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Leveraging Maker Learning in STEM to Promote Children's Interest in Cancer Research: A Pilot Program

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Abstract
Children's early awareness about cancer, through exposure to cancer biology and prevention strategies and research principles, is a promising focus of education and learning. It may also benefit the pipeline of people entering into science, technology, engineering, and math (STEM) careers. We describe an educational pilot program for elementary school students, using developmentally appropriate activities focused on cancer at a museum dedicated to children's maker-centered learning and STEM. The program was implemented through a public school in Washington, DC serving students underrepresented in STEM. Program conceptualization, museum and school engagement, and maker learning pedagogy are described, as well as curricular outcomes. A total of $N = 111$ students (44% female, 75% Black/African American, 5% Latine) participated in a day-long field trip. Museum educators, assisted by cancer center researchers, led a multipart workshop on cancer and the environment and hands-on rotation of activities in microbiology, immunology, and ultraviolet radiation safety; students then completed self-report evaluations. Results indicate that nearly all (> 95%) students practiced activities typical of a STEM professional at the program, and > 70% correctly answered factual questions about topics studied. Importantly, 87–94% demonstrated clear STEM interest, a sense of belonging in the field, and practice implementing skills for success in STEM (e.g., perseverance, imagination, teamwork). This pilot demonstrated acceptability and feasibility in delivering a cancer-focused curriculum to underserved elementary students using maker learning while favorably impacting key objectives. Future scale-up of this program is warranted, with the potential to increase students' motivation to engage in STEM and cancer research.

Keywords Children · STEM · Cancer-focused curriculum

Introduction

Raising children's awareness of cancer may ultimately result in the prevention and control of the disease, especially awareness of environmental drivers of cancer causation and lifestyle-related cancer risk factors. Children may be exposed to this knowledge from a number of different sources, including the direct experience of cancer in their families as well as their school's health curricula. Greater awareness of cancer and cancer risk may be further strengthened in children when they have a deeper understanding of the foundations of and science behind cancer biology. Importantly, providing children with education about cancer biology and prevention may foster their interest and engagement in science, technology, engineering, and math (STEM) more broadly and pathways of study and career fields in STEM. To the extent that this knowledge could be translated into achieving greater health equity among people of all backgrounds, it could diminish well-known cancer disparities that exist across different racial, ethnic, and socioeconomic groups.

Despite this potential, there is a significant disconnect between the knowledge and skills students develop in school and those required to not only excel in STEM careers, but also to solve many of society's most pressing challenges (e.g., global climate change, pandemic responses, and other public health crises), many of which require STEM-based solutions [1]. Maker learning (i.e., hands-on, project-based

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learning through inquiry, experimentation, and the engineering design process) has been lauded as a way to develop children's STEM competencies, promote creative problem-solving skills, and improve social-emotional learning. Education research on makerspaces (i.e., the places where maker learning occurs) in elementary school settings has revealed compelling evidence of the benefits of this type of learning approach, specifically, that makerspaces can be highly effective at developing children's creativity, critical thinking, design thinking, and digital skills [2]. These competencies are shared by STEM professionals, including cancer researchers.

In the greater Washington, DC area, a number of nationally prominent science museums are available to the general public, including the Smithsonian Institution. However, even in this museum-dense region, there are no publicly-sponsored museums exclusively devoted to maker learning. Thus, a new museum was established in 2014 to help fill this gap. There, and through dynamic, deep-dive programs, youth build interest in STEM and computer science in the context of real-world, creative problem-solving and collaborative, project-based education. Since its inception, this museum has served more than 370,000 students, family members, and educators, with a strong commitment to equity and inclusion: greater than 60% of those served come from under-resourced communities.

These museum's partnerships are designed to inspire and cultivate the next generation of diverse and creative problem-solvers and change-makers. Through direct onsite educational programming, classroom curricula, and staff professional development, students and teachers immerse themselves in the museum's "Mind of a Maker" framework (see Fig. 1), which empowers youth with practices and habits of mind that build creativity, agency (i.e., personal directness), and empathy. There, they learn to cultivate a growth mindset, enjoy challenges, and consistently develop new skills.

The Mind of a Maker framework comprises eight core dimensions of cognitive, social, and emotional development—imagination, reflection, perseverance, exploration, initiative, teamwork, perspective taking, and skill building—that are necessary for children to become empathetic and persistent problem-solvers, teammates, and agents of change. These aspects were identified by exhibitions and education staff during internal reflection in 2014, and though the precise terminology has evolved over time, the Mind of a Maker as a pedagogical model represents a convergent evolution with frameworks from like-minded institutions and disciplines. Other museums and informal education institutions, including the Tinkering Studio at the Exploratorium [3], the MAKESHOP at the Children's Museum of Pittsburgh [4], and the New York Hall of Science [5], as well as formal academic initiatives, such as MIT Media Lab's Lifelong Kindergarten group [6], have designed frameworks with an overlap in many domains such as exploration, teamwork, perspective taking, inquiry, and reflection. These approaches engage students in technical skill building while fostering crucial social-emotional abilities in the context of meaningful, empathic, collaborative, and applied problem-solving. The museum's ongoing program

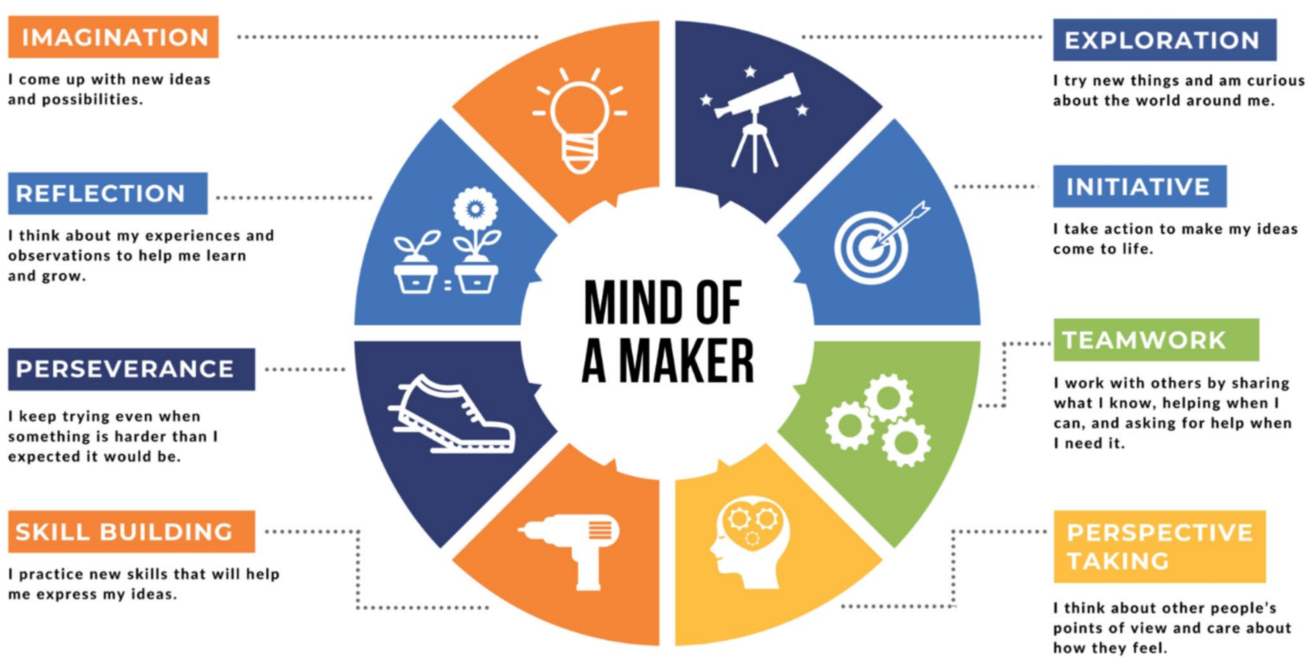

Fig. 1 Mind of a maker framework

evaluations indicate success in cultivating students' sense of belonging in STEM, accompanied by agency and confidence as learners. In a sample of over 1000 elementary students surveyed after engaging in the museum's inventor program, 89% reported feeling a sense of belonging at the museum, and 86% felt that the museum helped their ideas come to life. Moreover, 92% were inventive during their experience, and 89% liked building and inventing more because of their museum experience [7].

A recent review paper investigated the effectiveness of interventional cancer educational programming, including those delivered in school and other community settings, on raising children's awareness of cancer biology and prevention. Based upon their 20-year retrospective, the authors concluded that cancer education interventions can enhance the cancer knowledge, prevention attitudes, self-efficacy, and behavioral intentions of school students from elementary school to high school [8]. Empowered by these and other findings, we sought to determine the extent to which cancer research–focused educational content could be integrated within a maker learning curriculum and delivered in an informal educational context as part of a university cancer center and museum partnership that was directed toward children attending elementary school in an under-resourced community. Specifically, we developed a curriculum for a day-long experience for children in Grades 3 and 4 at a maker learning museum, co-delivered by cancer center faculty and staff and museum educators. As part of this effort, we evaluated the impact of the program (the "Young Scholars Program") on measurable learning objectives, including the comprehension of three fundamental health lessons in cancer biology, risk, and prevention and the implementation of the museum's Mind of a Maker learning framework.

In this report, we outline the conceptualization of the program and the development of the curriculum and present outcome data from the first cohort of students. We further describe how the university cancer center engaged with the museum and local elementary school and obtained financial support for the endeavor. We anticipate that other university cancer center and museum partnerships could benefit from these experiences to co-develop similar programs that meet the needs of children in their local communities and help to promote a pipeline of future STEM professionals focused on cancer research.

Method

Program Conceptualization

The Young Scholars Program (YSP) at the university cancer center was created to educate members of the community about cancer biology and prevention, with a specific focus on outreach to elementary school students from historically underrepresented groups in STEM in the greater Washington, DC metropolitan area. Leadership at the cancer center sought to expand its scope of youth education beyond its pre-existing programs for high schoolers and college undergraduates to enhance awareness and understanding of STEM career pathways beginning as early as elementary school.

In order to survey the landscape of ongoing elementary school engagements at the university and to outline a curriculum that would be integrated with the elementary school students' standards of learning, the YSP leadership met with content experts in educational service provision to students from schools meeting federal Title I designation. Through multiple rounds of brainstorming, the YSP leadership identified new opportunities for synergy and developed a strategy whereby the cancer center could strengthen pre-existing university partnerships with local elementary schools and a hands-on, K-12 maker learning and STEM museum to create an engaging, interactive, and impactful opportunity.

Museum Engagement

The YSP program approached a museum specializing in children's maker learning to develop the concept for a single-day educational event to best leverage the cancer center's resources. The YSP program's educational mission matched the museum's priority audience target of elementary school students from under-resourced communities and led to the collaborative design of a bio-tinkering and health-relevant curriculum with content specifically addressing cancer biology and prevention. Shared relationships among the university, museum, and local schools were explored to identify potential school district partnerships and their elementary schools enabling YSP leadership to engage school administrators.

Elementary School Engagement

Together, the cancer center and museum successfully identified two schools (with Title I designation, having a poverty rate at or above 35%) in the greater Washington, DC community that primarily serves students historically underrepresented in STEM and contacted a representative from each school. One school expressed strong interest in the YSP, as their classroom teachers had already engaged in professional development programming in maker learning and STEM education with the museum as part of their curriculum development and in-service training. Museum staff, cancer center leadership, and the school's educators discussed the program's goals and objectives and the school's priorities for what an educational experience could achieve. Together, they explored how to develop a day-long museum program grounded in maker learning activities led by museum educators that would best cultivate students' (a) interest in STEM, STEM careers, and fundamental scientific research and process skills; (b) learning about key concepts in cancer biology and prevention; and (c) sense of belonging in STEM and maker learning environments that have historically excluded non-dominant identities.

Financial Support

Financial support for the program was obtained through an initial gift to the cancer center from a philanthropic organization whose mission is to support young children's health, education, and well-being. This funding was augmented by the cancer center to provide release time for faculty to advise on the development and implementation of the curriculum and for faculty and staff to volunteer to organize and participate in YSP events.

Curriculum

After identifying the participating school and teacher responsible for program coordination, it was next determined which grade levels the YSP could best serve based on interest and availability. Program leadership then met with STEM curriculum development experts from the museum to formulate developmentally appropriate learning objectives for the cancer biology and prevention curriculum. The curriculum was initially tailored to elementary school students in Grades 3–5, with optional expansion modules for older and younger students, and addressed environmental and social determinants of health present in their communities. In the spirit of community-based participatory research, the YSP recognized that it was important that lessons learned could be readily translated back to students' classrooms and applied to their daily lives. For example, the selected elementary school was located near a previously contaminated river and watershed. Hence, one of the learning objectives focused on environmental health, including clean drinking water and the impact of pollution on health and cancer risk. Moreover, the YSP and museum practitioners saw value in providing students with physician and scientist role models in health-based and cancer research careers at the bachelor's, master's, and doctoral levels, including those from diverse backgrounds. For this reason, the volunteers for the program's event days were sought from within the center's research and clinical faculty and ably supported by center staff.

The YSP was structured so that students would rotate through four hands-on STEM activities focusing on different areas of cancer biology and prevention. Up to 60 students could be accommodated onsite at one time at the museum: round-trip bus transportation and lunch were provided at no cost to the participating school. Upon arrival, students were evenly divided into two groups and rotated through their assigned schedules. Group A devoted the first 90 min to an environmental health workshop, followed by lunch, and then three 30-min activities. Meanwhile, Group B completed the rotation in reverse order. Prior to the conclusion of the visit, students and teachers gathered together as a full group to reflect on their learning, participate in evaluation activities (see below), and be prepared to return to school with tokens of appreciation from the YSP for their classrooms. The entire visit day lasted approximately 3 h in total.

Environmental Health

In the 90-min environmental health workshop, students combined the scientific method and the engineering design process by exploring an environmental case study and building a solution to the health problem they uncovered. They were presented with a scenario about lake pollution and contaminated drinking water. In order to investigate the issue and uncover solutions, students needed to interview key stakeholders about their points of view. Those interviewed included the fish in the lake, the water itself, the gravel at the lake's bottom, people who lived near the lake, and un-recycled trash disposed of in the lake. Cancer center volunteers were provided with role-play scripts prepared by the museum staff and acted the part of these stakeholders, while students interviewed them in groups. Students learned how to ask research questions, using the prompts who, what, why, and how, with follow-up questions using where and when. After gathering their environmental health data, the students engaged in an engineering design process to identify a specific problem, design a solution, test their solution, and improve their prototype. They used the museum's maker studios and explored a variety of tools and materials to help strengthen their key maker skills and build their prototype. For example, if students discovered that the lake was polluted with recyclable garbage that was covering the gravel, harming the fish, and preventing fresh drinking water, they could propose a novel invention to collect the garbage without harming the environment (e.g., a solar-powered, underwater trash scooper). At the conclusion of the workshop, each team of students presented their prototype to the class, and other teams were encouraged to ask questions.

Cancer Biology and Prevention Activities

There were three 30-min activities that students rotated through in groups of six to eight: (1) cardboard sun structures, (2) microscope making, and (3) immune response coding. In the cardboard sun structure activity, students designed and built protection solutions to block ultraviolet radiation when people are exposed to the sun. Students tested their designs on a small-scale model of a beach where a lamp served as the sun and powered a small fan. If the structure effectively blocked the "sun's harmful rays," then the fan would stop rotating. If not, students worked with museum educators and cancer center volunteers to reimagine their design and rebuild their solution. Similarly, for microscope making, students learned how to prepare slides and use microscopes by exploring how changes (e.g., when heat is applied) in materials (e.g., wood, sandpaper, hair) appeared under different levels of magnification. Some changes were visible to the naked eye, while others required magnification in order to be seen. Finally, students explored the mechanics of the human body's immune response by using computer coding to control color-sensitive robots. Robots symbolized white blood cells, and students were challenged to activate them to respond to different health conditions on a large graphic of a person. The person had a scratch, a bruise, an infection, a stomach bug, and sunburn—each represented by a different color. Students who successfully coded their robot (white blood cells) sent it to specific ailments. If unsuccessful, the robot was reprogrammed with guidance from museum educators and cancer center volunteers.

Program Outcome Evaluation

Overview

In collaboration with the YSP leadership, the museum designed a comprehensive outcome evaluation based on their prior work, including a combination of direct observations, as well as developmentally appropriate surveys collecting students' self-reported feedback. First, a brief survey tool was administered at the museum prior to departure and assessed the indicators of the program's overall success in achieving its curricular objectives (to cultivate student learning and engagement in STEM). For instance, two items measured the extent to which students participated in STEM practices (e.g., "Today I practiced being a scientist"). Responses were collected using a 3-point scale (1 = "not at all," 2 = "a little," 3 = "a lot"), and each scale included a graphic representation of a smiling, neutral, or frowning face to support students with early reading and/or limited English language learning skills.

Student Comprehension

At the conclusion of the YSP, museum staff read students' questions aloud about their learning. Oral conveyance of questions ensured that any developmental differences in reading levels or proficiency would not impact survey results. These questions, written by museum staff, measured comprehension of three fundamental health/cancer lessons embedded throughout the rotation of activities. The questions were as follows: (1) Can the sun's UV rays hurt your skin cells without giving you a sunburn? 2) Can a doctor see a problem in our cells without a microscope? 3) Does your immune system recognize different types of threats to your body? Students indicated their responses (yes, no, or maybe) by placing a token in a jar with the corresponding label.

Take Home Assessment and Mind of a Maker Principles

To assess the implementation of the museum's Mind of a Maker learning framework and its constituent dimensions of maker and social-emotional learning, an additional 15 items assessed 8 pedagogical constructs: imagination, exploration, initiative, teamwork, perspective taking, skill building, perseverance, and reflection. This developmentally appropriate assessment had been successfully implemented in the past with several large local school districts and was created in collaboration with a consultant specializing in assessing STEM learning in informal education contexts. This retrospective self-report survey, distributed to teachers at the end of the field trip, orally conveyed by teachers, and completed by students when they returned to school, measured several STEM-related attitudes, including STEM interest and engagement, knowledge of STEM career pathways, and the development of a positive STEM identity. The survey also asked students to report their grade level and collected their responses to each item using a 3-point scale (1 = "not at all," 2 = "a little," 3 = "a lot") with graphical depictions.

Statistical Analysis

All program data were entered, cleaned, and screened for statistical assumptions before conducting analyses. Demographic characteristics of the sample were examined using frequencies/percentages and means/standard deviations. Univariate, bivariate, and reliability statistical analyses were conducted using SPSS.

Results

The partner elementary school enrolled more than 370 elementary students during the 2022–2023 academic year. Based upon publicly available school-level demographic data, 64% of students were Black or African American, 21% were White, 9% identified as being 2 or more races, and 5% identified as Hispanic/Latine. As shown in Table 1, a total of $N = 111$ students from the partner school participated in the YSP, including $N = 60$ students in Grade 3 and $N = 51$ students in Grade 4. Participating students were 56% male and 44% female. The racial and ethnic composition of the

Table 1 Elementary student demographics

	Grade 3 (*N*=60)		Grade 4 (*N*=51)		Total (*N*=111)	
	N	%	*N*	%	*N*	%
Race						
White	12	20.0%	7	13.7%	19	17.1%
Black	42	70.0%	40	78.4%	82	73.9%
Biracial/Other	6	10.0%	4	7.8%	10	9.0%
Gender						
Male	30	50.0%	32	62.8%	62	55.9%
Female	30	50.0%	19	37.2%	49	44.1%
Ethnicity						
Hispanic/Latine	3	5.0%	2	3.9%	5	4.5%
Not Hispanic/Latine	57	95.0%	49	96.1%	106	95.05%

participating classes was similar to school-wide demographics, with slightly fewer students identifying as White (17%), more students identifying as Black or African American (74%) and multi-racial (9%), and a consistent 5% identifying as Hispanic/Latine. Faculty and staff who volunteered at the university cancer center were also racially and ethnically diverse. Specifically, 27% of cancer center volunteers identified as non-White, and 36% identified as Hispanic/Latine. These individuals included faculty who trained as biomedical researchers, physicians, and population scientists, with 64% identifying as female.

Onsite Assessment Results

In the survey administered immediately after the workshops (completed by 79% of students) and as shown in Table 2, 97.7% of all participating students affirmed that they had "practiced being a scientist" during the day's activities, and 95.5% endorsed that they had "practiced being an engineer." There were no statistically significant differences between grades or items, as 100% of Grade 4 students identified as having "practiced being a scientist" and 97.5% as having "practiced being an engineer" on the day of the activity.

Student Comprehension

When asked about STEM content from the day's activities (completed by 91% of students, see Table 3), a majority of participants demonstrated retention of key concepts by correctly answering questions relating to cancer prevention (73%) and biology (82% microscopy and 77% immune functioning). Again, there were no statistically significant differences by grade, although Grade 4 students tended to answer more items correctly than Grade 3 students, especially in the area of microbiology.

Mind of a Maker Principles

As part of the formal evaluation for the YSP, a standardized assessment was administered to all students in the days following the event. The assessment measured three factors that have previously been reported in the research literature to support young children's exploration of future careers in STEM [9]. These factors included (1) "Mind of a Maker" characteristics that relate to students' perseverance, imagination, innovation, teamwork, and perspective taking; (2) "belonging," which is defined as establishing a greater sense of inclusion and empowerment to

Table 2 Onsite assessment results

	Grade 3 (*N*=48)				Grade 4 (*N*=40)				Total (*N*=88)			
	Yes		No		Yes		No		Yes		No	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Today, I practiced being a scientist	46	95.9%	1	2.1	40	100	0	0	86	97.8	1	1.1
Today, I practiced being an engineer	45	93.8	0	0	39	97.5	1	2.5	84	95.5	1	1.1

Note. Data do not sum to 100% in all cases due to sporadic missing data, as well as incomplete survey responses by students

Table 3 Student learning comprehension results

	Grade 3 ($N=60$)		Grade 4 ($N=41$)		Total ($N=101$)	
	N	% Correct	N	% Correct	N	% Correct
Can the sun's UV rays hurt your skin calls without giving you a sunburn? (Yes)	44	73.3	31	75.6	75	74.3
Can a doctor see a problem in our cells without a microscope? (No)	49	81.7	34	82.9	83	82.2
Does your immune system recognize different types of threats to your body? (Yes)	46	76.7	40	97.6	86	85.1

Note. Data do not sum to 100% in all cases due to sporadic missing data, as well as incomplete survey responses by students

become a scientist or engineer in the future (e.g., emerging STEM professional empowerment); and (3) "STEM interest," which measures students' affinity for science, building/engineering, inventing, and math. When combined together, the internal consistency reliability of this measure was adequate (Cronbach's alpha = 0.75).

This assessment was completed by 62% of all students participating in the program. As shown in Table 4, outcome data indicate very high success rates in advancing YSP learning objectives across multiple measured dimensions: 94% for Mind of a Maker constructs, 94% for belonging, and 87% for STEM interest. When combined, these results demonstrate an overall program success rate of approximately 92% for YSP objectives based upon evaluation metrics from a reliable and valid assessment tool. Additionally, students participating in this program performed statistically significantly above participants in population-level data acquired by and maintained by the museum for the dimension of belonging ($Z = 2.47$, $p < 0.01$).

Additionally, open-ended response data from students allowed their voices and experiences to shine through qualitatively. From these outcome data, we determined that the YSP was successful in engaging students cognitively and emotionally, strengthening their identification with and promoting their interest in STEM, as typified by statements such as "I like…science, inventing, and building" or "I like building and inventing more" or "My favorite part of today was being an engineer."

Adoption

In the following school year, the YSP has now tripled its reach by adding two additional elementary schools and retaining the original elementary school. The two new elementary schools serve predominantly Latine student populations, and the YSP is scheduled to be delivered in the spring semester.

Discussion

As part of this program, a university-based cancer center partnered with a museum and designed a maker learning curriculum focused on cancer biology and prevention. The program was developed with the intent of enlarging the pipeline of young individuals tracking into future careers in STEM and enhancing the diversity of the cancer research workforce by focusing on elementary school students. After engaging third- and fourth-grade students from underserved and minority backgrounds through the program, some of the most important findings included (1) high levels of salience around STEM career identities, (2) significant knowledge about the cancer research topics taught, and (3) strong interest in and affinity for STEM. Specifically, the vast majority of students practiced being scientists (97.8%) and/or engineers (95.5%) as part of the YSP. Across both grades, over 70% of students correctly understood information about cancer prevention, and over 80% understood information about cancer biology. We believe that the YSP's success may be due, in large part, to the pedagogical approach of maker learning. This approach is rooted in the idea of capitalizing

Table 4 Standardized assessment results

	Mind of a Maker ($N=67$)	Belonging ($N=67$)	STEM interest ($N=69$)	Total ($N=69$)
Response range	5–15	2–6	3–9	5–30
Average score (M) and variance (SD)	$M=13.0$, SD = 2.3	$M=5.1$, SD = 1.0	$M=7.2$, SD = 1.5	$M=24.8$, SD = 4.9
Success rate	94%	87%	94%	92%

Note. Data do not sum to 100% in all cases due to sporadic missing data, as well as incomplete survey responses by students. At the item level, "success" was defined as meeting or exceeding "a little" agreement with the statement on children's imaginations, skill building, initiative, and other elements noted by our conceptual model. It was also a highly engaging and enjoyable learning experience for students. Quantitative findings suggested this to be true, as evidenced by high scores on a standardized assessment of Mind of a Maker and related principles; qualitative data further reinforced these notions—highlighting children's favorite parts of the program.

It should be noted that the STEM professional role models, both from the university cancer center as well as the museum partner, were racially and ethnically diverse. As of 2023, the museum's full staff identified as 9% Asian, 17% Black/African American, 2% Hispanic/Latine, 70% White/Caucasian, and 2% of two or more races; the team also identified as 70% female, 24% male, and 6% non-binary individuals. Among the university volunteers, 36% identified as Hispanic/Latine and 27% as non-White. The extent to which the young scholars, who excitedly engaged in the program, identified with these STEM professionals—both because of their roles and/or backgrounds—could promote greater workforce diversity over time. As children observe others like themselves performing roles they wish to emulate, they may ultimately do so themselves as part of their training and education pathways; the positive impact of representation in mentors and role models has been documented for other populations of STEM learners [10].

It is our belief that change begins young and that our young scholars have the potential to grow up and someday enter biomedical research fields to help address the nation's cancer burden. This program, which was highly feasible, widely accepted, and promisingly effective, could be replicated in other settings. The bulk of the resources needed to organize and deliver the program were devoted to the children's museum, as university-based faculty and staff donated their time and effort to participate (with permission from the employer), and co-funding by a philanthropic organization and the cancer center. Although the curriculum is expected to become part of the museum's future offerings, its delivery is strengthened by its partnership with the university. Not unlike other STEM and maker-education efforts with children that include a focus on health, the YSP adds to the field of cancer education by its emphasis on empirically-based curriculum development and outcomes evaluations to measure success [11–13].

Limitations

This project is not without its limitations, including the relatively small number of students who participated in the pilot program during its inaugural year and from whom outcome evaluation data could be gathered. It is also limited by its cross-sectional, post-test assessment only, which precludes understanding change over time in the constructs measured. Finally, the YSP itself is presently designed as a single-session educational intervention which may or may not have a sustainable impact. Future research with larger study samples, and more rigorous evaluation designs, could overcome these limitations, along with deeper, longitudinal integration of the YSP into classroom STEM curricula. Scale-up of these efforts is planned for the future and is currently underway. Despite these limitations, the program did reach more than 100 students from underrepresented backgrounds. Post-test outcome data were suggestive of favorable short-term impacts.

As a next step, we anticipate that the Young Scholars Program will be offered in future academic years to greater numbers of and more diverse students and will engage with the two largest public school systems in the greater Washington, DC metropolitan area. The Biden administration's support and increase in federal funding for educational STEM initiatives at all levels presents a remarkable opportunity. Leaders in cancer research training and education should reimagine how to solve the "pipeline problem," not just by focusing on post-secondary education, but also by intervening in and being inclusive of primary school settings. Intentionally designed expanded learning time during the school year and school day, similar to the YSP intervention, has been shown to be an evidence-based strategy to support accelerated learning, particularly for students from historically underserved populations [14]. In addition, research has shown that exposure to in-group mentorship/role models (shared identity between the mentor and the mentee) increases motivation and persistence in STEM and the formation of a positive STEM identity [15, 16], and furthermore, there is often a strong preference and positive outcome for students in STEM to see and have access to role models who share an identity with them [17]. Therefore, providing young scholars with exposure to STEM role models with whom they may more closely identify is an important building block toward the development of a diverse pool of future STEM leaders. It may take time to accrue the benefits of this approach to address the nation's cancer burden; however, we believe it will positively impact the field because future leaders and change-makers will be more representative of the population who are most deeply affected by cancer. Additionally, these individuals may also bring new and different insights to preventing and curing cancer than have been considered to date.

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Declarations

Ethics Approval This program was reviewed by the sponsoring university's institutional review board and was determined to not meet the requirements of human subjects research.

Consent to Participate Not applicable.

Competing Interests The authors declare no competing interests.

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