International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: http://www.tandfonline.com/loi/tsed20

Scientist role models in the classroom: how important is gender matching?

Laura D. Carsten Conner & Jennifer Danielson

To cite this article: Laura D. Carsten Conner & Jennifer Danielson (2016): Scientist role models in the classroom: how important is gender matching?, International Journal of Science Education, DOI: 10.1080/09500693.2016.1246780

To link to this article: http://dx.doi.org/10.1080/09500693.2016.1246780

Published online: 01 Nov 2016.

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, 2016
http://dx.doi.org/10.1080/09500693.2016.1246780

Routledge
Taylor & Francis Group

Scientist role models in the classroom: how important is gender matching?

Laura D. Carsten Conner [a] and Jennifer Danielson [b]

[a]Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK, USA; [b]Goldstream Group, Fairbanks, AK, USA

ABSTRACT

Gender-matched role models are often proposed as a mechanism to increase identification with science among girls, with the ultimate aim of broadening participation in science. While there is a great deal of evidence suggesting that role models can be effective, there is mixed support in the literature for the importance of gender matching. We used the Eccles Expectancy Value model as a framework to explore how female science role models impact a suite of factors that might predict future career choice among elementary students. We predicted that impacts of female scientist role models would be more pronounced among girls than among boys, as such role models have the potential to normalise what is often perceived as a gender-deviant role. Using a mixed-methods approach, we found that ideas about scientists, self-concept towards science, and level of science participation changed equally across both genders, contrary to our prediction. Our results suggest that engaging in authentic science and viewing the female scientist as personable were keys to changes among students, rather than gender matching between the role model and student. These results imply that scientists in the schools programmes should focus on preparing the visiting scientists in these areas.

ARTICLE HISTORY
Received 17 May 2016
Accepted 6 October 2016

KEYWORDS
Gender; equity; role models

Introduction

Female under-representation in Science, Technology, Engineering, and Math (STEM) fields has been studied intensively over the recent years and still remains a problem. While there have been advances towards equity, particularly in fields such as biology, the overall proportion of female science researchers, as compared to males, is low internationally (28% female worldwide; UNESCO, 2015). The causes of this under-representation are myriad, but can be attributed at least in part to a lack of interest and identification with science among young girls (Baram-Tsabari & Yarden, 2010; Jones, Howe, & Rua, 2000; Kahle, Parker, Rennie, & Riley, 1993; Murphy & Whitelegg, 2006). Girls frequently report that science is not relevant to their interests (Archer et al., 2012; Brotman & Moore, 2008), and they commonly perceive science as a rote, uncreative, and passionless enterprise that leads to an unattractive lifestyle (Miller, Blessing, &

CONTACT Laura D. Carsten Conner ldconner@alaska.edu Geophysical Institute, University of Alaska Fairbanks, 903 N. Koyukuk Drive, Fairbanks, AK 99775, USA

Schwartz, 2006). Girls also commonly perceive scientists as male (Chambers, 1983; Finson, 2010), which can lead to conflicts between gendered identities and science identities.

Science identities can not only be cultivated through experiences that stimulate interest in science, but are also affected greatly by sociocultural factors (Bell, Tzou, Bricker, & Baines, 2012) such as *significant persons* (Sjaastad, 2012; Woelfel & Haller, 1971) who exert influence on the youth. These influencers include teachers, parents, scientist role models, and others. Connections with significant persons can either positively or negatively impact interest and identification with science. For instance, parents and teachers can have a positive influence on STEM motivation and persistence (Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Hazari, Sonnert, Sadler, & Shanahan, 2010; Ing, 2014), but they can sometimes negatively impact identity through reinforcing negative stereotypes about girls' abilities in math and science, as well as the suitability of science careers for girls (Andre, Whigham, Hendrickson, & Chambers, 1999; Colley, Comber, & Hargreaves, 1994; Gunderson, Ramirez, Levine, & Beilock, 2012; Tenenbaum & Leaper, 2003). Here, we examine the influence of female scientist role models on a suite of factors that may predict the choice to become a scientist through the framework of the Eccles Expectancy Value Model (EVM) (Eccles, 2009).

Background

Who young persons want to become depends in part on the possibilities they see for themselves with respect to their social and cultural environment (e.g. Markus & Nurius, 1986). Youths take cues from those around them in order to envision and enact new 'Possible Selves'. Yet, the cues that young girls receive in and out of school about what science is and who does science are often not conducive to envisioning themselves in science. Many studies have revealed that school science, in particular, often does not connect with the interests and concerns of girls (e.g. review by Brotman & Moore, 2008). Osborne, Simon, and Collins (2003) suggest that school science tends to focus on the names of scientists and accomplishments in the far past, rather than focusing on what contemporary scientists actually do (e.g. experimentation and other science practices), and how modern-day science might relate to everyday life. Further, when science is taught in the absence of the opportunity to engage in practice, conceptions of what science actually is, and subsequent interest in the subject, are limited among students (Driver, Leach, Millar, & Scott, 1996).

With respect to scientists themselves, the literature has repeatedly documented that K-12 aged students hold stereotypical views (e.g. Chambers, 1983; Finson, 2010; Fralick, Kearn, Thompson, & Lyons, 2009), particularly with respect to gender. The 'Draw-a-scientist' test (DAST) has revealed that students typically see scientists as male, wearing a white lab coat, and often doing something dangerous (Chambers, 1983; Finson, 2010). Girls may see science as 'a boy thing' or something that does not connect to their interests (Archer et al., 2013; Miller et al., 2006). Such ideas are at the heart of conflicts between gendered identities and science identities. As girls develop ideas about what constitutes a conventional 'female' identity, they may be disinterested in pursuing avenues such as science that seem 'unfeminine' (Brickhouse & Potter, 2001), or they may be encouraged to participate in science in ways that are consistent with more conventional gender identities (e.g. obedient, good student, and quiet; Brickhouse, Lowery, & Schultz, 2000). It is commonly suggested that the introduction of female role models might help girls envision themselves in science careers, as gender-matched role models can provide information about roles that are appropriate specifically for one's own social group (e.g. Zirkel, 2002).

So who are these role models, and how should they interact with youth? Role models are variously defined in the literature, but here we use the concept of 'significant persons', modified by Sjaastad (2012) from Woelfel and Haller's (1971) original conception of 'significant others'. Within this conception, role models can range from people who have little interaction with individuals, such as someone read about in the news, to individuals who have a significant level of interaction with individuals, such as parents or teachers. The former type can be thought of as 'models,' who can provide examples of possible selves either with or without directly interacting with individuals, while the latter can be thought of as 'definers,' who provide information about possible selves through direct interaction (Sjaastad, 2012).

A number of studies have looked at the impact of definers and models on women's career choices, as well as factors that might later predict career choice among girls. While role models have a significant impact on many of these factors, there is mixed support in the literature for the importance of gender matching. Quimby and DeSantis (2006) used a quantitative approach to examine the influence of female role models on career choice among women. They found that both the influence of the role model and perceptions of self-efficacy were important, but that the role model influence accounted for career choice over and above the influence of self-efficacy, especially for non-traditional careers. Zirkel (2002) found that exposure to a gender- and race-matched model resulted in increased academic performance, increases in achievement-related goals, and increases in achievement-related activities among girls. In another study, Stout, Dasgupta, Hunsinger, and McManus (2011) found that exposure to female STEM role models promoted science self-efficacy, positive attitudes, and STEM identification among girls. Buck, Plano Clark, Leslie-Pelecky, Lu, and Cerda-Lizarraga (2008) showed that girls' ideas about scientists changed significantly after long-term exposure to female science role models. However, Carrington, Tymms, and Merrell (2008) found that gender matching between teachers and students did not matter with respect to attitudes about science, mathematics, and other subjects. Bagès, Verniers, and Martinot (2016) found that role model gender did not matter in improving girls' math scores, but instead, the message communicated by the role models was most influential (in this case, that hard work is more important than innate talent for math success). Betz and Sekaquaptewal's (2012) work showed that overly feminine science role models can actually demotivate girls to pursue science, possibly because girls perceive the match between a non-traditional career and a 'girly' girl as too unlikely.

Purpose

The purpose of this study was to extend existing knowledge about the influence of gender matching with respect to scientist role model influences on elementary students. Specifically, our purpose was to better understand (1) to what extent female scientist role models impact affect towards, and beliefs and ideas about, science and scientists among elementary students; and (2) in what ways does interacting with female scientists lead to changes in these areas. We used a mixed-methods approach to assess ideas about scientists, interest in science, participation in science, and self-concept of science.

Theoretical perspective

We approach the question of influence and outcomes through a social cognitive lens, where the emerging self is shaped by a suite of experiences, including behaviour, cognition, and environmental factors. In particular, we rely on the Eccles EVM (Eccles, 1994, 2009; Eccles et al., 1983) to frame this study. EVMs originated with Atkinson (1964), but have since been elaborated and linked to a fuller set of variables (Eccles & Wigfield, 2002). Importantly, the Eccles form of the EVM links to identity theory, where questions about who the person is and what they want to become are paramount (Eccles, 2009; Markus & Nurius, 1986; Markus & Wurf, 1987).

Eccles and her colleagues have developed the EVM to explain how social and affective factors impact a number of outcomes, such as career aspirations, achievement, and avocational and behavioural choices. In particular, the EVM links such outcomes to the input of socialisers, social role-related beliefs, self-perceptions and self-concept, and to the individual's perceptions of activities and tasks (Eccles & Wigfield, 2002). The EVM has been applied extensively to questions of differential behavioural choices associated with gender or race. The EVM generally posits that behavioural choices are the consequence of a constellation of factors, including a person's confidence, and expectation of success, in a given task (expectancy value) and the value that one places on a given task. The value component of the model includes interest (how much a person thinks he or she might like doing a particular thing), utility value (how useful the person perceives the task to be), attainment value (how well the task reflects a person's identity), and cost (anxiety about the task and fear of failure, for instance). The collective value of an activity relates to the relative balance between the perceived benefits and costs associated with the behavioural choice or task. In turn, expectancy and attainment value are heavily influenced by emerging identity and ideas about the self, which in turn are influenced by a suite of social factors.

With respect to gender differences in vocational and educational decisions, Eccles (1994) posits that *interest* is key to the choices that girls make, and that this interest is mediated by factors such as gender role identification, which in turn may be mediated by social influencers. If social influencers hold stereotypical beliefs about the suitability of science activities and careers with respect to gender, or about girls' science- and math-related abilities, this is likely to influence girls' own beliefs, and may impact interest.

Conversely, a prediction proposed by Eccles (1994, p. 590) is that role models may legitimise 'novel and/or gender role-deviant options'. Thus, a female scientist in the classroom may have the potential to turn around the scenario described above, providing a social influence that mediates gender role identification in a positive way. These predictions are consistent with Possible Selves Theory (Markus & Nurius, 1986, p. 954), which helps explain 'individual's idea of what they might become, what they would like to become, and what they are afraid of becoming'. In Possible Selves Theory, sociocultural and historical factors, such as role models and other influences, provide the grist from which individuals can envision types of possible selves. These ideas about potential future selves represent hopes, fears, and goals that feed into self-concept, and can influence behaviour. Thus, exposure to a female role model could provide the spark for imagining oneself as a scientist. The fact that these scientists were significantly younger, on average, than the classroom teachers, could also be of importance. Some studies (Bruce, Bruce, Conrad, & Huang, 1997; Laursen, Liston, Thiry, & Graf, 2007) suggest that working with a scientist who is closer in age to students may be a factor in identifying with the scientist.

As is consistent with EVM, interest in science, ideas about scientists, self-concept towards science, and voluntary participation in science-related activities are all important aspects that influence behavioural choices such as the decision to become a scientist. We posited that interactions with a female scientist over the course of the year would serve as a mediator to influence these aspects in a positive direction. While actual career choice could not be measured in this study, the factors measured here can serve as strong proxies for STEM pursuit throughout life (Simpkins, Davis-Kean, & Eccles, 2006).

Methods

Context of the study

The study took place in the context of the CASE (Changing Alaska Science Education) GK-12 programme, a scientist–teacher partnership programme that paired graduate student scientists with teachers from the local school district in grades K-12. The programme was part of the National Science Foundation's Graduate STEM Fellows in K-12 Education (GK-12) Program. The broad goals of this programme as a whole include (1) improved STEM communication and teaching skills for graduate fellows, (2) professional development opportunities for K-12 teachers, and (3) enhanced learning and STEM career interest for K-12 students. CASE goals specifically reflected these broad programmatic goals.

The scientists participated in project activities (including preparation and lesson development) for 15 hours per week for one year (typically 10 hours in the classroom and 5 hours in preparation). CASE scientists working at the elementary school level were each partnered with two teachers, and spent an average of five hours per week in each classroom. Prior to their work in the schools, the scientists received pedagogical training during a 1-week intensive summer institute and two semester-long classes. The spring semester class prior to the start of the fellowship was a 2-credit course, while the fall semester class during the course of the fellowship was a 1-credit, seminar-style course. The training was embedded in the 'six strands' science learning framework (developing science interest and excitement, understanding scientific knowledge, engaging in scientific reasoning, reflecting on the nature of science, engaging in science practice, and identifying with science; Feder, Shouse, Lewenstein, & Bell, 2009). Instructors modelled techniques and provided experiences that prompted the scientists to think about the nature of alternate conceptions and other areas relevant to science learning. Scientists also learned techniques for classroom management and gained experience in mapping activities to state science standards. Approaches to inclusivity and diversity were also addressed, including embedding lessons in an appropriate cultural context. Finally, training included a focus on respecting student ideas and interacting with students in an empathetic manner.

During the year of the actual scientist–teacher partnership, scientists generally created and taught lessons that were linked to the mandated state curriculum. However, they also had the latitude to develop a number of science experiences and lessons that were more closely tied to their specific research area. Thus, they served as knowledgeable content experts, while the partner teachers provided pedagogical guidance. The activities that the scientists led varied tremendously, but generally incorporated science practices such as observing, hypothesising, predicting, analysing and interpreting data, developing and using models, and constructing explanations. While the sheer extent of activities (10 hours per week of science over the course of a year, with unique activities for each scientist) makes a full account untenable, some examples are illustrative.

One activity involved activating prior knowledge about the sun and solar energy, then asking students to make predictions about whether or not the heat from the sun could be strong enough to cook S'mores. In groups, the students built solar cookers and took observational and temperature data during the cooking process. They graphed data and then had a discussion about variables that may have influenced the outcomes. In another activity, the scientist set up a scenario in which a professional volcanologist called the class and gave them clues about a mock volcanic eruption in progress. The students then analysed and interpreted data about different volcanoes to solve the mystery of which volcano was erupting. They extended this knowledge by building models of various actual Alaskan volcanoes. Several of the scientists explored concepts related to anatomy or physiology by having students build large-scale models of the digestive tract, or engaging in a participatory dissection of a moose heart. The scientists frequently led science-based games with the students, as well.

During the years of the present study, a large proportion of female graduate students applied to and was accepted to the programme, making a fortuitous circumstance for studying the impact of female role models on students. This study focused only on outcomes associated with the CASE scientists who were female and worked at the elementary school level.

Participants

This study took place in a small city in Alaska over two years. There were seven participating female scientists (mean age = 28.5). All of the scientists were Caucasian. Each of these scientists worked in two public school classrooms for a total of 14 classrooms reached. We elected to focus on grades 2–6 only, as students below second grade did not yet have the skills necessary to complete the written survey. Thus, one classroom reached by one of the scientists was not included in the study, as it was a first-grade classroom. We enrolled students in the study with cooperation from the regular classroom teacher, using standard Institutional Review Board guidelines. One teacher elected not to use the study tools with her class, bringing the total number of classrooms studied to 12. Study participant grade level broke down as follows: 63 students were in second/third-grade multi-age classrooms (~age 7–8 years); 41 students were in straight third-grade classrooms (~age 8 years); 48 were in fourth- to sixth-grade multi-age classrooms (~age 9–11 years); 40 were in straight fifth-grade classrooms (~age 10 years); and 39 were in straight sixth-grade classrooms (~age 11 years) (all ages are the approximate age of students at the beginning of the school year). In total, 231 students were enrolled

(118 females and 113 males). The ethnicity of participants was as follows: 64% Caucasian; 17% Alaska Native; 7% two or more races; 6% Hispanic; 3% African American; 2% Asian; and 1% Native Hawaiian.

Quantitative data collection and analysis

To look at the impacts of having a role model in the classroom, we used a mixed-methods sequential explanatory design, in which it is standard to collect quantitative data, and then follow up with a subset of participants through interviews (Creswell & Plano Clark, 2007). For quantitative data collection, we developed a survey that included 26 items. Participants were asked to what extent they agreed with each statement on a Likert-like scale, where 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. For questions related to science participation, a four-point scale was also used, where 1 = never, 2 = rarely, 3 = sometimes, and 4 = very often. When items indicated a negative association with science (e.g. 'a career as a scientist would be boring'), we reverse scored the answers. Twenty-five of the questions fell into four constructs that represent features consistent with the Eccles EVM: ideas about scientists, interest in science, participation in science, and self-concept towards science. The survey also included one item, 'science is a better career choice for a man than for a woman', that was evaluated independently (it did not reliably fall into one of our four constructs, yet was an important question to evaluate). To measure the reliability of the constructs, we calculated Cronbach's alpha coefficient for each, incorporating both pre- and post-survey scores (Table 1). Cronbach's alpha is a measure of internal consistency among items included in a construct. All of our scales have alphas in the reliable range (acceptable reliability values can range from 0.7 to 0.95 depending on the context; Nunnaly, 1978). Pre-surveys were given at the beginning of the school year, prior to the students meeting the female scientist (August). Post-surveys were given two months prior to the close of the school year (March). To assess the impacts of having a scientist in the classroom with respect to interest in science, ideas about scientists, science participation, and self-concept towards science, we first calculated an average score for each construct. We used statistical procedures (e.g. ANCOVA) to detect differences in scores by gender, and paired *t*-tests to assess overall changes from pre- to post-surveys.

Qualitative data collection and analysis

As indicated above, the study utilised a mixed-methods sequential explanatory design. Thus, the goal of the qualitative portion of the study was to build on quantitative results by seeking to elucidate the ways in which any detected impacts may have come about. We made methodological choices that minimise validity threats to our chosen

Table 1. Reliability of survey constructs.

Construct	Number of items in construct	Cronbach's alpha
Ideas about scientists	6	0.729
Interest in science	3	0.830
Science participation	11	0.713
Self-concept towards science	5	0.787

design: (1) we used a large sample for the quantitative component and a small sample for the qualitative component and (2) we chose a subset of the original quantitative participants for participation in the qualitative phase (Creswell & Plano Clark, 2007).

In the qualitative phase, we conducted post-only interviews (near the end of the school year), observed each female scientist a minimum of two times while she was working with students, and reviewed lesson plans developed by the scientists. For the interviews, we selected classrooms associated with three scientists who worked at different grade levels: two second/third-grade classes (~ age 8–9 years at the time of the interviews), two fourth-grade classes (~age 10 years at the time of the interviews), and two sixth-grade classes (~age 12 years at the time of the interviews). These classrooms were randomly selected from the full set of classrooms surveyed. We interviewed 5 students from each of the 6 classrooms reached by these scientists (one interview was truncated for a total of 29 complete interviews). Students were randomly picked from lists of female vs. male students to assure an equal gender representation among interviewees. Fourteen interviewees were female and 15 were male.

Our interviews were semi-structured and focused on areas predefined as constructs in the survey: interest in science, ideas about scientists, self-concept towards science, and science participation. Two interviewers conducted the interviews. We specifically asked if and how interactions with the female scientists led to change in these areas. We also asked questions about how the student felt about the female scientist, and what kinds of activities she did with the students. There were 14 questions in all. Interviews generally lasted from 7 to 13 minutes, with one interview lasting only 4 minutes. The interviews were audio recorded and transcribed.

With respect to data analysis, we used a directed content analysis approach, in which initial codes are predefined based on existing theory (Hsieh & Shannon, 2005). Thus, our initial round of coding involved applying a priori codes that matched survey constructs as defined above (interest in science, ideas about scientists, self-concept towards science, and science participation). We provide a description and anchor example for each code in Table 2. Both authors independently applied these initial codes to the interviews; inter-rater reliability was 91% (this statistic was derived using the group consensus method, DeCuir-Gunby, Marshall, & McCulloch, 2011). During subsequent rounds of coding, we defined additional codes to help identify emergent themes. We applied these codes

Table 2. Codes, descriptions, and examples for qualitative phase.

Code	Description	Example(s)
Ideas about scientists	Students discuss views of scientists before and after the scientist came to their classroom	Before: 'I always thought scientists would wear lab coats and do crazy experiments.' After: 'They're usually just normal people; you might not even know they're scientists. They're not like people might think they are.'
Interest in science	Students indicate that interacting with the scientist changed their interest level in science	'Not always [did I have interest in science], but since she came, I have.' 'Ever since I met her, it sounded like a lot of fun, being a scientist.'
Science participation	Students indicate that interacting with the scientist changed how often they do science in their everyday life	'I like making volcanoes at home now. The only bad part was I was the one who has to clean it up'
Self-concept towards science	Students indicate a change in attitude towards their own science ability as a result of interacting with the scientist	'When she came I got better at science.'

to excerpted text segments using Dedoose. During a period of code refinement, we grouped many codes together and re-parented the codes under the initial codes (e.g. 'personality traits of scientist' was re-parented under 'ideas about scientists'.). The sub-themes identified within each of the major categories helped us understand the ways in which having a female scientist in the classroom may have brought about changes in some of the survey construct/initial code areas. We discuss these themes below.

Results

Survey outcomes

We set out to examine the extent to which female scientist role models impact affect towards, and beliefs and ideas about, science and scientists among elementary students. To assess this, we used a paired *t*-test that compared the mean pre-survey construct scores with the mean post-survey construct scores. Scores as a whole increased significantly in all construct areas except interest in science (Table 3). Effect sizes were highest for self-concept towards science and for all constructs together. In these cases, the effect sizes were medium, while the effect sizes for the ideas about scientists construct and the science participation construct were between small and medium (Cohen, 2013). Thus, score changes appear to be both statistically significant and meaningful in a real-world context.

In addition to looking at the overall impact of the female scientist in the classroom, we were interested in looking at impact by gender. We predicted that the impact of female role models would be more pronounced among girls than boys. To assess whether student gender was a significant factor, we conducted an ANCOVA, with gender as the independent variable, class (the classroom that hosted the female scientist) as a random factor, and pre-survey scores as a covariate. Using ANCOVA with this covariate adjusts the post-survey means in a way that accounts for differences in pre-survey scores among groups, so it is the most appropriate approach for this study (Dimitrov & Rumrill, 2003). Contrary to our prediction, there was no significant effect of gender on the total scores or any construct areas (Table 4). There was also no class or class × gender effect on the total scores or on any of the construct areas. That is, there was no difference between girls and boys with respect to how their scores changed from pre- to post-survey across constructs.

We analysed one item, 'science is a better career choice for a man than for a woman', individually rather than as part of a construct. We reverse scored the answers, so that a higher score means that students were more likely to *disagree* with the statement. We

Table 3. Changes in pre- vs. post-scores in five construct areas and entire survey.

Construct area	Pre-survey mean	Post-survey mean	*t*-Value	SD	df	Cohen's *d*	Difference pre to post
Ideas about scientists	3.26	3.36	2.85	0.57	230	0.22	**0.10***
Interest in science	2.93	3.01	1.43	0.85	226	N/A	0.08
Science participation	2.14	2.26	3.66	0.53	230	0.23	**0.12****
Self-concept towards science	2.76	3.04	5.90	0.70	230	0.46	**0.28****
TOTAL	2.77	2.92	4.76	0.50	231	0.35	**0.15****

Note: Significant differences at $p \leq .05$ are in bold. *$p < .01$, **$p < .001$.

Table 4. Effect of gender and class on construct areas (difference between pre- and post-scores).

		F				
Source	df	Ideas about scientists	Interest in science	Science participation	Self-concept towards science	All constructs
Gender	1	0.04	0.12	1.17	.61	0.77
Class	11	1.58	1.36	1.95	.47	1.41
Gender * class	11	1.37	1.89	0.55	.79	1.08

Note: No significant differences at $p \leq .05$ were detected.

measured differences in response using ANCOVA, with gender as the independent variable, class as a random factor, and pre-survey scores as a covariate. In this case, there was a significant effect of gender (Table 5). Class and class × teacher were not significant. Descriptive analysis and a paired *t*-test indicated that there was less change in girls' answers from the pre- to post-survey than there was in boys' answers, and that changes from pre- to post-survey were only significant for boys' scores alone, and for pooled gender scores (Table 6). The lack of significance for girls was likely due in part to the high pre-survey scores among girls. That is, girls were highly likely to disagree with the statement prior to any interaction with the female scientist, and thus, there was not much room for movement on the scale.

Interview responses

As indicated above, we coded according to four a priori categories that aligned with our survey constructs and were consistent with the EVM: ideas about scientists, interest in science, self-concept towards science, and change in science participation. Below, we detail the narratives that emerged around each. With respect to gender, there were no quantifiable differences in the nature of interview responses among girls vs. boys in any categories, which is in accordance with the quantitative finding of no gender effect.

Ideas about scientists

The majority of participants (20 out of 29) noted that interacting with the female scientist changed their ideas about scientists. Interview responses indicated that most participants, regardless of gender, generally held stereotypical ideas about scientists before the scientist came to the classroom. A large number of participants mentioned that they previously thought scientists wore lab coats, engaged in 'crazy experiments', and did not like kids.

Interview participants talked about ways in which interactions with the female scientist changed their ideas about scientists. One common theme was positive affect towards the scientist. Participants reported liking the scientist because she was unexpectedly nice, fun,

Table 5. Effect of gender and class on men vs. women career item (difference between pre- and post-scores).

Source	df	*F*
Gender	1	**8.85****
Class	11	2.28
Gender * class	11	0.72

Note: Significant differences at $p \leq .05$ are in bold. $^{**}p < .01$.

Table 6. Changes from pre- to post-scores for the question regarding suitability of science as a career for men vs. women. Four is the maximum score.

	Pre-survey mean	Post-survey mean	*t*-Value	SD	df	Difference pre to post
Girls' answers only	3.70	3.80	1.27	0.82	110	0.10
Boys' answers only	3.11	3.44	2.79	1.20	102	**0.33***
All answers	3.42	3.63	3.00	1.02	213	**0.21***

Note: Items that changed significantly from pre to post at $p \leq .05$ are bolded. *$p < .01$.

cool, or funny, and that she did interesting and fun things with the students. Several were surprised that the scientist appeared to like interacting with them.

> I didn't really think of scientists as kid-liking people. But then it was like 'wow,' she's really nice and really kid-friendly …

A number of participants also talked about how after interacting with the female scientist that their ideas changed about who can be a scientist. Surprisingly, only one participant brought up gender with respect to how their ideas about scientists had changed, saying 'some people say that scientists are boys' but noted that the scientist was a girl. Responses tended to include the idea that anyone could be a scientist, as illustrated in the representative quotes below:

> Yeah, anybody can be a scientist from kindergarteners – two-year-olds to as old as you can get.

> They don't have to be just a type of person; they don't have to be smart, but if they just – if they try hard enough they can be.

Interest in science

About half of the interviewees (17/29) reported increased interest in science as a result of interacting with the female scientist. Several participants indicated that they now wanted to be a scientist, and at least three participants indicated that they wanted to engage in the same specialty as the female scientist that they interacted with (e.g. volcanology). Responses that uncovered the reasons for this change tended to be related to change in ideas about science itself. Participants talked about how their conceptions of science became broader in terms of things that a scientist could study. Several participants talked about how working with the scientist gave them an appreciation for the complexity and depth of science and that science is more than just a list of facts:

> And so, when she came, I was like, 'Well, there's more to it just than Pluto's not a planet anymore; Mars is made of this.' It's like more complex. And yes, because she taught us about lots of different scientists that I didn't know that they studied that stuff even.

Another change in ideas about science involved students seeing the personal relevance of science. Students expressed that science is a part of everyday life, something that covers 'the whole world'.

> Before Scientist xxxx came, I thought scientists were just people who have all these magic potions and all that stuff, but then I learned that earthquakes, peanuts, anything that you study can be science.

Self-concept towards science

Most interviewees (22 out of the 29) agreed that they were better at science since they started working with the female scientist. Participants thought that they were better at science because they learned new things from the scientist, or that their depth of science understanding had increased. In general, these changes were attributed to the way the scientist did things in the classroom, such as in-depth explanations and process-driven science activities:

> Because with science before, when we would have it, the people would just be straight on facts and not really explain much, so that way you would just get the information but you wouldn't get the processes or things behind the information that made it interesting like Ms. xxxx showed us.

Participants also explicitly discussed the impact of hands-on activities in increasing their self-concept, as opposed to learning only from books. They referred to the games and other activities that the scientist led as 'good and cool ways' to teach science, and noted that this resulted in a better understanding and self-concept towards science.

Change in science participation

About half (16/29) of the participants reported that interacting with the female scientist changed their level of participation in science outside of school. Many of the respondents made reference to the types and range of activities that the scientist did with them, such as making volcano or bee models, building circuits, touching a moose heart, or doing experiments, in sparking an interest to explore science further outside of the classroom. As previously noted, the scientists focused on practices of science such as open experimentation, and a number of participants commented on how this made science 'fun'. Participants talked about building on classroom activities and practices to further explore something:

> [after she came] I started breaking up rocks at home with a hammer, just to see what's inside.

> I've done some science. Like at my grandma's house, I used to do little science projects, and now I really love to do them at her house. So, Ms. xxxx talked about something. I'll kind of find a project in that little book she has that has to do with that, and I'll do those experiments [at home] now.

Some participants noted trying to replicate a mock volcanic eruption with a 'Hawaiian' volcano at home after working with 'Alaskan' volcanoes at school with the scientist. After one of the female scientists led an experiment with worms in the classroom, one participant reported trying the same experiment with ants instead of worms at home. Another participant talked about teaching science to her two-year-old sister by replicating an activity about water filtration that she had done with the scientist.

Quantitative and qualitative triangulation

The purpose of a mixed-methods, explanatory design is generally to explore questions of impact through quantitative means, and to explain findings using qualitative results. Taken together, the two phases of this study paint a picture in which several constructs related to the EVM, specifically ideas about scientists, self-concept towards science, and change in science participation, were impacted by the visiting scientist. These areas are both statistically significant (quantitative) and robust with respect to explanations of how changes in these areas came about (qualitative). With respect to the interest construct, although interest did not change significantly in the quantitative phase, the qualitative phase indicates ways in which a subset of participants may have increased their interest in science. Overall, the two phases point to a picture in which the personality characteristics of the scientists and the nature of the activities that they conducted in the classroom were impactful for students with respect to science dispositions and attitudes.

Discussion

We set out to examine the ways in which interactions over an extended period of time with a female scientist role model would lead to changes among elementary students in areas that might predict the choice to become a scientist. The fact that we detected changes in a number of areas among girls is consistent with the predictions of Possible Selves Theory and the EVM, in that the female scientists could be serving to normalise what is often perceived as a gender-deviant role. Girls interacting with a female scientist might see new possible selves in science as a result of these interactions.

However, we saw that changes in ideas about scientists, level of science participation, and self-concept towards science occurred among boys, as well. Contrary to our prediction that impacts would be more pronounced among girls, there was no detectable difference in these changes across genders. Thus, interactions with the female scientists in this study appeared to have benefits for all students, with respect to changes in how students see themselves in science. It is clear from the interview responses that the majority of students held stereotypical ideas about scientists prior to the visits by the female scientists, and that these ideas changed as a result of interacting with the scientists in this study (although the fact that the girls in this study strongly believed that science is a good career choice for a woman as well as a man at the pre-interaction stage suggests that these girls were not fully bought in to typical gender role stereotypes with respect to science careers). Identity theory predicts that input and interactions with socialisers are keys to the development of science interest, self-concept, and further participation (Eccles, 2009); thus, the change in these stereotypical views may be at the root of the changes we detected across genders, regardless of gender matching, or lack thereof, with the female scientist. After interactions with the scientist, many participants characterised science as something that everyone can do, which has been identified as an important message that supports science identity development (e.g. Baker, 2013). It is important to note that boys were more likely to see science as an appropriate career choice for both a man and a woman after interacting with the scientist.

A key finding from the qualitative analysis was that the female scientists went beyond book learning and 'facts', instead delving into authentic practices of science. The literature indicates that school science often does not adequately allow students to engage in the practices of science (e.g. Osborne et al., 2003) and that students often have a limited understanding of the true nature of science (e.g. Lederman, 2007). Because scientists have first-hand experience with science, they are ideally positioned to guide students in these practices. Direct engagement with science practice, such as interpreting scientific explanations, generating and evaluating evidence, and participating in scientific discourse, is not only essential for students to achieve proficiency in science (Feder et al., 2009; Schweingruber, Duschl, & Shouse, 2007), but is also an important component of coming to identify with science (Barton & Brickhouse, 2006). We posit here that the nature of the activities done with the scientist (e.g. rich with science practices such as observing, analysing, etc., as well as the hands-on nature and 'fun' format) and the enjoyment of the activities were important components in increasing the expectancy value (self-concept towards science) and utility value (through connection to everyday life) components with respect to students' positioning towards science. Thus, the nature of the activities was probably at least as important in the impacts we detected as was the socialising impact of the female scientists.

While we have implicitly defined the female scientists in this study as role models, the question remains as to whether or not the research participants explicitly viewed them as such. While we did not ask specifically if students viewed the female scientists as role models, anecdotal evidence suggests that at least in some cases, students looked up to the scientists and wished to emulate them. For instance, in one classroom, one of the scientists started a cultural trend among girls in which they emulated her style of dress. A few studies have posited that the younger age of scientists in the classroom, as opposed to classroom teachers, is a factor in student/scientist connections, and it may have been a factor here. Certainly the anecdotal evidence and some of the comments from the students suggest that sometimes the scientists in this study were viewed as 'cool' and desirable to emulate. Further, our findings are consistent with the literature with respect to how students identify role models. For instance, Buck et al. (2008) found that students saw the scientists that they worked with as role models based on whether or not they had 'a good personality, expertise in science, and [were] able to make personal connections' (p. 12). Similarly, Sjaastad (2012) found that a personal connection was paramount to students with respect to who they perceive as a role model. Our study found that there was a high level of positive affect towards the female scientist among both genders, and students tended to characterise the scientist as someone who was nice, fun, and made science interesting, suggesting that the students did make meaningful connections with these scientists in the context of a 'definer' type of role model. To the extent that this implication holds true, our study adds further support to the literature suggesting that personal connection is perhaps more important than gender matching when it comes to role models.

There are some limitations to our inferences. The quantitative portion of our study was designed to test the hypothesis that outcomes would be different across genders, and thus, used procedures to detect differences across groups. We did not find such differences; instead, we found gains in construct areas across *both* student genders. These results rely on a pre-/post-design with no control, and thus, it is possible that our study could be subject to internal validity threats. However, the qualitative results reveal specific ways in which the research participants themselves report changes over the course of the year, and the research participants discussed ways in which these changes were brought about by interacting with the female scientist. We believe that this methodological triangulation significantly reduces validity threats. We also acknowledge that other factors may have been at play with respect to impacts that we detected, including the long duration of the exposure (over the course of a year), or the novelty of having a visitor who was not the regular classroom teacher. Future studies should attempt to disentangle the effects of gender, age, novelty, and duration.

Our results imply that programmes that place scientists in classrooms hold great potential for impacting students. There are a large number of 'scientist in the schools' programmes worldwide. Such programmes should place an emphasis on authentic, hands-on science, as well as making meaningful connections with students. It is unlikely that meaningful personal connections that led to the types of changes we detected in this study can be made during the course of a single visit; thus, we suggest that interactions put in place by other programmes should be of significant duration to establish a personal connection. However, dosage effect was not studied here, so we have little to say about what specific duration of contact would be appropriate and impactful. Visit dosage would be a ripe area for future role model studies. Finally, we suggest that programmes training scientists emphasise empathy and positive interactions with students, as the perception of a scientist as nice and friendly appears to be directly linked to many of our results.

Acknowledgements

We thank the partner teachers of the female scientists for working with us to conduct the study in their classrooms. We also thank Suzanne Perin and the two anonymous reviewers for their helpful comments that greatly improved the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Science Foundation under [grant number DGE-0948029].

References

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching*, *36*(6), 719–747.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus how families shape children's engagement and identification with science. *American Educational Research Journal*, *49*(5), 881–908.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, *21*(1), 171–194.

Atkinson, J. W. (1964). *An introduction to motivation*. Princeton, NJ: Van Nostrand.

Bagès, C., Verniers, C., & Martinot, D. (2016). Virtues of a hardworking role model to improve girls' math performance. *Psychology of Women Quarterly*, *40*, 55–64.

Baker, D. (2013). What works: Using curriculum and pedagogy to increase girls' interest and participation in science. *Theory Into Practice*, *52*(1), 14–20.

Baram-Tsabari, A., & Yarden, A. (2010). Quantifying the gender gap in science interests. *International Journal of Science and Mathematics Education*, *9*(3), 523–550.

Barton, A. C., & Brickhouse, N. (2006). Engaging girls in science. In C. S. Skelton, B. Francis, & L. Smulyan (Eds.), *The Sage handbook of gender and education* (pp. 211–235). London: SAGE.

Bell, P., Tzou, C., Bricker, L., & Baines, A. D. (2012). Learning in diversities of structures of social practice: Accounting for how, why, and where people learn science. *Human Development*, *55*, 269–284.

Betz, D., & Sekaquaptewal, D. (2012). My fair physicist? Feminine math and science role models demotivate young girls. *Social Psychological and Personality Science*, *3*, 738–746.
Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*, 441–458.
Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching*, *38*(8), 965–980.
Brotman, J., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, *45*, 971–1002.
Bruce, B. C., Bruce, S. P., Conrad, R. L., & Huang, H. J. (1997). University science students as curriculum planners, teachers, and role models in elementary school classrooms. *Journal of Research in Science Teaching*, *34*, 69–88.
Buck, G., Plano Clark, V., Leslie-Pelecky, D., Lu, Y., & Cerda-Lizarraga P. (2008). Examining the cognitive processes used by adolescent girls and women scientists in identifying science role models: A feminist approach. *Science Education*, *92*, 688–707.
Carrington, B., Tymms, P., & Merrell, C. (2008). Role models, school improvement and the 'gender gap' – do men bring out the best in boys and women the best in girls? *British Educational Research Journal*, *34*(3), 315–327.
Chambers, D. (1983). Stereotypic images of the scientist: The draw a scientist test. *Science Education*, *67*, 255–265.
Cohen, J. (2013). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
Colley, A., Comber, C., & Hargreaves, D. J. (1994). Gender effects in school subject preferences: A research note. *Educational Studies*, *20*, 3–18.
Creswell, J. W., & V. L. Plano Clark. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: SAGE.
DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2011). Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field Methods*, *23*, 136–155.
Dimitrov, D. M., & Rumrill, P. D. (2003). Pretest-posttest designs and measurement of change. *Work*, *20*(2), 159–165.
Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.
Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78–89.
Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgly, C. (1983). Expectations, values and academic behaviors. In J. T. Spence (Ed.), *Perspective on achievement and achievement motivation* (pp. 75–146). San Francisco, CA: W.H. Freeman.
Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*, 585–609.
Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109–132.
Feder, M. A., Shouse, A. W., Lewenstein, B., & Bell, P. (Eds.). (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.
Finson, K. (2010). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics*, *102*, 335–345.
Fralick, B., Kearn, J., Thompson, S., & Lyons J. (2009). How middle schoolers draw engineers and scientists. *Journal of Science Education Technology*, *18*, 60–73.
Gunderson, E., Ramirez, G., Levine, S., & Beilock, S. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*, 153–166.
Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science*, *23*, 899–906.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978–1003.

Hsieh, H., & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*, 1277–1288.

Ing, M. (2014). Can parents influence children's mathematics achievement and persistence in STEM careers? *Journal of Career Development*, *41*, 87–103.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests and attitudes toward science and scientists. *Science Education*, *84*, 180–192.

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (1993). Gender differences in science education: Building a model. *Educational Psychologist*, *28*, 379–404.

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K-12 classrooms. *CBE—Life Sciences Education*, *6*, 49–64.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 831–879). New York: Routledge.

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist*, *41*, 954–969.

Markus, H., & Wurf, E. (1987). The dynamic self-concept: A social psychological perspective. *Annual Review Psychology*, 38, 299–337.

Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high-school students' views about science. *International Journal of Science Education*, *28*(4), 363–381.

Murphy, P., & Whitelegg, E. (2006, June). *Girls in the physics classroom: A review of the research into the participation of girls in physics* (Institute of Physics Report). London.

Nunnaly, J. (1978). *Psychometric theory*. New York, NY: McGraw-Hill.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*, 1049–1079.

Quimby, J. L., & DeSantis, A. M. (2006). The influence of role models on women's career choices. *The Career Development Quarterly*, *54*, 297–306.

Schweingruber, H. A., Duschl, R. A., & Shouse, A. W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: National Academies Press.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*, 70–83.

Sjaastad, J. (2012) Sources of inspiration: The role of significant persons in young people's choice of science in higher education. *International Journal of Science Education*, *34*(10), 1615–1636.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology*, *100*, 255–270.

Tenenbaum, H., & Leaper, C. (2003). Parent-child conversations about science: Socialization of gender inequities. *Developmental Psychology*, *39*, 34–47.

UNESCO Institute for Statistics. (2015). *Women in science UIS fact sheet*. Retrieved March 15, 2016, from http://www.uis.unesco.org/ScienceTechnology/Documents/fs34-2015-women20in20science-en.pdf

Woelfel, J., & Haller, A. O. (1971). Significant others, the self-reflexive act and the attitude formation process. *American Sociological Review*, *36*, 74–87.

Zirkel, S. (2002). Is there a place for me? Role models and academic identity among White students and students of color. *Teachers College Record*, *104*(2), 357–376.