elaine: “I would be fine with it. If anything, it would give me a chance to prove that I’m just as good as they are at it.”

IP girls demonstrated awareness that science careers are dominated by men. For the most part, they did not express misgivings about being in the minority. However, there is an implicit contradiction in their statements. *No I’m not bothered*. *Yes*, *I feel compelled to work harder to prove myself*. IP camper Matilda summed this feeling up, “If there were less women, I would strive to be better than all the other guys.”

The qualitative methods permitted the exploration of IP girls’ attitudes toward science not just in terms of *positive* or *negative* but in terms of the ideas and stereotypes girls have about science and how those attitudes influence their choices. In the focus groups and interviews, IP girls were asked what came to their minds when they thought about science and scientists. Typical responses included lab coats, goggles, chemistry experiments gone wrong, and Albert Einstein. IP girls readily acknowledged, without any probing by the researcher, that these ideas and images were based on stereotypes mined from Saturday morning cartoons, movies, and the collective consciousness. Digging deeper, however, IP girls had many nuanced and sometimes contradictory ideas about science and scientists. Overall, they hold scientists in high regard as people who are smart, passionate about learning, and spend their time solving problems. Alexandria said, “When I think of scientist, I think they are trying to make the world a better place with their research, so I feel a bit of admiration for them.” IP girls’ stereotypic responses and their general sense of admiration for scientists are consistent with what the literature finds about the public’s attitudes toward and ideas about science (Chambers 2006; Christidou 2011; Falk et al. 2007).

IP girls agree, being a scientist is hard work. Hard work was invoked by 25 IP girls in the focus groups and four IP girls in the individual interviews. In 13 instances, IP girls linked hard work with fun or rewards. They expressed a value for persistence and resilience that ends in success. An equal number of girls linked hard work with negative outcomes. IP girls often described the life of the scientist as fraught with frustration and failure and requiring a high level of knowledge and understanding, but also possessing a measure of self-determination not present in all career options. Girls were particularly negative about “boring desk jobs” and perceived STEM jobs as largely free of the constraints of typical office work. In their conception, scientists are free to set their own schedules but choose to work long hours because of their passion for the subject matter.

Some IP girls seemed less worried about the professional challenge science presents, and more worried about the personal costs that come with a career in science. They mentioned loss of family, loss of personal time, and loss of sleep. These concerns relate directly to attitudes and beliefs about the personal costs of science as a career. In general, IP girls seem to be positive about their prospects as future scientists, but their concerns and reservations are consistent with what others have found about girls’ attitudes about science careers (Kitts 2009; Miller et al. 2006). One way to help increase motivation, per expectancy-value theory is to help reduce perceived costs. A reduction in costs could be achieved by providing examples of work-life balance in a STEM career.

IP girls were asked what made them feel the least like scientists. The most common answer was frustration. Frustration was cited by nine girls in focus groups and five in individual interviews. The frustration born of inability to understand was the most vexing to the IP girls. Four girls explicitly discussed how failure and repeated frustration had turned them off of specific science topics.

Frustration is a problem in science. Too many failures may lead girls to turn away from science. Bandura (1997a) observed that negative experiences were more influential in self-efficacy than positive experiences. Research in psychology consistently shows that bad experiences are more powerful and long lasting than good ones (Baumeister et al. 2001). As noted earlier, four girls reported specific science disciplines or activities that they actively avoided due to past negative experiences. Each time a girl turns away from an aspect of science, one more door leading to STEM careers is closed. As girls accumulate these negative experiences, their chances of persisting in STEM diminish. Coupled with girls' diminished access to meaningful science experiences as compared to boys, negative events can have a powerful impact (Alexander et al. 2012; Jovanovic and King 1998).

The requirement for knowledge and skill in science careers was interwoven throughout the discussion of ideas and attitudes toward science. Seven campers directly referenced knowledge and scientists in conjunction. However, the construct was laced throughout most conversations about science and scientists. Some campers discussed knowledge in terms of safety in scientific experiments; others discussed knowledge and mastery as core drivers behind scientific discovery. Other IP girls emphasized that scientists are people who are both knowledgeable *and* engaged in science.

IP girls' ideas about the knowledgeable scientist relate back to both identity and self-efficacy. Before individuals adopt identities, they build a bank of experiences and mastery that demonstrates to themselves (and usually others as well) that they are capable of enacting the roles required by that identity (Bandura 1976; Bergen 2002; Erikson 1968; Schwartz et al. 2011).

A subgroup of IP girls touched on the idea that scientists, while hardworking, have a certain amount of freedom to decide what they will do and how they will go about it. When IP girls talk about future jobs, they would not like, almost all of them invoked clearly distasteful images of "desk jobs" and "paperwork."

While scientific rigor requires meticulous documentation, it seems to be somewhat offset in their minds by the perception that scientists have more control over their work than other occupations. For some IP girls, this freedom is defined in opposition to the structure of school. School is a place of boundaries, rules, and dictated activities. Scientists, on the other hand, have choices in ordering their workday and choosing the topics they will study.

Control over work process is a priority for IP girls, many of who are only just out of elementary school. Adults, clocks, and bells regulate much of their day. They still have a less than complete ability to regulate their own bodies, and yet must sit for what seems like long periods of time paying attention to subjects they have not chosen. The battle for greater independence is a major part of growing up, so it follows that girls would be invested in identifying careers where they have control over their time.

In teasing out emergent science identities in the IP girls, three elements were consistently present in conversations about their own identities: curiosity, symbolic enactment, and doing science.

When the IP girls talk about the ways they are like scientists and what makes them to want to do science, they often speak of a driving curiosity and a desire to discover new places, ideas, and things. "Figuring out" or "creativity" was invoked by 11 participants during focus groups and interviews. Discovery and curiosity were used by 10 IP girls in the focus groups and two in interviews to describe either the most appealing aspects of science or to describe what makes someone a scientist. Campers were particularly intrigued by the idea of uncovering or creating something new with science. Responding to the question "What does it mean to be a scientist?", eight girls identified discovery as a key element to being a scientist. One IP girl summed up a scientist as "an important person who helps discover things." For the IP girls, being a good scientist means exploration and curiosity. The quest for discovery is the key characteristic of a scientist as someone who wants to figure out, understand, and discover. Another camper put it this way, "You can't be a good scientist if you don't ask questions or don't want to figure out why or what or how."

When asked what comes to mind when they think about science and what makes them feel the most like scientists, the campers overwhelmingly talked about the trappings of science. Just like small children enjoy dressing up as firefighters, princesses, and superheroes, the IP girls cannot get enough of lab coats, goggles, gloves, and test tubes. The focus group and interview transcripts include dozens of quotes referencing how much girls enjoy and value symbolic enactment of science roles.

Dress up may seem like a childish activity, and it is, but symbolic enactment is a powerful part of induction into identity groups and is often incorporated in to rites of passage (Erikson 1968; Gennep 1909) and early social development (Bergen 2002). Clothing is a powerful part of transitions in identity. Children are dubbed "big" girls and boys when they can dress themselves and start choosing their own clothes. A major transition into womanhood for many girls is gaining the privilege of wearing makeup, high-heeled shoes, and jewelry. During camp, when it was time to prepare for an activity using scientific garb, the enthusiasm always hits a crescendo as instructors helped participants resize goggle straps, roll up coat sleeves, and demonstrated the proper technique for donning and removing latex gloves. Social and cultural groups often incorporate garb in public rituals (Schwartz et al. 2011). These are symbols of belonging to a group, and the role play involved provides powerful social persuasion and feedback experiences that are the foundation of building efficacy and identity (Bandura 1977; Erikson 1968).

If curiosity is the gateway and symbolic enactment is part of ritual induction, then for the IP girls, the act of *doing* science is the core of being a scientist. The IP girls express a universal preference for learning science from hands-on activities. This preference extends beyond a preferred method for learning; however, it also represents the act of being a true scientist. Scientists are knowledgeable and creative, but above all, for the Intervention Program girls, scientists *do science*.

One camper elaborated on the difference between a person who simply enjoys "messing" around with science and someone who is a scientist (emphasis added):

> I think being a scientist would be really fun, but to be serious, you have a certain responsibility or else you can't really call yourself a scientist if you're not really *doing science*. I think you have to have the responsibility to at least try to figure things out.

Archer et al. (2010) reported similar findings in their study of elementary science identities. For children, science identities are rooted in hands-on experiences and performative acts more than they reside in mastery of subject matter. The Intervention Program campers agree. While many of them enjoy the intellectual side of science and the problem solving, what makes them feel like scientists is ritual and activity. Associating doing science with science identities may be problematic for IP girls. Research shows girls are less likely to have the opportunity to directly engage with science (Alexander et al. 2012; Hill et al. 2010; Jovanovic and King 1998). Girls may also find their nascent science identities in conflict with their femininity. The masculine perception of science as rooted in the cerebral, not nurturing, and antisocial, is in direct contradiction to most girls' conceptions of themselves as normal, caring, active, and feminine (Archer et al. 2012, 2013).

Discussion

Extant research indicates that until about the age of 10 or 11, boys and girls both have strong interest and confidence in their science abilities (Archer et al. 2010). The research literature also suggests that as early as the second grade, boys and girls have internalized stereotypes associating science and mathematics with boys and reading with girls (Cvencek et al. 2011). During the middle school years, girls begin losing their initial interest in science at a faster rate than boys and by the age of 14: most adolescents have developed the level of interest in science that will persist throughout their lifetime (Blickenstaff 2005; Chesler et al. 2010; Cundiff et al. 2013; Watt et al. 2006). As a key predictor of the later pursuit of STEM education and careers, the level of early science interest serves as a focal point for interventions designed to retain more girls and women in STEM education and careers (Osborne et al. 2003).

Quantitative Findings

The downward trend in middle school girls' interest in science was the motivating factor underlying the current study. We sought to investigate whether participation in an informal summer science program was associated with a positive short-term change in middle school girls' science affinities and examine girls' perceptions regarding science norms and practices.

Examination of study participants' science affinity scores revealed that post camp means were higher than the pre camp means by upwards of a quarter of a standard deviation, but the differences were not statistically significant. Perhaps more importantly, the variability in science affinity outcomes was associated with IP girls' background characteristics and experiences. While first year participants from economically disadvantaged backgrounds (i.e., those who received a need-based scholarship) had a positive increase in science affinities, peers who were participating in their second or third camp demonstrated a decline. The reverse was true for IP girls from economically advantaged backgrounds (i.e., no need-based scholarship), resulting in a large difference in science affinity outcomes for veteran participants from divergent economic backgrounds.

Figure 3 provides a conceptual composite graphic of predicted affinity scores by scholarship status. As the figure shows, those awarded a need-based scholarship initially experience gains in science affinities, peaking after the first or second year before decreasing over time. Economically disadvantaged participants were thus predicted to end the second year of camp with higher average science affinity scores than they started with prior to their first year in the program. Conversely, non-scholarship campers were predicted to experience only small (or slightly negative) gains in their first year, and experience increasing science affinities over time. Although it is not currently known why the Intervention Program participants from different economic backgrounds had divergent longer term trajectories, the joint relationship between scholarship status and years in the program on science affinities may be due in part to the Intervention Program not providing enough, or the right kind of intervention for low-income girls. The relationship could also be due to higher income IP girls who were already on an upward trajectory *vis a vis* science affinities prior to attending camp. In addition, it should also be noted that the Intervention Program participants receiving scholarships might have had a more pronounced decline in science affinities without the intervention. Examined from this vantage point, temporarily sustaining a relatively high affinity for science is an improvement over what the literature predicts will happen to most girls, a steady decline and turn away from STEM.

Qualitative Findings

Major themes that emerged from the qualitative data included IP girls' perceptions of gender and science, IP girls' ideas about scientific work as challenging and potentially frustration, and the ways in which IP girls' ideas about scientists can both support and undermine formation of strong science identities. As outlined next, the Intervention Program participant perspectives and experiences were largely consistent with extant research about science affinities in girls and identity and self-efficacy formation.

Gender Perceptions and the Intervention Program

Many Intervention Program girls acknowledged traditional gender roles as an impediment to science careers, though they were defiant in the face of social restrictions. In focus groups and interviews, IP girls consistently acknowledged the history of sexism and gendered expectations in keeping women out of STEM careers. They took two different perspectives about how gender discrimination might impact their own prospects as women in science. Some IP girls felt that gender discrimination was still a factor in STEM careers while others relegated discrimination to the past. When the issue of gender discrimination in science careers came up during focus groups and interviews, the researchers asked participants if they believed discrimination was still a barrier. Roughly, two thirds of IP girls in these groups believed that it was. About one third believed it was not. A few were uncertain.

Interestingly, IP girls from both perspectives expressed the intent to succeed in STEM studies by surpassing boys in achievement, by being "better than all those guys." Sentiments like these were expressed in interviews and focus groups and were consistently seconded by other IP girls during focus groups. Other comments from girls included a willingness to fight back against sexism and "whack them on the head with my [science] wand." Statements like these were provided by girls who felt that gender discrimination was a still a problem in science and those who did not. They consistently agreed that if they encountered gender-based problems in possible future science careers, they would rise to the challenge and prove their worth as scientists.

On the surface, these declarations of defiance are encouraging, signaling that IP girls are prepared to resist gender discrimination in STEM. However, a closer examination reveals a dangerous ideology. That is, in order to be successful in STEM careers, women must be exceptional to the point of besting *all* of their male colleagues (and implicitly the majority of women), something simply not possible for any but an extremely small portion of STEM aspirants.

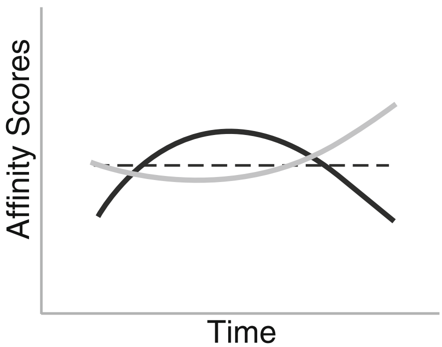

Fig. 3 Predicted science affinity scores over time by scholarship status

IP girls' perceptions of imbalances in interest in science seemed to be influenced heavily by the presence of science-engaged peers. IP girls with friends who enjoyed science were more likely to cite girls as being more interested in science than boys. IP girls who felt a dearth of female science peers observed more boys engaged with science. Relatable peers are an important component for both identity and self-efficacy (Bandura 1997a, b; Schwartz et al. 2011). Research has shown that students are more likely to identify with science if they have peers like themselves who also identify with science (Olitsky 2007; Taconis and Kessels 2009).

The Intervention Program is designed to be particularly strong in addressing gendered perceptions of science. The program provides female role models, peers, and many opportunities to try and share science activities (Riegle-Crumb and Moore 2013). A more explicit discussion of how to cope with stereotypes and challenges might also be helpful to IP girls. Participants in the focus group that discussed disparities in depth seemed galvanized by the sharing and determined to proceed with their interest in science despite obstacles. Previous research has shown that direct discussion of gender disparities in STEM has helped motivate girls toward science careers (Hazari et al. 2013; Weisgram and Bigler 2007). However, the program occurs only once per year and the Intervention Program alone may not be enough to overcome messages that undermine girls' science-efficacy.

Attitudes and the Intervention Program

The IP girls held a range of stereotypical ideas about scientists (fuzzy-haired, old, white, male chemists), but they also had more sophisticated ideas about scientists and science. The main attitudes that relate to the IP girls' interest in science are: scientists as highly knowledgeable, scientists as hard workers, frustration and failure in science, and self-determination in science careers.

IP girls' ideas about scientists as highly knowledgeable and hardworking are closely interrelated. Intervention Program girls see scientists as people who spend long nights puzzling over research, perhaps at the cost of their social lives and families. Scientists work hard to become experts. The IP girls are not particularly excited about the notion of hard work; however, they also believe that scientists choose to work hard because they are passionate about science. This more nuanced view of science provides evidence that children may be engaging in deeper thinking about science and what it means to be a scientists than is presented in the literature on attitudes toward science (Chambers 2006; Falk et al. 2007). Archer et al. (2010) explored a divide between children's ways of *doing science* (dangerous, exciting, intrepid) and the act being a scientist (socially awkward, obsessive, lonely). Children in Archer's study did not associate the kind of science they enjoyed with a true science identity, which was, on balance, unattractive to children. IP girls' trepidation about science careers centered more around personal sacrifice than social standing, but the divide was similar. IP girls acknowledge the less than glamourous stereotypes about scientists, but their reservations were rooted in deeper concerns about the impact of a science career.

The history of research on girls in STEM has focused on achievement in science over investigation of psychosocial factors. Dweck and colleagues have shown that a focus on achievement over process in science education can turn girls away from mathematics and science (Dweck 2008; O'Rourke et al. 2014; Yeager and Dweck 2012). Emphasis on achievement over persistence and growth sends the message that science is only for the brilliant and innately talented. Another recent study has shown that women avoid disciplines with a reputation for innate talent being a prerequisite for success (e.g., physics and economics

(Leslie et al. 2015). IP girls' concerns about the hard work and inevitable frustration of a career in science may be early symptoms of the tendency among IP girls to adopt a *fixed-mindset* in science that Dweck observed in mathematics and science students (Dweck 2008).

The Intervention Program provides opportunities to both confirm and mitigate IP girls' ideas about scientists as knowledgeable and hardworking. The Intervention Program instructors are knowledgeable role models who share their experiences as students with the campers. The IP girls get to see that scientists do work hard because they enjoy science, but also that they are relatable human beings with social lives and interests outside of science.

IP girls see practicing science as a source of potential frustration and failure. Science is challenging, and failure is common. IP girls also see scientists as having more control over their work and more choices in what they do. Still no one enjoys constant failure and frustration. The Intervention Program helps provide girls with context in defining failure. While an experiment may not turn out as expected, there is always room to learn from mistakes. The Intervention Program camp allows girls to fail in an environment where they can work through frustration with support and encouragement.

It should also be noted that the multivariate analysis of the change in science affinities revealed that identity and self-efficacy played a larger role in distinguishing the groups than attitudes toward science. This is consistent with more recent research by Glass et al. (2013) that revealed girls' attitudes toward science are improving, but their interest in pursuing science study and careers is not. It may be that for IP girls, positive attitudes are not enough to increase persistence in STEM, thus highlighting the importance of self-efficacy and identities in science.

Limitations

The goals of this study were twofold. First, the study sought to gain a better understanding of the Intervention Program and changes in girls' science affinities, and second, to explore how girls build identities as scientists. However, it should be noted that in order to determine the short and longer term impacts the Intervention Program may have on girls' science affinities, an experimental research design with random assignment to conditions or a strong quasi-experimental design (i.e., regression discontinuity) and pre- and post-measurements of both groups would be necessary. Without use of these designs, no causal claims can be made about changes in participants' science affinities or the divergent outcomes of participants with different background characteristics. The small sample also had limited power, thereby compromising the ability to detect statistically significant relationships. Furthermore, due to the select sample of girls who participated in a unique informal science camp, readers are necessarily cautioned about generalizing the statistical findings to other populations or informal science intervention programs.

Generalizability concerns also extend to the qualitative findings. Although all participants' were present during the focus group sessions, some of the more reserved IP girls and IP girls who appeared to not have strong opinions about science remained quiet during the conversations. The data presented here were from IP girls' eager to speak out on the subject who may not be representative of girls in general. Similarly, interviews were conducted with a small sample (n = 11) of IP girls whose parents were willing to take time out to meet with the researchers in the months following the camps. These parents were eager for their daughters to participate in the research, and as a result, the voices of IP girls whose parents were not as invested in the project are not well represented.

Implications for Practice

Despite the select sample of IP girls studied herein, the Intervention Program participants' experiences and affinities likely share common elements that are present in the wider population of middle school students. As the Intervention Program operationalizes well-researched theory into clear guidelines for engaging adolescent girls with science, these practices could easily be adapted to other outreach programs and possibly into the formal classroom environment. One advantage of the emphasis on engagement and psychosocial supports in the Intervention Program is the broader applicability of the techniques employed. Outreach programs, particularly those sponsored by professional organizations overwhelmingly focus on a particular discipline or career area (American Chemical Society 2017; American Physical Society 2017; Society of Women Engineers 2017), making it challenging to adapt innovations in one subject area to a different discipline. One advantage of the Intervention Program's emphasis on engagement and providing support for psychosocial development is the broader applicability of the techniques employed. The Intervention Program has adapted a wide range of material across many disciplines over the years. It is the approach that has remained constant rather than specific curriculum. Other programs may find it useful to adapt the Intervention Program camp approach to their specific subject matter.

IP girls' reflections on the Intervention Program and classroom study also suggest a number of improvements for classroom science curriculum delivery. IP girls' engagement at the Intervention Program camp is high and is attributed to the operationalized elements of hands-on science engagement, use of tools, language, and garb of science, access to relatable experts, and engaged peers. Though providing hands-on science in school classrooms can be challenging and cost more than textbooks and worksheets, the potential for increasing engagement by students traditionally disengaged in science class may possibly outweigh the challenges. Some simple changes that could increase engagement in science classrooms would involve inviting diverse expert guests into the classroom, highlighting the accomplishments of underrepresented scientific trailblazers, discussing science careers, and acknowledging the accomplishments of students. These are, however, fairly common recommendations. To extend the idea of role models in the classroom, inviting relatable peers involved in scientific activities might be more powerful. Special attention should be placed on finding role models that are relatable to young girls. Rather than career women, who can be challenging to locate and schedule, classrooms can ask older local students engaged in STEM-related pursuits like robotics teams, green clubs, and school garden projects to share their experiences applying scientific process to concrete enjoyable pursuits. Coaching guest speakers (adult and youth) in connecting their interests to current or future uses of scientific learning could help girls in the science classroom develop expectancy-value for their science studies (Colvin et al. 2013; Weisgram and Bigler 2007).

IP girls expressed concerns about the compatibility of work/life balance with STEM careers. Teachers can open up honest dialogs with students about students perceived gendered obstacles to STEM careers. Hazari et al. (2013) found that explicit discussions were predictive of girls' interest in science careers. Teachers can also draw attention to dangerous assumptions, like those that women must be better than men in STEM to succeed. A large body of research shows that women receive less recognition for their scientific accomplishments (Bayer Corporation 2010; Hill et al. 2010; Holmes 2011; Rosser 2012) but rather than encouraging girls to accept this standard and seek to succeed through perfection, educators can channel girls' energy into seeking attention and support for their accomplishments. Learning these skills early will help girls secure mentors and build valuable self-advocacy skills that are often cultivated implicitly and explicitly in boys (Blickenstaff 2005; Jovanovic and King 1998; Leibham et al. 2013; National Science Board 2008a; National Science Foundation 2014; National Science Foundation and Directorate for Social 2017; Stake and Nickens 2005).

Study participants consistently expressed desires for more hands-on scientific engagement in and out of the classroom. In cases where hands-on activities for all students are not possible, including students directly in front of the classroom demonstrations would provide engaging vicarious learning opportunities, while signaling that students are both trusted and capable of conducting scientific experiments. Teachers can also provide students with information on activities that can be carried out outside of school, and encouraging them to engage in science with friends is another way teachers can support girls. To help incentivize, teachers could provide brief opportunities for students to share the results of their independent explorations to the classroom and make sure to keep a gender balance in presentations. Mini presentations would permit students to enact the role of and benefit from being a science expert.

Future Directions

Research on gender and science identities has traditionally focused on building theory about how girls construct science identities (Brickhouse et al. 2000; Calabrese Barton and Brickhouse 2006). Few studies have actually examined the role of interventions (formal and informal) in contributing to the science identity building process (Haussler and Hoffman 2002; Hazari et al. 2010; MacDonald 2000; Todd 2013, 2015). By examining how girls participating in an informal STEM intervention exhibit identities, attitudes, and self-efficacy around science, this study sought to help fill the gap. Going forward, research on the Intervention Program will focus on replicating the study with a control group, collecting multiple years of data for longitudinal analysis, and refining the scales of measurement to better discriminant participants' science affinities.

Continuation of the study over multiple years will provide a larger data set with repeated measures on the same participants. A longitudinal study design with a randomized control group will support causal inference regarding short and longer term program effects. Repeated measures over several years will also provide the opportunity to track the trajectory of change in girls' science affinities. Lastly, modification of the science affinities scale to facilitate distinctions at the high end of the distribution might be useful in revealing subtle changes in the affinities of already highly science-engaged girls. By expanding the scaling options, it might be possible to differentiate between girls who enjoy science and girls who are fiercely passionate about science, allowing a more individualized targeting of program resources.

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