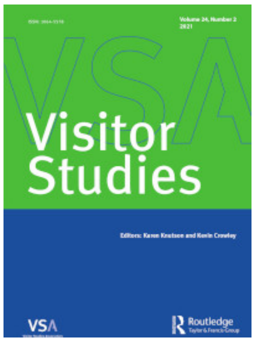

Visitor Studies

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Impact of Youth and Adult Informal Science Educators on Youth Learning at Exhibits

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ABSTRACT

The impact of educators in informal science learning sites (ISLS) remains understudied from the perspective of youth visitors. Less is known about whether engagement with educators differs based on the age and gender of both visitor and educator. Here, visitors (5–17 years old) to six ISLS in the United States and United Kingdom ($n = 488$, female $n = 244$) were surveyed following an interaction with either a youth (14–18 -years old) or adult educator (19+ years old). For participants who reported lower interest in the exhibit, more educator engagement was related to greater self-reported learning. Younger children and adolescents reported more engagement with an adult educator, whereas engagement in middle childhood did not differ based on educator age. Participants in middle childhood showed a trend toward answering more conceptual knowledge questions correctly following an interaction with a youth educator. Together, these findings emphasize the promise of tailoring educator experiences to visitor demographics.

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Educator engagement; informal learning; STEM interest; STEM learning; youth educators

Introduction

Educators are thought to play an important role in informal science learning sites (ISLS; science centers, museums, zoos, aquaria) by leading interactive experiences and structuring learning for visitors, guiding school and family group visits, and programming educational activities. However, the impact of these educators on visitors to ISLS remains understudied. Research has demonstrated that different exhibit features can influence youth learning at these sites (Boisvert & Slez, 1995; Borun et al., 1996; Not et al., 2019; Phiddian et al., 2020; Shaby et al., 2017), however, we know less about how visitors' experiences are related to experiences of engaging with educators themselves.

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Therefore, there is a need for research that focuses on how children's and adolescents' experiences as visitors to ISLS are related to their interactions with educators.

Furthermore, we know less about how the age and gender of educators might be related to the engagement of young visitors. Youth programs and panels have been recognized as a growing phenomenon in ISLS (Styx, 2019). So far, very little is known regarding how educator demographics may impact visitor engagement in sites where youth (here, adolescents between 14–18 years old) are recruited as educators. The present study included children and adolescents who were visitors to six ISLS in the United Kingdom and United States and assessed their engagement with an educator (who varied by age and gender) following an interaction at an exhibit. Further, we examined the relation between this engagement and youth visitors' own interest in the topic of the exhibit and their conceptual learning.

Educators in ISLS

Educators play key roles in ISLS as they guide visitors' experiences and develop educational programs. Research has examined some key facets of the educator role. For example, educators guide visitors to understand what they can do in sites (Koran et al., 1988) and can introduce learning goals to deepen family investigation (Dierking, 2013; Munley, 2012; Pattison & Dierking, 2013). Interactions with educators at ISLS have a positive impact on inquiry-based learning by increasing time spent at exhibits (Pattison et al., 2018).

This body of evidence emphasizes the important role that educators play in ISLS. However, the majority of these studies have focused on family outcomes reported by adults (Brown et al., 2019). In the present work, we aimed to extend the existing literature by not only examining parental reports of explicit learning, but by probing children's own subjective experiences. To do so, we measure youth visitors' perceived learning from an exhibit, self-reported interest in the exhibit topic, and their objective learning using a series of conceptual knowledge questions.

In the context of science, technology, engineering, and mathematics (STEM), interest is a focal variable in motivation and future career aspirations and can help to explain why some groups are underrepresented in certain STEM domains (Shapiro & Williams, 2012). By 11–12 years old, girls report less interest in male-dominated STEM areas (Blickenstaff, 2005; Ceci & Williams, 2010; Diekman et al., 2010; Riegle-Crumb et al., 2011). For example, in mathematics, reduced interest has been documented between childhood and adolescence (Frenzel et al., 2010; Nosek et al., 2002), which is in turn reflected in girls' lower enrollment in mathematics courses (WISE, 2019). Interest is related to career aspirations (Kang et al., 2019), provides a pathway to learning itself (Nugent et al., 2015), and is therefore an important construct to understand and measure in informal science contexts.

Educators have been shown to increase the amount of time that children and their parents or caregivers spend at exhibits, which is in turn related to greater family satisfaction with the exhibit experience (Pattison et al., 2018). One possibility posited by researchers in this area is that educators are key because they actively engage visitors in ISLS and that this in turn leads to positive outcomes in terms of interest and learning.

Indeed, engagement has been related to learning in a number of studies (Munley, 2012; Packer, 2006; Piscitelli & Everett, 2003). In the present work we adopt Skinner and Chi's (2012) definition of engagement by focusing on the "enthusiastic, willing, [and] emotionally positive" components of a learning experience that educators may facilitate. Here, for the first time, we examine the relation between youth's engagement with educators (hereafter referred to as "educator engagement") and youth's own reported interest and learning to more fully understand whether different educators might be able to promote interest and encourage learning.

Youth educators & peer learning

The present work makes a novel contribution to the literature by examining how engagement, interest, and learning differ depending on the age and gender of the participant and the age and gender of the educator. Here we recruited participants at six ISLS in the United Kingdom and United States. Each ISLS involved in the study had an existing youth educator program, where youth (aged 14–18 years old) from the local area could volunteer or work as educators alongside adult docents. Our six ISLS were chosen based on their preexisting teen programs and their subject diversity (see methods). These sites serve a wide age range of youth visitors, allowing us to generalize our findings to these types of interactions at other ISLS. Our sample was designed to allow us to look at visitor–educator interactions across institutions and countries to move beyond findings that might be specific to the content or approach of an individual institution.

Although youth educator programs and panels have been recognized as a growing phenomenon at ISLS (Styx, 2019), the role of youth educators in ISLS remains understudied. We know that educator-facilitated exhibits are more effective at engaging visitors than nonfacilitated exhibit materials alone (Pattison et al., 2018). It is an open question as to whether children's and adolescents' self-reported engagement, interest, and learning might differ following an interaction with a youth educator or an adult educator.

One possibility is that youth educators are better placed than adult educators to engage with young visitors to ISLS through making personally relevant connections and rapport building. Previous research has demonstrated the effectiveness of peer tutors in teaching other youth (Leman, 2015; Leung, 2015; Rohrbeck et al., 2003). The present study draws from seminal work by Vygotsky (1978) by arguing that youth can serve as successful tutors to their peers. Specifically, Vygotsky argued that educators are most successful when they scaffold a learning experience within the zone of proximal development (distance between what can be learnt through independent problem solving and what can be learnt with guidance from an educator). Vygotsky noted that scaffolding could be achieved not only through adult guidance but also by more capable peers. This is of importance in the ISLS context where youth educators may scaffold the learning of younger visitors. One possibility that the present study tests is that educators are particularly effective at engaging youth younger than themselves by scaffolding learning within a zone of proximal development that the educators themselves have more recently crossed. Therefore, we might expect youth educators (adolescents aged 14–18 years) to be most effective at engaging youth in middle childhood (9–11 years old) as they are able to scaffold learning in ways they themselves more recently experienced. In contrast, adult educators may be most effective at engaging adolescent visitors to ISLS.

Although much research on peer tutoring has been conducted in formal settings, some research has documented the impact of youth docents in informal learning settings and suggests that the Vygotskian argument for peer tutoring may indeed extend to ISLS. For example, Cox-Petersen and Ramirez (2001) demonstrated that adolescents (16–17 years old) reported greater satisfaction and learning following a library tour led by a youth docent. Further, recent evidence has documented that visitors to ISLS aged between 9- and 11-years-old answered more questions about an exhibit correctly following an interaction with a youth educator compared with an adult educator (Mulvey, McGuire, Hoffman, Goff, et al., 2020). Together, this evidence suggests that youth educators may be particularly good learning models for young visitors to ISLS. However, it remains an open question as to whether youth visitors' perceptions of educator engagement are related to their interest and learning.

The present study also examines whether the gender of a youth visitor and educator are related to engagement, interest, and learning in ISLS. Identity-based motivation theory (IBM; Oyserman & Destin, 2010) argues that identities themselves can act as motivation as individuals are more likely to engage with behaviors that are congruent with their identity. IBM argues that these identities are dynamically constructed in the moment. For example, if a girl reads a report that suggests men are more likely than women to succeed and earn more in STEM, she may then believe that STEM is incongruent with her female identity.

Following this idea of dynamic identity construction, female role models and teachers have been shown to play an important role in challenging the consequences of STEM gender stereotypes (Cheryan et al., 2011; Marx & Roman, 2002; Master et al., 2014; Stout et al., 2011). Recent research has documented that girls who visit ISLS report being more interested in mathematics following an interaction with a female educator (McGuire et al., 2021). It remains an open question as to whether reports of engagement, interest, and learning differ depending on the gender of an educator. Based on IBM and existing literature regarding the benefits of interacting with female educators, we expected to observe a gender-match effect where female visitors would report greater engagement with a female educator. In contrast, male visitors were expected to report greater engagement with a male educator.

The present study

Educators in ISLS provide crucial support for visitors' learning experiences and engage visitors beyond nonfacilitated exhibit content (Pattison et al., 2018). However, the mechanisms underlying this have yet to be studied from the perspective of child and adolescent visitors to ISLS. In the present study children and adolescents (aged between 5–17 years old) were surveyed about their exhibit topic interest, perceived learning, and conceptual knowledge following an interaction with an educator. We also assessed participants' perceptions of the educator to try to understand whether differences in engagement could help explain differences in self-reported learning and interest. Finally, we explored whether different types of educators may more effectively engage different visitors, especially those from underrepresented groups.

Hypotheses

H1. Based on Vygotskian theory (Vygotsky, 1978) and the benefits of peer-to-peer tutoring (Leman, 2015; Leung, 2015; Rohrbeck et al., 2003), youth in middle childhood were expected to report greater engagement with a youth educator as compared with an adult educator. In contrast, we expected that participants in adolescence would report greater engagement with an adult educator as compared with a youth educator.
H2. Based on IBM (Oyserman & Destin, 2010), we expected female visitors would report greater educator engagement following an interaction with a female educator. In contrast, male visitors were expected to report greater educator engagement following an interaction with a male educator.
H3. Participants' self-reported interest in the topic of an exhibit was expected to be positively related to their self-reported learning. Further, we expected this relation to be moderated by the level of engagement with an educator. Specifically, when participants' topic interest was low, greater educator engagement was expected to predict greater self-reported learning.
H4. We expected adolescent participants to answer more conceptual knowledge questions correctly than participants in early childhood and middle childhood. However, when taking the educator into account, we expected participants in middle childhood to answer more questions correctly following an interaction with a youth educator given recent findings (Mulvey, McGuire, Hoffman, Goff, et al., 2020) and literature on peers scaffolding learning (Leman, 2015; Leung, 2015; Rohrbeck et al., 2003).

Methods

Participants

Participants ($n = 488$, female = 244, male = 244) were recruited from six ISLS (see next section). Four participants reported their gender as "other" and were excluded from the analyses presented below because of the small cell size of this group. Participants were divided into three age groups: early childhood ($n = 246$, $M_{age} = 6.53$, $SD = 1.08$, min. = 5 years, max. = 8 years), middle childhood ($n = 156$, $M_{age} = 9.98$, $SD = .82$, min. = 9 years, max. = 11 years), and adolescence ($n = 82$, $M_{age} = 13.61$, $SD = 1.71$, min. = 12 years, max. = 17 years). Sixty-five percent of participants identified as members of the ethnic majority group of the country of testing (White British in the United Kingdom, White European American in the United States). See supplemental materials for a full breakdown of the sample by ethnicity. Parental consent and child assent were obtained for all participants.

Institutions

Participants were sampled at Riverbanks Zoo ($n = 104$), Virginia Aquarium ($n = 100$), and EdVenture ($n = 44$) all located in the southeastern United States, as well as Thinktank ($n = 194$) in the Midlands of the United Kingdom and the Center of the Cell ($n = 33$) and the Florence Nightingale Museum ($n = 13$) in the South East of the United Kingdom. These institutions are all part of the STEM Teens project in which academics, and practitioners from each of the ISLS, are equal partners in research design and dissemination (Mulvey, McGuire, Hoffman, Hartstone-Rose, et al., 2020). These institutions were chosen prior to the initiation of this research because of their diversity of foci and the preexistence of ongoing teen educator programs. Each site is dedicated to the education of visitors on their STEM content and to the opportunities afforded to the participants in these teen programs.

Procedure

All measures were approved by the IRB of North Carolina State University psychology department and the ethics committee of the University of Exeter psychology department as part of the STEM Teens project. The protocol was completed using either online survey software (Qualtrics, Provo, UT) on a tablet computer or in hard copy using the same measures. Participants could select to complete the survey independently or in a one-to-one interview format with an experimenter.

Participants were recruited on site and offered either an electronic gift card, gift shop voucher or gift bag worth $/£5 in exchange for completing a questionnaire. Participants were part of family groups consisting of at least one adult and one child. Participants were approached at the exit of preselected galleries or exhibits following an interaction with an educator. These exhibits were chosen in conjunction with ISLS staff, recognized as popular areas where educators were regularly stationed. Although the specific exhibit topics varied by site (see supplemental materials), the exhibits all included explanatory (nonfacilitated) media allowing visitors to engage with the topic in the absence of an educator.

These sites were also chosen because they offer broadly comparable visitor experiences in terms of educator interaction. Interactions between educators and visitors at these sites most often involved educators guiding visitors' learning (e.g., educators showing visitors a gorilla skull at a gorilla enclosure in the zoo), assisting in the completing of exhibit activities, or answering questions about the exhibit topic that were not covered in the exhibit explanatory media. Participants either interacted with a youth educator ($n = 221$, female educator = 149, male educator = 72) or an adult educator ($n = 267$, female educator = 186, male educator = 81) based on the ISLS scheduling of educators. The educators' ethnicity was as follows: 58% White British or White European American, 17% South East Asian British (including Bengali, Indian and Pakistani), 16% Black/African American or Black British, 6% Hispanic or Latinx, and 19% other groups (including mixed race/dual heritage, biracial, American Indian, American Asian, and Pacific Islander). All educators regardless of age received onsite training prior to beginning their role. Although the exact content of this training varied by site, across sites training programs included learning content knowledge about the exhibit, exhibit tours, customer service training, public speaking practice, and team building opportunities.

Measures

The below measures were part of a larger questionnaire that also included measures related to STEM learning, motivation, and engagement in ISLS.

Exhibit learning

Participants were asked, "How much did you learn from this exhibit?" (1 = *nothing*, 6 = a *lot*).

Topic interest

Participants were asked, "How interested are you in the topic you just learned about?" (1 = *not at all*, 5 = *really interested*).

Educator engagement

A composite educator engagement score was created from three items. First, participants were asked, "How much of your time at the exhibit did you spend with someone who works here?" (select one: *0–2 minutes*, *3–5 minutes*, *5–10 minutes*, *10–15 minutes*, *more than 15 minutes*). Second; "How much did you like talking to that person?" (1 = *not at all*, 6 = *a lot*). Third, "How much did you learn from talking to that person?" (1 = *nothing*, 6 = *a lot*). Scale reliability analysis suggested that these three items had acceptable reliability ($\alpha = .63$) and therefore a mean average "educator engagement" score was calculated from these three items.

Conceptual knowledge questions

To assess conceptual understanding of the content of the exhibit, participants were asked a series of three questions specific to the exhibit they visited. These questions were designed by practitioners at each site and refined in conversation with academic partners (all questions available in supplemental information). These questions assessed the comprehension and application objectives key to each of the exhibits. The questions were designed explicitly to evaluate the apply level of Bloom's Taxonomy (Bloom, 1956). Previous research has shown that educators can facilitate knowledge within the remember and understand levels of Bloom's taxonomy (Mulvey, McGuire, Hoffman, Goff, et al., 2020). Here we aimed to extend the examination of the role of educators into the apply level. These questions assessed the same applied concepts for participants of all age groups, and we refined the language of these questions to be accessible for our youngest participants. Our youngest participants were also offered assistance with reading comprehension.

The questions assessed concepts that were represented in the nonfacilitated exhibit media but required the participant to apply this knowledge to a new context. Educators were not primed to discuss these concepts but were instead guided by visitors' interests and questions. For example, participants who visited a wildlife exhibit were asked questions covering the core concepts of (a) food pyramids, (b) climate change, and (c) natural selection. Each question had four possible multiple-choice options with one correct response. In the wildlife example, participants were asked the following question to assess their understanding of an acquired camouflage trait that would be compromised by human intervention: "Imagine you live near a woodland area where there are going to be new houses built. Once they are built there will be fewer trees and green spaces. One of the animals that lives in a pond in the woods is a species of green and brown frog. What do you think will happen to the frog?" (a) it will be more easily spotted by

Table 1. Intra-class Correlation Coefficients (ICC) accounting for site and exhibit level variance in key dependent variables.

Dependent variable	Site ICC	Exhibit ICC
Exhibit learning	0.14	0.32
Topic interest	0.02	0.04
Educator engagement	0.17	0.12
Conceptual knowledge questions	0.08	0.08

predators, (b) it will have to move up the food chain, (c) it will have to move down the food chain, or (d) it will be harder to spot by predators. Correct responses were given a score of 1 (incorrect responses were scored as 0) and scores were summed for possible total score of 3.

Data analytic plan

Considering the multi-site nature of our data we calculated intra-class correlation coefficients (ICC) for our sites and exhibits within sites across our dependent variables (see Table 1). The ICCs for exhibit topic interest and educator engagement suggested that multi-level modeling was the most appropriate analytic approach to account for the nested nature of our data. Multilevel models were fit using the mixed command in SPSS Version 25 (IBM Corp, 2018) following best practices (O'Dwyer & Parker, 2014) in order to account for variance based on exhibit and site.

We assessed differences in educator engagement and number of conceptual knowledge questions answered correctly using a series of 3 (age; early childhood, middle childhood, adolescence) × 2 (gender; female, male) × 2 (educator age; youth educator, adult educator) × 2 (educator gender; female, male) mixed model ANOVAs accounting for exhibit and site variance. Follow-up tests with Bonferroni corrections for multiple comparisons applied were used to probe interactions where appropriate.

Hayes' PROCESS macro for SPSS was used to test our moderated moderation hypothesis (H3). We examined the relation between self-reported topic interest and exhibit learning moderated by educator engagement and educator age (Model 3; Hayes, 2012).

Results

Descriptive statistics and correlations between our key dependent variables are reported in Table 2.

Educator engagement

Analyses revealed a main effect of educator age on educator engagement, $F(1, 317) = 3.78$, $p = .05$, $\eta_p^2 = .01$. Participants' in the adult educator condition reported greater engagement ($M = 3.83$, $SD = .92$) than participants in the youth educator condition ($M = 3.63$, $SD = 1.05$). To complement this main effect, we report *t*-tests that demonstrate the key difference between adult and youth educators overall lies in reports of how much the individual learnt from the educator (see Table 3).

Table 2. Bivariate correlations between key variables.

Variable	1	2	3	4	5	*M*	*SD*
1. Age	—					8.84	2.88
2. Exhibit learning	−0.05	—				4.63	1.48
3. Topic interest	−0.22**	0.40**	—			4.08	1.07
4. Educator engagement	−0.16**	0.46**	0.40**	—		3.75	0.98
5. Total correct questions	.24**	.05	.06	−.05	—	1.61	1.02

**Indicates correlation significant at $p < .01$ level (two-tailed).

Table 3. Independent sample *t*-tests based on educator age for the three composite questions underlying the educator engagement score.

Variable	Educator age	*M*	*SD*	*t*-value	*df*	*p*
Time with educator	Adult	1.98	0.96	−0.93	370	0.35
	Youth	1.88	1.05			
Like talking to educator	Adult	4.86	1.34	−0.74	399	0.46
	Youth	4.75	1.38			
Learn from educator	Adult	4.73	1.46	−2.69	398	0.007
	Youth	4.30	1.72			

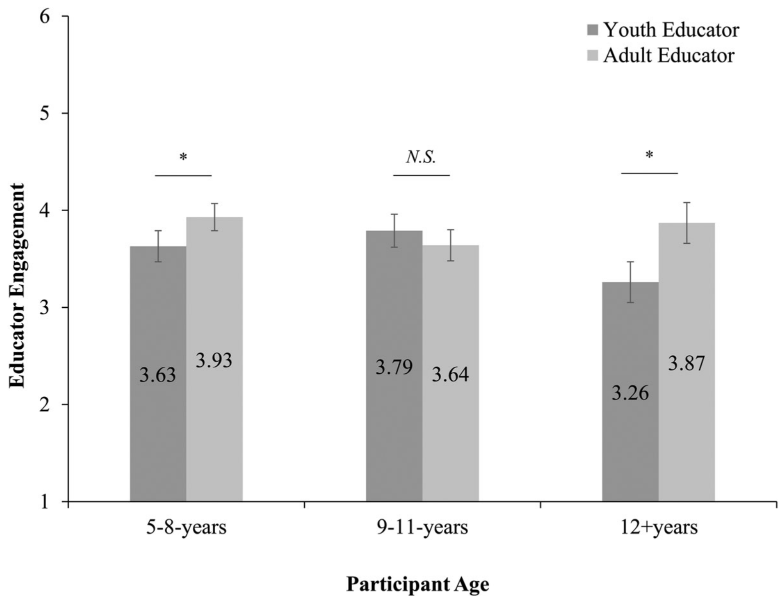

Figure 1. Educator engagement as a function of participant age and educator age (w. standard error bars, * indicates p <.05, *N.S.* = nonsignificant).

In support of H1, this main effect was qualified by an interaction between educator age group and participant age group, $F(2, 329) = 3.11$, $p = .05$, $\eta_p^2 = .02$ (Figure 1). Participants in early childhood reported greater educator engagement in the adult educator condition ($M = 3.93$, $SD = .91$) compared with the youth educator condition ($M = 3.63$, $SD = 1.11$, $p = .05$). Similarly, adolescent participants reported greater educator engagement in the adult educator condition ($M = 3.87$, $SD = .89$) compared with the youth educator condition ($M = 3.26$, $SD = .98$, $p = .04$). In contrast, there was no difference in educator engagement between the adult educator ($M = 3.64$, $SD = .95$) and youth educator conditions ($M = 3.79$, $SD = .98$, $p = .49$) for participants in middle childhood.

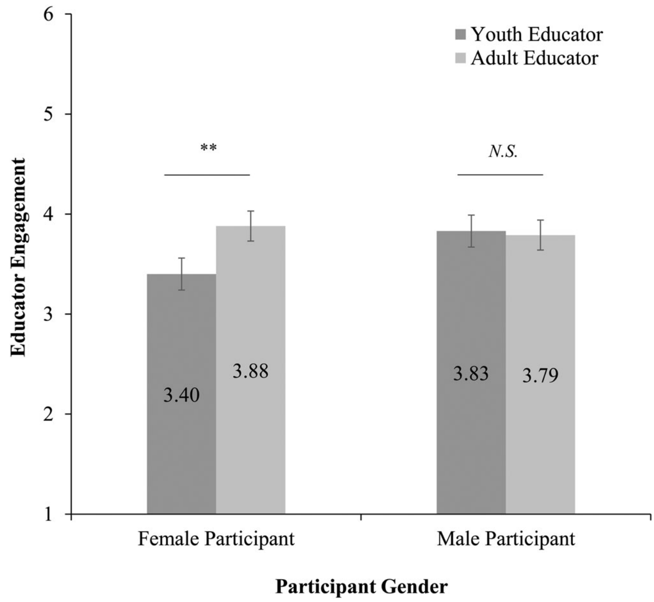

Figure 2. Educator engagement as a function of participant gender and educator age (w. standard error bars, ** indicates p <.005, *N.S.* = nonsignificant).

There was a significant interaction between educator age and participant gender, $F(1, 326) = 6.94$, $p = .009$, $\eta_p{}^2 = .02$ (Figure 2). Female participants reported greater educator engagement in the adult educator condition ($M = 3.88$, $SD = .95$) compared with the youth educator condition ($M = 3.40$, $SD = 1.01$, $p = .002$). In contrast, male participants' educator engagement did not differ between adult educator ($M = 3.79$, $SD = .90$) and youth educator conditions ($M = 3.83$, $SD = 1.04$, $p = .81$). Male participants reported greater educator engagement in the youth educator condition than female participants ($p = .006$). In contrast, there was no difference in educator engagement in the adult educator condition between male and female participants ($p = .50$).

Counter to H2, we did not observe a main effect of participant gender, educator gender, or an interaction between participant gender and educator gender.

Moderation of exhibit learning

We next analyzed our hypothesized model (H3) between topic interest and exhibit learning, moderated by educator engagement (see Table 2 for the correlation matrix including the key variables). The overall model was significant, F (9, 337) = 16.75, $p <$ .001, $R^2 = .31$. There was a direct effect of topic interest on exhibit learning, $\beta = 1.04$, $t(337) = 3.42$, $p < .001$, lower-level confidence interval (LLCI) = .44, upper-level confidence interval (ULCI) = 1.64. Educator engagement had a direct effect on exhibit learning, $\beta = 1.37$, $t(337) = 3.73$, $p < .001$, LLCI = .65, ULCI = 2.09. These effects were qualified by the interaction between topic interest and educator engagement, $\beta = -.21$, $t(337) = -2.38$, $p = .02$, LLCI = −.39, ULCI = −.04.

We probed the moderation of topic interest by educator engagement by examining the conditional effects of educator engagement at three values of topic interest (low, medium,

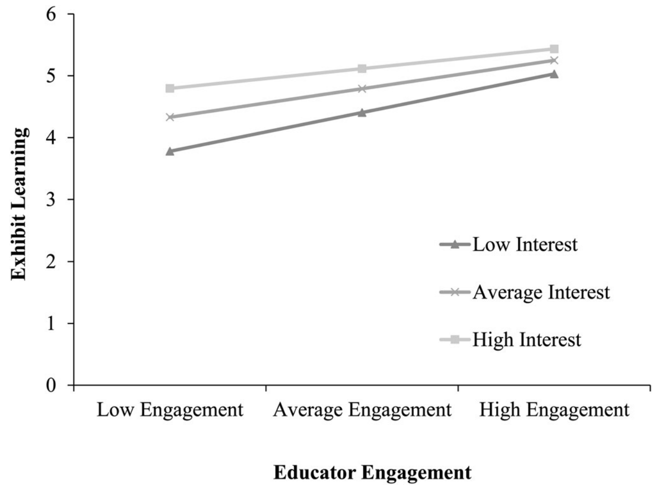

Figure 3. Moderation of self-reported exhibit learning by educator engagement and topic interest.

high; Figure 3). These conditional effect groups are computed as ±1standard deviation from the mean. In the low topic interest group, $\beta = .56$, $t(337) = 6.65$, $p < .001$, LLCI = .39, ULCI = .72, a unit increase on the educator engagement composite measure was related to a .56 increase in self-reported exhibit learning. In the average topic interest group ($\beta = .34$, $t(337) = 4.28$, $p < .001$, LLCI = .18, ULCI = .49), a unit increase on the educator engagement composite measure was related to a .34 increase in self-reported exhibit learning. Finally, in the high topic interest group, $\beta = .23$, $t(337) = 2.13$, $p = .03$, LLCI = .02, ULCI = .43, a unit increase on the educator engagement composite measure was related to a .23 increase in self-reported exhibit learning. The Johnson-Neyman procedure was used to assess the point at which educator engagement and exhibit learning were significantly related. Educator engagement and exhibit learning were significantly related, $\beta = .22$, $t(337) = 1.97$, $p = .05$, LLCI = .00, ULCI = .43, for participants responding 4.73 or below on the topic interest measure. Above 4.73, educator engagement was not related to self-reported exhibit learning. Taken together, this moderation analysis suggests that educator engagement is important for participants who had relatively lower interest in the topic of the exhibition. For these participants, greater educator engagement was related to higher self-reported exhibit learning.

Conceptual knowledge questions

Finally, consistent with H4, analyses revealed a significant main effect of participant age group on number of conceptual knowledge questions answered correctly, $F(2, 415) = 8.57$, $p < .001$, $\eta_p^2 = .04$. Adolescents ($M = 1.91$, $SD = .98$) answered more questions correctly than participants in early childhood ($M = 1.38$, $SD = 1.01$, $p = .003$). Participants in middle childhood ($M = 1.78$, $SD = .99$) also answered more questions correctly than those in early childhood ($p = .001$). There was no difference in questions answered correctly between participants in middle childhood and adolescence ($p = .99$).

This main effect was qualified by a significant interaction between participant age group and educator age, $F(2, 415) = 3.03$, $p = .05$, $\eta_p^2 = .01$ (Figure 4). We observed a

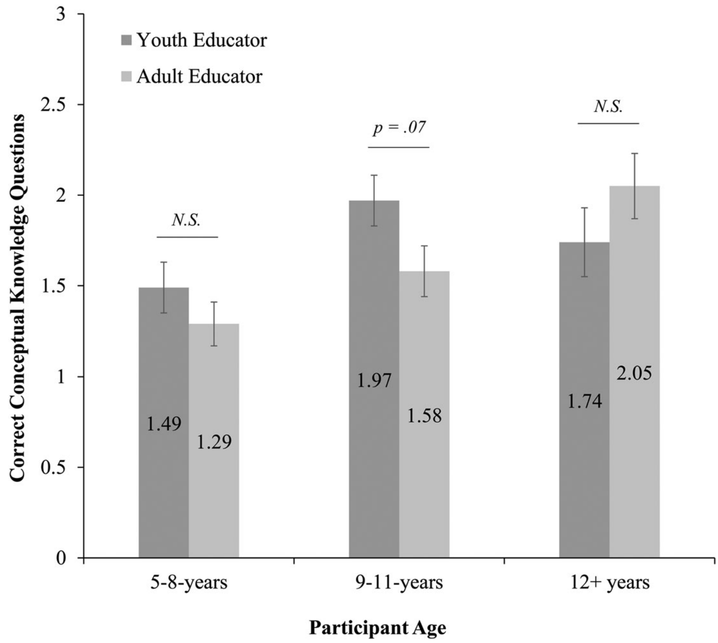

Figure 4. Correct conceptual knowledge questions as a function of participant age and educator age (w. standard error bars, *N.S.* = nonsignificant).

marginal difference in middle childhood where participants correctly answered more questions in the youth educator ($M = 1.96$, $SD = .98$) condition than in the adult educator condition ($M = 1.58$, $SD = .98$; $p = .07$). For participants in early childhood, there was no difference between youth ($M = 1.51$, $SD = 1.03$) and adult educator conditions ($M = 1.29$, $SD = 1.00$; $p = .42$). Similarly, in adolescence there was no difference between the youth educator ($M = 1.74$, $SD = .96$) and adult educator conditions ($M = 2.05$, $SD = .99$; $p = .11$).

When interacting with a youth educator, participants in middle childhood answered more questions correctly than those in early childhood ($p = .009$). In the youth educator condition, there was no difference in correctly answered concept questions between participants in early childhood and those in adolescence ($p = .87$), nor between middle childhood and adolescence ($p = .62$).

When interacting with an adult educator, participants in adolescence answered more questions correctly than those in early childhood ($p < .001$). There was no difference between participants in early childhood and those in middle childhood ($p = .17$), nor between middle childhood and adolescence ($p = .11$).

Discussion

The present study extends the existing literature on educators in ISLS by demonstrating that the age of educators and the age and gender of visitors play an important role in youth visitors' interest and learning. Further, children's and adolescents' interest in the topic of an exhibit was positively related to their self-reported learning at this exhibit. Crucially, when participants' topic interest was lower, higher educator engagement was related to a greater increase in perceived exhibit learning. Together these findings open a range of possible pathways for research in this area to further explore the boundary conditions and mechanisms that can help explain when and why educators can complement and extend the effectiveness of nonfacilitated exhibit media in ISLS.

Analyzing educator engagement revealed differences based on the age and gender of the participant, as well as the age of the educator. Overall, participants reported higher levels of engagement following an interaction with an adult educator. Participants in early childhood and adolescence reported greater educator engagement in the adult educator condition as compared with the youth educator condition. For participants in middle childhood, there was no difference in educator engagement between the youth and adult educator conditions. There are several possible explanations for these age-related differences. First, our composite engagement score included participants' self-reports of how long they spent with the educator. It is possible that adult educators, given their experience working in ISLS, may be more comfortable spending longer with participants. Concurrently, it is possible that participants in early childhood report learning more from adult educators as this most closely matches their limited experience of didactic teaching and learning in a formal educational setting. A third possibility is that consistent with our hypotheses, educators are most effective at engaging and scaffolding the learning of those younger than themselves. Social interactionist accounts of learning (Vygotsky, 1978) posit that effective tutoring occurs when a more knowledgeable individual is able to speak to the learner's existing knowledge and guide them to learn beyond their existing capabilities. Therefore, adult educators may be particularly effective at recognizing the learning capacity of, and engaging with, adolescents. The lack of observed difference between the youth educator and adult educator conditions for participants in middle childhood may also be accounted for by this Vygotskian argument. Youth educators (adolescents) may be as competent as adult educators at recognizing the learning and engagement needs of visitors in this middle childhood range.

Female participants reported greater engagement with an adult educator than with a youth educator. For male participants, there was no difference in reported engagement between the educator conditions. Although we did not predict differences in engagement based on participant gender, this is a finding worth future exploration. One possibility is that male visitors to ISLS are generally more comfortable in the context of STEM where stereotypes perpetuate the innate abilities of men and how they "belong" in these contexts (Leslie et al., 2015; Meyer et al., 2015). These stereotypes may also lead educators to engage differently with male and female visitors. Parents have been shown to spend more time explaining scientific concepts to boys than girls (Crowley et al., 2001). Future observational research could test whether there are similar differences in how educators talk to children of different genders. Alternatively, adult educators may use knowledge of inequitable gender representation and stereotypes to tailor their educational style to engage female visitors. Future work is needed to explore whether educators themselves use different approaches to engage visitors from different gender groups, and if so, whether this is related to knowledge of inequalities in the STEM context.

For participants who reported lower interest in the topic of the exhibit, higher engagement with the educator was related to higher self-reported learning about the topic of the exhibit. This finding suggests that educators play an important role in supporting the experiences of children and adolescents who are less interested in an exhibit. By actively engaging these individuals, they can reach the same levels of self-reported learning as their more interested peers. The challenge for educators will be in identifying children who are less interested to begin with. Future work could first examine how educators estimate visitors' interest levels (what, e.g., are the verbal or visual cues that educators use to gauge interest), and in turn whether this is accurately related to children's own self-reported interest. Understanding how educators gauge interest will allow them make the most impact on the exhibit floor.

The age of both the educator and participant were related to how many conceptual knowledge questions participants answered correctly. Specifically, when interacting with an adult educator, adolescent participants answered more questions correctly than those in early childhood. In contrast, when they interacted with a youth educator, they did not answer more questions correctly than participants in early or middle childhood. For participants in middle childhood, there was a trend toward answering more questions correctly following an interaction with a youth educator as compared with an adult educator. Following the social interactionist argument, participants in middle childhood ought to learn more from youth educators only slightly older than themselves who can more accurately assess the learner's existing knowledge and capabilities. Similarly, adult educators may more accurately relay knowledge to adolescent visitors. Future observational work and content analysis of discussion between educators and learners is required that can tease apart *why* these different educator experiences translate into conceptual knowledge takeaway for youth visitors. Interestingly, self-reported learning was not correlated with the number of questions answered correctly by participants. However, self-reported learning was correlated with educator engagement. These two findings indicate that self-reported learning is more closely aligned with feelings of overall engagement following an interaction experience, but not necessarily related to the learning or knowledge objectives of the exhibit. More work therefore is required to understand the mechanism that lies between interaction with youth and adult educators and knowledge takeaway.

Limitations & future directions

Educator engagement was measured using three single item self-report questions. This approach was adopted as understanding the perspectives of young visitors to ISLS was a key focus of the present work. To do so, self-report was the most appropriate method. Given the practical time constraints of data collection with youth in ISLS, we opted to use single item measures to ensure youth remained engaged with the questionnaire in the short amount of time available. However, future work may wish to complement this approach by using observational methods and scales to measure interest and engagement. For example, researchers could observe interactions between educators and visitors and code for verbal and visual cues to engagement (Callanan et al., 2017), as well as measuring the exact amount of time visitors spend with educators. This approach could corroborate and extend the present findings by examining some of the methods that effective educators use to engage visitors who are low in interest.

Further, more research is needed to fully understand specifically what it is that children and adolescents find engaging about different types of educators. It is not clear from the present findings whether how much the participant enjoyed talking to the educator and perceived they learned during this experience was in turn related to other factors—for example, how comfortable or welcome the educator made them feel in the site, or how successfully they challenged stereotypes about STEM. Evidence has demonstrated that in the context of computer science, role models who embody stereotypes about the domain (independent of their own gender) are less effective at engaging women than those who challenge these stereotypes (Cheryan et al., 2011). It is possible that similar effects can be observed in ISLS where educators who challenge gender stereotypes can more effectively engage visitors, independent of the educators' own gender.

Finally, the present study did not have sufficient power to analyze whether there were differences in engagement and learning as a function of participant and educator ethnicity. As evidence has documented that adolescents from Black and minority ethnic backgrounds do not feel that informal science contexts are "for me" (Dawson, 2014), this is an important avenue to understand. Although nearly a third of our sample included non-White visitors, cell sizes meant that meaningful statistical comparisons between individual ethnic identity groups were not possible. It is important to recognize the different lived experiences of these groups in the STEM context. For instance, STEM stereotypes pertaining to African Americans as compared with Asian Americans lead to quite different experiences in STEM education (McGee, 2018). Although our sample included a substantial percent of non-White visitors— especially relative to the historically troublingly low percent of non-White museum visitors (Olivares & Piatak, 2021)—these subsets were too small for individual statistical comparison and too discrete for meaningful combination. In future work we will use stratified sampling methods to make meaningful comparisons between visitors from different ethnic groups.

Similarly, we excluded from our analyses four participants who identified their gender as "other." Because of the small size of this group, meaningful comparisons with participants who identified as male or female were not possible. Future work is needed that examines whether interacting with someone "like me" in terms of gender identity in the context of ISLS can again challenge stereotypes and lead to effective engagement. Answering this question will require dedicated projects that recognize that youth from these groups often do not feel belonging in ISLS, aiming to explore the possible benefits of existing educator programs tailored to youth visitors' experiences. These educator programs could play an important role alongside youth panels, disability advisory committees and community-curated programs to disrupt dominant exclusionary narratives and lack of representation in these spaces.

Conclusion

By actively engaging children and adolescents, educators in ISLS can counter the possible consequences of low interest in an exhibit topic. Further, the present study suggests that ISLS can benefit from training youth and adult educators to engage young visitors (especially those lower in interest) and to consider the age of educators and visitors alike. When running a demonstration or activity, or placing educators on exhibits, ISLS may wish to consider the target age range of the activity. For younger children and adolescents, adult educators may be most effective. There is evidence that youth educators can effectively engage visitors in middle childhood. Taken together these findings point to the promise of educator programs tailored to engage youth visitors of all ages to ISLS.

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References

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17*, 369–386. https://doi.org/10.1080/09540250500145072

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals*. Longmans, Green.

Boisvert, D. L., & Slez, B. J. (1995). The relationship between exhibit characteristics and learning-associated behaviors in a science museum discovery space. *Science Education*, *79*(5), 503–518. https://doi.org/10.1002/sce.3730790503

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. *Curator: The Museum Journal*, *39*(2), 123–138. https://doi.org/10.1111/j.2151-6952.1996.tb01084.x

Brown, R., Jeanneret, N., & Andersen, J. (2019). Are we on the same page? Family and museum staff perceptions of engagement and learning. *Visitor Studies*, *22*(2), 213–232. https://doi.org/10.1080/10645578.2019.1668235

Callanan, M. A., Castañeda, C. L., Luce, M. R., & Martin, J. L. (2017). Family science talk in museums: Predicting children's engagement from variations in talk and activity. *Child Development*, *88*, 1492–1504. https://doi.org/10.1111/cdev.12886

Ceci, S. J., & Williams, W. M. (2010). Sex differences in math-intensive fields. *Current Directions in Psychological Science*, *19*(5), 275–279. https://doi.org/10.1177/0963721410383241

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in stem? *Social Psychological and Personality Science*, *2*(6), 656–664. https://doi.org/10.1177/1948550611405218

Cox-Petersen, A. M., & Ramirez, A. Y. (2001). An investigation of student and adult docents during guided school tours. *The School Community Journal*, *11*, 65–73.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science*, *12*, 258–261. https://doi.org/10.1111/1467-9280.00347

Dawson, E. (2014). "Not designed for us": How science museums and science centers socially exclude low-income, minority ethnic groups. *Science Education*, *98*, 981–1008. https://doi.org/10.1002/sce.21133

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, *21*, 1051–1057. https://doi.org/10.1177/0956797610377342

Dierking, L. D. (2013). Museums as social learning spaces. In I. Braendholt Lundgaard & J. Thorek Jensen (Eds.), *Museums as social learning spaces and knowledge producing processes*. (pp. 198–215). Kulturstyrelsen.

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence*, *20*(2), 507–537. https://doi.org/10.1111/j.1532-7795.2010.00645.x

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation and conditional process modeling.

Kang, J., Hense, J., Scheersoi, A., & Keinonen, T. (2019). Gender study on the relationships between science interest and future career perspectives. *International Journal of Science Education*, *41*(1), 80–101. https://doi.org/10.1080/09500693.2018.1534021

Koran, J. J., Koran, M. L., Foster, J. S., & Dierking, L. D. (1988). Using modeling to direct attention. *Curator: The Museum Journal*, *31*(1), 36–42. https://doi.org/10.1111/j.2151-6952.1988.tb00673.x

Leman, P. J. (2015). How do groups work? Age differences in performance and the social outcomes of peer collaboration. *Cognitive Science*, *39*, 804–820. https://doi.org/10.1111/cogs.12172

Leslie, S.-J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science*, *347*, 262–265. https://doi.org/10.1126/science.1261375

Leung, K. C. (2015). Preliminary empirical model of crucial determinants of best practice for peer tutoring on academic achievement. *Journal of Educational Psychology*, *107*(2), 558–579. https://doi.org/10.1037/a0037698

Marx, D. M., & Roman, J. S. (2002). Female role models: Protecting women's math test performance. *Personality and Social Psychology Bulletin*, *28*(9), 1183–1193. https://doi.org/10.1177/01461672022812004

Master, A., Cheryan, S., & Meltzoff, A. N. (2014). Reducing adolescent girls' concerns about STEM stereotypes: When do female teachers matter? *International Review of Social Psychology*, *27*, 79–102. https://doi.org/ISBN:9782706122880

McGee, E. (2018). "Black genius, Asian fail": The detriment of stereotype lift and stereotype threat in high-achieving Asian and Black STEM students. *AERA Open*, *4*(4), 233285841881665. https://doi.org/10.1177/2332858418816658

McGuire, L., Monzavi, T., Hoffman, A. J., Law, F., Irvin, M. J., Winterbottom, M., Burns, K. P., Butler, L., Drews, M., Fields, G., Hartstone-Rose, A., Rutland, A., & Mulvey, K. L. (2021). Science and math interest and gender stereotypes: The role of educator gender in informal science learning sites. *Frontiers in Psychology*, *12*, 904. https://doi.org/10.3389/fpsyg.2021.503237

Meyer, M., Cimpian, A., & Leslie, S.-J. (2015). Women are underrepresented in fields where success is believed to require brilliance. *Frontiers in Psychology*, *6*, 235. https://doi.org/10.3389/fpsyg.2015.00235

Mulvey, K. L., McGuire, L., Hoffman, A. J., Goff, E., Rutland, A., Winterbottom, M., Balkwill, F., Irvin, M. J., Fields, G. E., Burns, K., Drews, M., Law, F., Joy, A., & Hartstone-Rose, A. (2020). Interest and learning in informal science learning sites: Differences in experiences with different types of educators. *PLoS One*, *15*(7), e0236279. https://doi.org/10.1371/journal.pone.0236279

Mulvey, K. L., McGuire, L., Hoffman, A. J., Hartstone-Rose, A., Winterbottom, M., Balkwill, F., Fields, G. E., Burns, K., Drews, M., Chatton, M., Eaves, N., Law, F., Joy, A., & Rutland, A. (2020). Learning hand in hand: Engaging in research-practice partnerships to advance developmental science. *New Directions for Child and Adolescent Development*, *2020*, 125–134. https://doi.org/10.1002/cad.20364

Munley, M. E. (2012). *Early learning in museums: A review of the literature*. Smithsonian Institution's Early Learning Collaborative Network. https://www.si.edu/Content/SEEC/docs/mem%20literature%20review%20early%20learning%20in%20museums%20final%204%2012%202012.pdf

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology*, *83*(1), 44–59. https://doi.org/10.1037/0022-3514.83.1.44

Not, E., Cavada, D., Maule, S., Pisetti, A., & Venturini, A. (2019). Digital augmentation of historical objects through tangible interaction. *Journal on Computing and Cultural Heritage*, *12*(3), 1–19. https://doi.org/10.1145/3297764

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education*, *37*(7), 1067–1088. https://doi.org/10.1080/09500693.2015.1017863

O'Dwyer, L., & Parker, C. (2014). A primer for analyzing nested data: Multilevel modeling in SPSS using an example from a REL study (REL 2015–046).

Olivares, A., & Piatak, J. (2021). Exhibiting inclusion: An examination of race, ethnicity, and museum participation. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organisations*. https://doi.org/10.1007/s11266-021-00322-0

Oyserman, D., & Destin, M. (2010). Identity-based motivation: Implications for intervention. *The Counseling Psychologist*, *38*, 1001–1043. https://doi.org/10.1177/0011000010374775

Packer, J. (2006). Learning for fun: The unique contribution of educational leisure experiences. *Curator: The Museum Journal*, *49*(3), 329–344. https://doi.org/10.1111/j.2151-6952.2006.tb00227.x

Pattison, S. A., & Dierking, L. D. (2013). Staff-mediated learning in museums: A social interaction perspective. *Visitor Studies*, *16*(2), 117–143. https://doi.org/10.1080/10645578.2013.767731

Pattison, S. A., Rubin, A., Benne, M., Gontan, I., Andanen, E., Shagott, T., Francisco, M., Ramos-Montañez, S., Bromley, C., & Dierking, L. D. (2018). The impact of facilitation by museum educators on family learning at interactive math exhibits: A quasi-experimental study. *Visitor Studies*, *21*(1), 4–30. https://doi.org/10.1080/10645578.2018.1503879

Phiddian, E., Hoepner, J., & McKinnon, M. (2020). Can interactive science exhibits be used to communicate population health science concepts? *Critical Public Health*, *30*(3), 257–269. https://doi.org/10.1080/09581596.2019.1575948

Piscitelli, B., & Everett, M. (2003). *Enhancing young children's museum experiences: A manual for museum staff*. https://doi.org/10.13140/RG.2.2.31023.33443

Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011). Who wants to have a career in science or math? Exploring adolescents' future aspirations by gender and race/ethnicity. *Science Education*, *95*(3), 458–476. https://doi.org/10.1002/sce.20431

Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003). Peer-assisted learning interventions with elementary school students: A meta-analytic review. *Journal of Educational Psychology*, *95*(2), 240–257. https://doi.org/10.1037/0022-0663.95.2.240

Shaby, N., Assaraf, O., & Tal, T. (2017). The particular aspects of science museum exhibits that encourage students' engagement. *Journal of Science Education and Technology*, *26*(3), 253–268. http://doi.org/10.0.3.239/s10956-016-9676-7

Shapiro, J. R., & Williams, A. M. (2012). The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles*, *66*(3-4), 175–183. https://doi.org/10.1007/s11199-011-0051-0

Skinner, E. A., & Chi, U. (2012). Intrinsic motivation and engagement as "active ingredients" in garden-based education: Examining models and measures derived from self-determination theory. *The Journal of Environmental Education*, *43*, 16–36. https://doi.org/10.1080/00958964.2011.596856

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. https://doi.org/10.1037/a0021385

Styx, L. (2019). The impact of teen-centered intensive programming in museums. Museum Next. https://www.museumnext.com/article/teen-centered-intensive-programming-in-art-museums/

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

WISE. (2019). *Analysis of 2019 A Level core STEM entrants and results*. https://www.wisecampaign.org.uk/statistics/analysis-of-2019-a-level-core-stem-entrants-and-results/

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