

Learning Outcomes of a Community-Based Science Curriculum to Engage Youth from Title I Schools in Cancer Medicine, Biology, and Prevention Concepts

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Keywords: Education, Children, STEM, Underserved, Museum, Maker-learning

Publication Date: August 14, 2026

DOI: <https://doi.org/10.15695/jstem/v9i1.11>

ABSTRACT: The Young Scholars Program (YSP) with Title I schools aims to increase students' interest in STEM careers by engaging them in cancer medicine, biology, and prevention content through hands-on, maker learning experiences. Here, we report on aggregate and cross-grade level outcomes of a YSP cohort ($N = 441$; 49% female, 81% African American and/or Latine) of 3rd-5th graders. On the program's evaluation survey, knowledge was high for cancer prevention (90% overall; 98% Grade 5 vs. 83% Grade 3: $\chi^2 = 15.1$, $p = 0.001$), cell biology (82% overall; 91% Grade 5 vs. 77% Grade 3: $\chi^2 = 8.1$, $p = 0.004$), and immune response (97% overall). Identification with STEM careers was also high: 99% for science and 97% for engineering. Further, 91% endorsed beliefs associated with inventive learning, 85% with STEM interest, and 92% with belonging in STEM ($r = 0.26$, $p < 0.001$). In a grade- and knowledge-adjusted regression model of inventive learning, both STEM interest ($\beta = 0.25$, $SE = 0.13$, $t = 3.91$, $p < 0.001$) and feelings of belonging in STEM ($\beta = 0.30$, $SE = 0.09$, $t = 4.79$, $p < 0.001$) were significant contributors. Elementary students appear to have benefited from the YSP's curriculum, which may broaden the STEM and medical workforces over time.

INTRODUCTION

Engaging elementary school students from communities that are under-resourced is crucial for fostering early interest in STEM (Science, Technology, Engineering, and Mathematics) and broadening the future workforce (Hachey, 2020). Title I schools, which serve predominantly economically disadvantaged communities, often lack the resources needed to support hands-on learning and STEM engagement (National Center for Education Statistics, n.d.). These disparities in access have national implications: while 13.7% of the U.S. population is Black and 20% Hispanic, (U.S. Census Bureau, n.d.) only 2% of the biomedical science workforce is Black, and 6% is Hispanic (Heggeness et al., 2017). Addressing these inequities early in education is critical to breaking the cycle of underrepresentation in STEM fields, including cancer research and medicine, where disparities persist (Duma et al., 2022; Toretzky et al., 2018).

Maker learning, a pedagogical approach emphasizing creativity, problem-solving, and hands-on activities, ignites curiosity and student agency, empowering learners to explore STEM concepts in an engaging and accessible way. The hallmark of this hands-on approach to problem-solving is that it allows for tinkering and free-choice innovation incorporating manipulatives and interactives such as digital fabrication tools (e.g., 3D printers), electronics and micro-controllers (e.g., circuit kits), coding and software tools (e.g., coding platforms for beginners), and craft and building tools (e.g., hot glue guns and cardboard) that are housed within shared collaboration spaces (Hsu et al., 2017). Studies indicate that participation in maker learning enhances students' critical thinking skills and confidence in their ability to innovate (Bevan et al., 2015).

Inventive learning is a core outcome of engaging in maker learning. It has been described as a collection of developmental skills strengthened through solving a real-world issue or designing a project through collaborative maker learning (Scharon et al., 2024). Maker learning is a foundation for inventive learning because by making things, learners gain skills, confidence, and familiarity with tools and processes. Inventive learning builds on that base by encouraging learners to go beyond construction (making) into the novel development of an innovation (inventing) (Lo, 2024). For example, a maker project (construction of a circuit) can evolve into an inventive project (like designing a robot that solves a new problem). From a theory of change perspective, becoming a more proficient inventive learner offers the skill development needed for applied STEM research.

Many of the aforementioned learning activities can occur in STEM-focused museums, which expose students to in situ applications and cutting-edge innovations. Research indicates that such informal learning environments can significantly enhance student interest in STEM subjects, especially when they allow for interactive and inquiry-based exploration (Falk & Dierking, 2010). In the context of inventive learning, fostering an affiliation with STEM careers is pivotal. This approach integrates cognitive, emotional, and social dimensions, aiming to develop students' identities as inventors, problem-solvers, and changemakers; it also underscores the importance of maker learning environments in shaping students' perceptions and interests in STEM fields (Scharon et al., 2024). For students from underrepresented backgrounds, such experiences can foster a greater sense of belonging and participation and mitigate negative preconceptions of who belongs in STEM (Hansen et al., 2024). Further, meeting professionals in the field can help students visualize themselves in STEM careers when they grow up (Barr et al., 2008). At the same time, physicians, cancer researchers, and other health professionals can benefit by building deeper connections with their communities and gaining insights into the challenges faced by those in their catchment areas.

Thus, integrating maker practices and informal learning experiences into the education of elementary students from Title I schools could be a powerful strategy for promoting STEM careers, diversifying the workforce, and eradicating cancer disparities over time. Toward that end, this research investigated the outcomes of a community-based maker learning curriculum focused on cancer topics, co-created and offered by a comprehensive cancer center in partnership with KID Museum, a hands-on experiential museum and center for maker learning for K-12 youth. The primary purpose was to examine the program's effects on elementary school children's inventive learning, sense of belonging in STEM, and STEM interest.

METHODS

Young Scholars Program Design. This research was reviewed and approved by the Georgetown University Institutional Review Board (IRB #00007280). The Georgetown University Lombardi Comprehensive Cancer Center and KID Museum co-created the Young Scholars Program (YSP). It was designed to inspire elementary school students from Title I schools (with high populations of youth from Black/African American and Hispanic/Latine backgrounds) in the greater Washington, DC metro area in learning about cancer medicine, biology, and prevention (Statman et al., 2026; Tercyak et al., 2024). The YSP is facilitated by physicians, researchers, and other professionals in these fields, planting seeds of interest in medicine, biomedical and behavioral research, and STEM more broadly. Our theory of change is that through the YSP, students attending schools that are designated as Title I will be exposed to cancer biology and prevention concepts through maker learning. By engaging in maker learning, the program's young scholars will develop inventive learning mindsets: they will also form skills that can be applied to STEM. We anticipate that over time, the YSP may contribute to an increase in the number of students who have a lifelong interest in STEM fields. Ultimately, they may pursue higher education and experiences in these fields. This includes addressing cancer disparities by strengthening the diversity of individuals entering the biomedical and behavioral research and medicine pipelines.

The program was initiated in 2022 as an educational partnership between the university's cancer center and KID Museum, which has place-based hubs in the cancer center's catchment area. The museum's approach is dedicated to maker learning, a model that helps students imagine, invent and prototype solutions to problems and situations using STEM concepts, as well as gain important interdisciplinary skills (e.g., critical thinking, problem-solving, creativity, and curiosity) (Wardrip et al., 2021). Funded, in part, by a National Cancer Institute comprehensive cancer center core grant as well as philanthropy, the YSP is an integral aspect of the cancer center's research training and education efforts. The program benefits from the involvement of faculty, fellows, students, and staff from the center's three cancer research programs (cancer biology, cancer-host interactions, and cancer prevention and control) and its community outreach and engagement office.

During the YSP, students participate in day-long, in-person field trips to the museum that promote their learning about STEM opportunities and careers, cultivate their understanding of cancer biology and prevention, and seek to foster a sense of belonging in inventive STEM environments (see Table 1). The YSP has two components: a maker learning workshop that challenges students to combine the scientific method and the engineering design process to help reduce environmentally-based cancer risk factors in the community,

Table 1. *Young Scholars Program Structure and Schedule.*

Minutes	Component I	Component II
90	<i>Cancer Biology and Prevention Activities</i>	<i>Cancer-Focused Environmental Biology Workshop</i>
30	Ultraviolet (UV) Radiation Exposure Students collaborate in groups to create and test UV-blocking structures to see how sun exposure can be prevented. Their models are tested against lamps (sunlight) and are measured by if they can get a solar-powered fan to stop spinning. Cell Biology Students learn how to prepare slides for microscopes to examine changes in materials, such as when heat is applied to sandpaper, under different levels of magnification. Cancer Immunology Students learn how the immune system responds to disease by using computers to control color-sensitive robots that act as white blood cells. Students program their robots (white blood cells) to fight different health issues (bruises, infections, etc.)--all of which have corresponding colors--by coding their robot to pause at the correct colors.	Students learn how to use the scientific method and engineering skills to solve a case study of water contamination due to lake pollution. To investigate the causes of contamination, students interview volunteers who act as fish in the lake, the water itself, gravel at the lake's bottom, and other key stakeholders in the pollution of the lake. Scripts for the volunteers are provided. In students' interviews, museum educators teach students investigative skills by helping them to develop research questions using Who, What, Why, and How, with follow-up questions of Where and When. After gathering environmental health data, students work in teams to engage in an engineering design process in the museum's maker space to develop a prototype to help alleviate the water contamination problem. An example of a prototype might be the creation of an underwater trash scooper to pick-up litter in the lake. Students then present their creations to the class and engage in discussions about other teams' creations.
30	<i>If students are unsuccessful or require assistance in any of the activities, then volunteers, and museum educators are available to encourage them to rethink their solutions as a group while guiding them in the correct direction.</i>	
30	Lunch	
90	<i>Cancer-Focused Environmental Biology Workshop</i>	<i>Cancer Biology and Prevention Activities</i>
15	Assessment and Wrap-Up	

and a series of hands-on, maker learning activities devoted to cell biology, cancer immunology, and ultraviolet radiation exposure. About half of the students participate in each curricular component at a time. After a lunch break, students rotate in small groups to the other activity. Across both program components, inventive learning constructs are emphasized and activities are designed to elicit this aspect (e.g., perseverance in UV-blocking structure testing, teamwork in environmental engineering challenges). In the program, culturally relevant strategies include bilingual facilitation and inclusion of community-relevant cancer topics; collaborative problem-solving is another prominent strategy utilized. Program evaluations are completed on-site as well as in the classroom when students return to school. For a complete description of the YSP development, its day-long activities and culturally relevant content see Tercyak et al. (2024).

School Districts and Student Demographics. Across a two-year period (from the 2022-2023 and 2023-2024 school years), students who participated in the YSP were drawn from three Title I elementary schools within two public school districts in the cancer center's catchment area; these schools instruct a combined total of more than 200,000 students. Title I schools were eligible to participate if they were located within a roughly 25-mile radius of the museum. At each school, all students in Grades 3, 4, and 5 were eligible. Grades were selected through collaboration among the school principal (or their designee), the program, and museum leadership based on interest and scheduling; all schools approached for participation in the YSP chose to do so. Of

the schools selected, none had already planned a field trip to the museum in the upcoming school year. Additionally, the YSP ensures that students do not repeat the program if it returns to the same school. Grade-levels are staggered to avoid duplication, and all classrooms in selected grades participate in the YSP.

School population-level characteristics are presented in Table 2, including the gender, racial, and ethnic composition, as well as the number of students enrolled per academic year of the YSP. As shown, 49% of students in these districts were female, 35% were Black/African American, and 46% were Hispanic/Latine. One school participated twice, and two additional schools were introduced to the YSP in 2023-2024 to increase representation from Hispanic/Latine ethnic and cultural backgrounds, including monolingual Spanish-speakers. To accommodate this change, the YSP recruited additional volunteers from the cancer center who were fluent in both Spanish and English to help engage students in their preferred language. Bilingual volunteers and museum educators facilitated communication between and among students during the program.

Volunteers. As a group, the YSP volunteers ($N = 45$) were 80% female, 40% non-white, and 24% Latine; 6-10 typically participated per field trip, and 44% were trained at the doctoral level and held positions as faculty and fellows, while 20% were undergraduate or graduate trainees. All volunteers received written onboarding materials prior to the events regarding maker pedagogy, cultural responsiveness, and the YSP curriculum, as well as one-on-one and small-

Table 2. *School-Level Student Demographics.*

Academic Year	2022-2023*	2023-2024**				2022-2024
School	1	1	2	3	All	All
Grade(s)	3rd, 4th	3rd	4th	5th	3rd, 4th, 5th	3rd, 4th, 5th
Students (N)	372	392	487	742	1,621	1,993
Female	50%	50%	47%	48%	48%	49%
White	21%	18%	9%	5%	9%	12%
Black/African American	64%	67%	30%	8%	29%	35%
Hispanic/Latine	5%	6%	54%	82%	55%	46%
Asian	1%	1%	5%	6%	5%	4%
Biracial/Other	9%	8%	5%	5%	6%	6%
Response Rate by Evaluation Mode						
In-School Surveys	63%	86%	35%	95%	64%	64%
Exit Surveys	79%	100%	100%	100%	100%	94%
Polls	80%	92%	97%	100%	97%	93%

*Based on 2022-2023 public data; **Based on 2023-2024 public data.

group guided instruction on the day of the field trips. New volunteers were paired with more experienced volunteers, and all volunteers were supervised by one or more museum educators.

Program Performance Domains and Assessments. The YSP's learning outcomes are concentrated in three primary domains: 1) inventive learning, belonging, and STEM interest, 2) students' affiliation with STEM careers, and 3) cancer biology and prevention comprehension. To evaluate these outcomes, students were assessed on-site at the museum using an exit survey and poll, and upon returning to their school classrooms using a self-report survey (see Table 3). An exit survey is a brief assessment administered to students at the conclusion of a learning day to gauge their comprehension and recall of exposed content (Fowler et al., 2019). All assessments were offered in both English or Spanish and completed in a student's preferred language.

Inventive Learning, Belonging, and STEM Interest. The YSP's intended elements of growth were measured in three domains: 1) inventive learning, 2) sense of belonging, and 3) interest in STEM. *Inventive learning* has previously been conceptualized through KID Museum's Mind of a Maker framework which promotes students' development as empathic and persistent problem-solvers, teammates, and agents of change (Scharon et al., 2024). It includes eight

pedagogical constructs: imagination, reflection, perseverance, exploration, initiative, teamwork, perspective-taking, and skill-building. Education research also indicates that students who feel a stronger sense of *belonging* within the STEM community are more likely to engage in continued STEM learning (Hansen et al., 2024). The program facilitates learning where each student is able to make an active contribution to their team. To do so, KID Museum educators and cancer center volunteers engage every student in a group by encouraging them to work with each other to solve problems before asking for external help. Active participation among students supports and builds their self-confidence in working with others while learning STEM content. Regarding *STEM interest*, a young student's passion for learning STEM subjects is another crucial step to widening the pipeline of students entering STEM professions (Tercyak et al., 2024). The YSP aims to ignite a student's curiosity about each problem they encounter at the museum while encouraging them to apply knowledge and skills learned at school and at the museum, such as math or science. A student's sustained or increased affinity toward science, inventing, building and engineering—sparked by the experience of the YSP—may facilitate longer term STEM interest.

Measurement. The evaluation plan and bilingual (English and Spanish appearing side-by-side) assessment measures were analogous to a suite of tools that were developed, tested, and validated through prior educational research on children engaging with STEM teachings in informal settings (Noam et al., 2020). For the present evaluation, inventive learning, students' sense of belonging in STEM, and STEM interest were measured by a 10-item survey completed upon their return to school (facilitated by classroom teachers) (Scharon et al., 2024; Tercyak et al., 2024). Students rated each item on a three-point Likert-type scale using visual in-

Table 3. *Program Performance Domains and Evaluations.*

Domain	Source
Inventive Learning	Classroom Survey
Belonging	Classroom Survey
STEM Interest	Classroom Survey
Affiliation with STEM Careers	Exit Survey
Student Comprehension and Recall	Poll

dicators; students could circle a frowning face, neutral face, or smiling face that corresponded with each quantifier (1 = *Not at all*, 2 = *A little*, 3 = *A lot*). These visual indicators, paired with adjectives and quantifiers, along with verbal instructions by teachers to help reduce literacy demands, are reliable and valid ways to assess young children's experiences (Mpundu-Kaambwa et al., 2024). Higher item-level scores are considered indicative of more inventive learning, belonging, and STEM interest.

A confirmatory factor analysis was conducted to determine the appropriate placement of each of the 10 items onto one of three factors: Factor 1: "Inventive Learning" (5 items; e.g., "I keep trying when things are hard", "I came up with new ideas", and "I thought about other people's ideas"), Factor 2: "Belonging" (2 items; "I feel like I belong" and "I think people like me can be scientists or engineers"), and Factor 3: "STEM Interest" (3 items; "I like science more", "I like building and engineering more", and "I like math more"). The factor structure indicated correct item placements: root mean square error of approximation = 0.04, comparative fit index = 0.96, and Tucker-Lewis index = 0.94. The internal consistency of the overall scale (Cronbach's coefficient α = 0.72), and its factors (Cronbach's coefficient α Inventive Learning = 0.64; r of Belonging = 0.26, $p < 0.001$; semi-partial r of STEM Interest = 0.32, $p < 0.001$), were acceptable.

Affiliation With STEM Careers. The exit survey was individually administered and collected at the end of the YSP field trip day at the museum. It consisted of two items measuring students' affiliation with STEM careers: 1) "Today I practiced being a scientist" and 2) "Today I practiced being an engineer." Each item was rated on a three-point scale (1 = *Not at all*, 2 = *A little*, 3 = *A lot*); students completed and submitted their responses privately to avoid peer or other influences.

Student Comprehension and Recall. Similarly, students were assessed on their understanding of cancer biology and prevention concepts at the end of the YSP field trip day with three face-valid items: 1) "Can the sun's ultraviolet rays hurt your skin cells without giving you a sunburn?", 2) "Can a doctor see a problem in our cells without a microscope?", and 3) "Does your immune system recognize different types of threats to your body?" Students were then polled to individually vote "Yes", "Maybe", or "No" to each item using a token in a jar. Correct responses were taken as a percentage of the whole per item.

Data Analysis Plan. All program data were entered, error-checked twice, and screened for statistical assumptions before conducting analyses. Demographic characteristics of the sample were examined using frequencies, percentages, means, and standard deviations. For inventive learning,

belonging, and STEM interest, success in advancing YSP's objectives was defined as student's responses of "A little" or "A lot" combined (Boateng et al., 2018). For student comprehension and recall, responses of "Maybe" were included with the correct response for all items and counted and reported as such when assessing each domain. Combining response options in this manner was consistent and developmentally-attuned to the cognitive levels of children in these grades (Rochat, 2024). It also ensured adequate cell sizes for all statistical analyses to proceed and to simplify interpretations given the ages of the children who provided the data. Additionally, a more stringent scoring approach was utilized to determine correctness -- whereby "Maybe" responses were included with those that were incorrect, and the resulting differences in percent correct were calculated. In order to estimate the effect of this more stringent scoring method, comparative analyses were undertaken. In multivariable regression modeling of inventive learning, outcomes were adjusted for school grade-level to examine possible maturational effects. Statistical analyses were conducted using SPSS version 29.

RESULTS

As shown in Table 2, the YSP's evaluation sample is stratified across three modes of data collection (in-school surveys, exit surveys, polls). For in-school surveys, it consisted of $N = 257$ students, with an overall response rate of 64%. For one school in the second year of the program, the response rate was below the expected 65% threshold as school staff were unable to secure the successful completion or return of more surveys from students due to classroom time constraints and other teaching demands. For exit surveys and polls, data were collected from $N = 380$ and $N = 373$ students, respectively. The exit survey response rate was 94% across both years, and 93% for polls.

Inventive Learning, Belonging, and STEM Interest. For the primary outcome of inventive learning, a total of 92% of student participants responded "A lot" or "A little," as did 93% of students for belonging, and 85% for STEM interest. There were no differences across grade levels in these outcomes, suggesting equivalent performance by the YSP curriculum developmentally. Additionally, consistency among these outcomes across both years of the program suggests a balanced implementation of teaching.

Affiliation With STEM Careers. Across the YSP cohort, 99% of students self-reported that they "practiced being a scientist" and 98% "practiced being an engineer" "A lot" or "A little" during the program. Again, no grade-level differences in these outcomes were observed.

Student Comprehension and Recall. Across both years of the YSP, 90% of students correctly answered questions assessing identification of reducing sunburn risk as a form of cancer prevention, 82% correctly identified the role of microscopes in cell biology, and 97% correctly identified the body's immune response. Trends across grades indicated more advanced comprehension among older students in two of the three areas measured: a significantly higher percentage of students in 5th grade than in 3rd grade correctly answered questions about sunburn (5th = 98%, 3rd = 83%, $\chi^2 = 15.1$, $p = .001$) and cell biology (5th = 91%, 3rd = 77%, $\chi^2 = 8.1$, $p = .004$), but not immunology (3rd and 5th = 96%, $p = .13$). When a more stringent scoring method was used for the variables assessing students' comprehension and recall, changes in the proportion of those who correctly answered questions were observed: -22% for sunburn risk, -17% for cell biology, and -16% for immunology.

Linear Regression. In a multivariable regression model of students' inventive learning, controlling for grade-level and knowledge about cancer biology and prevention, both STEM interest and feelings of belonging in STEM were significantly associated with this type of learning and accounted for 22% of the model's variance (see Table 4a). Specifically, students' STEM interest ($\beta = 0.43$, $SE = 0.09$, $t(237) = 4.79$, $p < .001$) and feelings of belonging in STEM ($\beta = 0.52$, $SE = 0.13$, $t(237) = 3.91$, $p < .001$) were positively associated with their feelings of lifelong inventive learning. When students' "Maybe" responses were scored as incorrect, the model's results for both STEM interest and feelings of belonging in STEM were unchanged (see Table 4b).

DISCUSSION

The findings from this evaluation underscore the potential efficacy of the curriculum that powers the YSP in promoting

STEM interest, a sense of belonging, and inventive learning among elementary school students from Title I schools in communities that are under-resourced. By leveraging maker learning and informal educational environments in a local STEM-focused museum, the YSP attempts to address critical gaps in STEM education access and representation. These results align with prior research emphasizing the importance of early, hands-on STEM experiences in nurturing interest and competence in STEM fields (including cancer medicine, biology, and prevention), particularly for students from historically-underserved backgrounds (Falk & Dierking, 2010; Hsu et al., 2017).

The inventive learning outcomes highlight the potential value of engaging young students in hands-on, creative problem-solving activities that foster perseverance, imagination, and teamwork. This may be noteworthy given the demographic composition of the students that have historically confronted systemic and structural barriers to STEM education and careers. By providing a supportive and stimulating environment, students in the YSP may come to see themselves as capable and innovative learners, which is a key step in dismantling biases about who can succeed in STEM.

The success in creating a sense of belonging and fostering STEM interest further demonstrates the YSP's potential impact. A strong sense of belonging has been shown to enhance engagement and academic success, particularly for students from underserved groups (Hansen et al., 2024). By integrating bilingual instruction and culturally-relevant teaching methods, the YSP likely created an inclusive educational environment that allowed its learners to collaborate meaningfully with peers and mentors, further reinforcing their confidence in STEM settings. If replicated and extended, these findings suggest that similar programs could be instrumental in promoting students' learning.

The finding that a majority of students reported practicing being a scientist and/or engineer during the YSP field trip

Table 4a. Multivariable Regression of Inventive Learning.

Independent Variable	Unstandardized Estimate (B)	Standardized Estimate (B)	Standard Error	t	p
Grade	-0.72	-0.28	0.74	-0.97	0.33
Comprehension and Recall (1)	0.04	0.15	0.05	0.91	0.37
Comprehension and Recall (2)	0.06	0.23	0.05	1.29	0.20
Comprehension and Recall (3)	-0.09	0.04	0.20	0.45	0.65
Belonging in STEM	0.43	0.30	0.09	4.79	< 0.001
STEM Interest	0.52	0.25	0.13	3.91	< 0.001

"Maybe" Scored as **Correct**; $N = 237$; Adjusted $R^2 = 0.22$, $F(6, 237) = 11.99$, $p < 0.001$.

Note: Tables 4a and 4b differ by the treatment of students' "Maybe" responses for comprehension and recall.

Table 4b. Multivariable Regression of Inventive Learning.

Independent Variable	Unstandardized Estimate (B)	Standardized Estimate (B)	Standard Error	t	p
Grade	-0.60	-0.23	0.40	-1.50	0.14
Comprehension and Recall (1)	0.02	0.10	0.03	0.96	0.34
Comprehension and Recall (2)	0.03	0.19	0.02	1.60	0.11
Comprehension and Recall (3)	-0.01	-0.02	0.05	-0.21	0.84
Belonging in STEM	0.43	0.30	0.09	4.79	< 0.001
STEM Interest	0.52	0.25	0.13	3.91	< 0.001

"Maybe" Scored as **Incorrect**; $N = 237$; Adjusted $R^2 = 0.22$, $F(6, 237) = 11.99$, $p < 0.001$.

day highlights the potential effectiveness of hands-on, maker learning as an intervention for young scholars. This exposure may enable them to not only learn about new career pathways, but also visualize themselves in professional roles that might otherwise seem inaccessible. The YSP's incorporation of real-world STEM professionals with backgrounds in cancer medicine, biology, and prevention provided students with role models, further supporting the program's goal of breaking down perceived barriers to STEM careers.

The findings with respect to assessing knowledge about cancer biology and prevention concepts may suggest that complex topics such as these can be effectively communicated to young learners through interactive and engaging methods. Differences between fully and partially correct responses should be kept in mind, however, as the evaluation strategy awarded partial credit to students who were unsure. This is consistent with the YSP's developmental continuum approach to assessing learners' knowledge acquisition (Rochat, 2024). When partial credit was not awarded, students' performance in these domains was attenuated when examined individually. However, when put into the context of their school grade, the inventive learning model remained unchanged (Scharon et al., 2024). The subtle differences in knowledge demonstration between younger and older students in certain areas could point to the importance of age-appropriate scaffolding in future iterations of the program. Doing so would ensure that students across grade levels could achieve a deeper and more complete understanding of the material presented. The outcomes of such adaptations in future years of the program remain to be seen.

While the program achieved some success, there are several important limitations to consider. First, the reliance on self-reported data introduces potential biases, such as social desirability or inaccurate recall. Additionally, responses on some scales were combined to ease their interpretability and to acknowledge the development acquisition of new information. This resulted in a less granular analysis and may affect data interpretations that favor program outcomes when examined singularly. These effects were tested for and reported. They did not appear to influence the observed associations among study variables when examined simultaneously and within the inventive learning framework. The use of reliable measures (supported by a comprehensive psychometric analysis) may also mitigate these risks. Future evaluations could incorporate a pre-/post- evaluation design and observational measures or independent assessments to corroborate these findings, and work to assure a higher response rate for all data collection. Second, generalizability of the findings may be limited by (a) the school-administered survey response rate, which does not account for student absence on the day of the assessment, students' lack of willingness to respond, or awareness of classroom time restrictions; (b) sample size; (c) the geographic focus of the

cancer center's catchment area; and/or (d) the inability to link individual students' assessments across modes of data collection. The multivariable regression model may have been especially sensitive to the latter effect. Strengthening the YSP's survey response rate should increase the available sample size, and expanding the YSP to additional schools and regions may provide a more comprehensive understanding of the curriculum's impact, including paired assessment modes. Finally, the implementation of the program as a one-day intervention in elementary school, albeit successful, may limit the long-term impacts of the intervention. Longitudinal follow-up is necessary to assess whether the positive outcomes observed in inventive learning, belonging, and STEM interest translate into sustained engagement, as well as eventual vocations in STEM fields. Doing so would require establishing a student cohort that is tracked into middle and high school (and beyond), and with additional educational content and scaffolding, with opportunities to practice maker learning.

In sum, the YSP represents a model for addressing disparities in STEM education and sparking STEM career interest among students from Title I elementary schools in communities that are under-resourced. By combining maker learning with exposure to STEM professionals in cancer biology and prevention, the program appears to have fostered both a sense of belonging and enthusiasm for STEM and empowered students to see themselves as agents of change within their communities. Scaling such programs could play a role in diversifying the STEM workforce and reducing health disparities, particularly in fields like cancer medicine, biology, and prevention. Future efforts should focus on more stringent evaluation criteria, longitudinal tracking of students, and the integration of additional supports to sustain early gains, ensuring that the pipeline to STEM careers remains open and accessible to all students.

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ACKNOWLEDGMENTS

The authors would like to thank the students, teachers, and staff of the participating schools, as well as the faculty and staff at Georgetown University Lombardi Comprehensive Cancer Center and KID Museum.

FUNDING SOURCES

Research reported in this publication was supported, in part, by the National Cancer Institute at the National Institutes of Health under award number CA041008. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Partial support was also provided by the A. James and Alice B. Clark Foundation and the David Kelby Johnson Memorial Foundation.

ABBREVIATIONS

STEM: Science, Technology, Engineering, and Mathematics; UV: Ultraviolet; YSP: Young Scholars Program

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