A Comprehensive Model for Motivating and Preparing Under-represented Students, Educators and Parents in Science, Engineering and Technology

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A Chicago, Illinois comprehensive informal learning science, technology, engineering, and mathematics (STEM) outreach program for kindergarten through grade 4 (K-4) students is described along with the program's theory of change and findings based on the participation of more than 200 urban minority students and their parents over a four-year period. This NSF-funded informal learning program was grounded in parental engagement theory of planned behavior and integrated both active-learning pedagogies and in-situ professional development for teachers. A unique age-appropriate science, engineering and technology integrated curriculum was delivered as a series of Saturday workshops set in a community science museum. Each year, cohorts of K-4 African American and Latino students and their parents participated in eight 3-hour workshops comprised of student/parent sessions of hands-on science and engineering activities as well as separate parent awareness and development sessions in STEM education and technology skill development. Mixed methods research methodology is used to measure the program's contribution to the advancement of the program goals. This program has incorporated major findings of more than 10-years of research that suggests that improving children's academic outcomes are much more effective when the family is actively engaged.[1] This program has offered opportunities for parents to work along side their children; provided strategies promoting positive parental/child engagement; and provided ongoing training and professional development for project teachers.

Background

Changing demographics
The composition of the United States' student population is shifting significantly due to a rapidly increasing and dispersing Latino population. Latinos are the nation's largest and fastest growing minority group with over 53 million in population, according to 2012 U.S. Census Bureau data.[35] According to recent 2013 demographic data analyses[2] the hundred largest counties by Hispanic population contain 71% of all Hispanics. Eight states contain three-fourths (74%) of the nation's Latinos: California, Texas, Florida, Arizona, New Mexico, New York, New Jersey and Illinois. In Illinois schools, the setting of this research initiative, minority student population (49.4%) is on the cusp of surpassing white student population, with Latinos leading the increase[3]. An increasingly diverse student population coupled with larger percentages of economically disadvantaged students in Illinois schools adds to the challenges faced by teachers and other education providers. If the country's economic well-being is dependent upon having a well-educated workforce, it will be necessary to provide instructors at all levels with advanced professional learning opportunities that will enable them to help students succeed. Too many students and parents believe that STEM subjects are too difficult, boring or exclusionary.[1]

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The number of students choosing to pursue STEM careers has declined over the past ten years. This is particularly true for U.S. students from historically underrepresented minority groups. Reports from the President's Council of Advisors on Science and Technology[4,5] predict a shortage of approximately one million new STEM professionals in the next decade; the report also identifies low college enrollment in STEM disciplines and an even lower graduation rate (fewer than 40 percent). This problem is even more severe for women and members of minority groups, as stated in the report: "…women and members of minority groups…now constitute approximately 70 percent of college students while being underrepresented among students who receive undergraduate STEM degrees (approximately 45 percent). This underrepresented majority is a large potential source of STEM professionals." [4] Early academic experiences that include career information for students are vital.

Research on cultural-historical factors and their influence on African American and Latino student educational success point to community as a particularly important element. [6] The program described in this paper is founded upon a strong community partnership and features a career awareness component that exposes young children to role models found in engineering based storybooks[37] , as well as local Latina/o speakers who are professionals in the STEM fields. It is indeed powerful for children to hear from someone who looks like them and learn from their story—their journey—their career. Exposing children to STEM careers at a young age and over a period of several years can make an impact and such career awareness experiences are essential for students to learn the skills they need to succeed in the 21st century. In addition, the program's engineering education experiences provide the kinds of cultural mediation and social learning experiences essential in the learning theory of Lev Vygotsky. [7] Vygotsky maintained that social learning interactions and cultural mediation contributed to the development of a child's cognition and higher learning functions. Tools, technology, and the development of self-guided design help students internalize and "appropriate" or make their learning their own. [7]

African American and Latino students' achievement gaps in STEM
The attraction and retention of students in science, technology, engineering and mathematics (STEM) disciplines along the full length of their education is a national imperative. Many efforts in improving STEM education have traditionally targeted high school aged students. Nonetheless it is important to motivate and prepare students at even younger ages. Students have the ability to understand and learn about engineering concepts, practices and careers at a very young age. [8]This learning can be further motivated when parents and teachers are involved in both formal and informal learning spaces. The emphasis of engineering at the K-12 level is critical to addressing the cognitive challenges faced in college by students in (STEM) courses and responds to the prominent placement of engineering in the new *Framework for K-12 Science Education.*[9] Denson & Hill [10] document the many students, especially females and students from historically underrepresented minority groups, switching out of their career choices in STEM fields. Although Latinos and African-American students of college-age are increasing as a percentage of the U.S. population, their participation rates in STEM fields are significantly lower than those of White and Asian Americans students. [11]

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Early academic experiences in STEM

Major findings from nearly two decades of research indicate that the family makes critical contributions to student achievement from the earliest childhood years through high school. The National Center for Family & Community Connections with Schools reports that based on review of 51 studies, there is consistent, positive, and convincing evidence that families have a major influence on their children's achievement in school and through life. [12] A key finding highlighted in a subsequent report indicated that regardless of race, ethnicity, culture, or income, most families have high aspirations and concerns for their children's success. [13] Yet not all parents have the awareness or resources to take action to further these aspirations. Early academic experiences in math and science and exposure to STEM careers is essential to address the numerous factors that contribute to unequal participation of minorities in science education. Throughout the last decade, researchers have recommended that career exploration and awareness begin before high school. [1,14,15,] Tai et al. [16] used nationally representative longitudinal data and found that to attract students into the sciences and engineering, we should pay close attention to children's early exposure to science at the middle and even younger grades.

Engineering problem solving & design as context

In the U.S., there has been a particular interest in finding the overlap between engineering education and science, mathematics, and even the social sciences. Curricular units and engineering activities have been developed and introduced in elementary classrooms and in secondary mathematics and science classrooms. Wong and Brizuela, [17] in a series of hands-on investigations for middle school students, offer integrated engineering design activities in which students collect and analyze their own mathematical data while considering real-world situations. Such research-based activities, along with many others[38], allow students to develop algebraic thinking skills in engineering-integrated contexts. This work is based upon a constructivist theoretical basis which builds upon Piaget's findings that "firsthand experiences are necessary if children are to learn, think, and construct knowledge" [18,19] Such learning experiences can further be situated in a friendly open environment and aligning with Papert's [20] notion of constructionism and learning as "building knowledge structures" by allowing the learner to be consciously engaged in the art of construction.

Furthermore, effective instruction reaffirms students' cultural, ethnic, and linguistic heritages. [21,22] Many practical instructional approaches build on students' backgrounds to further the development of their abilities. Critically important is recognizing that the use of effective instructional practices as demonstrated by research will improve achievement for all children, including those who are not minorities or children of poverty. The implementation of sound, research-based strategies that recognize the benefits of diversity can build a better future for all of us. Engineering curriculum and instruction in the kindergarten to the twelfth grade classroom (K-12 engineering education) can serve as a vehicle to teach other content areas in a cross-curricular fashion.[8] Additionally, certain engineering curricula have been found to impact learning in the specific content areas of mathematics and science. [23] The Next Generation Science Standards [9] calls for a learning environment that is student-centered and engages students in asking their own

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questions and designing experiments to solve problems. They also call for students to make physical system models that demonstrate their learning and specifically call for integration of engineering principles in K-12 science instruction. K-12 engineering education facilitates meeting these objectives, and efforts have already resulted in novel curricular approaches that have formally structured activities and learning objectives around state curricular standards in mathematics and/or science. [24]

The intervention program

The Chicago Science and Engineering Program
The *Chicago Pre-College Science & Engineering Program (ChiS&E)* was established in January, 2008 with the objective of increasing knowledge, skills and interest in science and technology among African American and Latino students to prepare them for the STEM workforce of the future. Founded by Kenneth Hill, the program took its inspiration from and was modeled on the successful Detroit Area Pre-College Engineering Program (DAPCEP) he co-founded in 1976 and led for more than 28 years. The ChiS&E program goals were:

> 1. Increase the knowledge, skills, and interest of K–4th grade students from underrepresented population groups in STEM fields;
> 2. Increase parents' knowledge and skills in science and engineering along with their capacity to support their children in pursuing education and careers in these fields;
> 3. Increase the effectiveness of teachers in engaging students and parents in the Saturday science-related learning activities.

In partnership with the Chicago Public Schools, the program targeted K-4th grade students from seven schools in five low-income communities of color on the south and west sides of Chicago. The ChiS&E program was a multi-year commitment for students and their families with four-five weekend instructional sessions scheduled in fall and spring/summer semesters of each school year for five years, beginning in the spring semester of Kindergarten. For example, in the spring of 2009, classes began with 64 first graders and 64 parents. Sixty percent were African American and forty percent Latino. Forty-seven of the initial 64 students and their parents successfully completed the five-year program.

Table 1 displays the number of students in each cohort as they progressed from semester to semester. As of 2013, four cohorts of students were participating in the program. In total, 221 (S) students and 221 parents (P) were a part of the program.

Table 1: Students in the ChiS&E program									
Grade	Spring + Summer 2009	Fall 2009	Spring + Summer 2010	Fall 2010	Spring + Summer 2011	Fall 2011	Spring + Summer 2012	Fall 2012	Spring 2013
K	64 S 64 P		64 S 64 P		55 S 55 P		62 S 62 P		
1		64 S 64 P	64 S 64 P	60 S 60 P	60 S 60 P	52 S 52 P	52 S 52 P	62 S 62P	62 S 62
2				53 S 53 P	53 S 53 P	60 S 60 P	60 S 60 P	52 S 52 P	52 S 52 P
3						47 S 47 P	47 S 47 P	60 S 60 P	60 S 60 P
4								47 S 47 P	47 S 47 P
Participants	64 S 64 P	64 S 64 P	128 S 128 P	113 S 113 P	166 S 166 P	159 S 159 P	221 S 221 P	221 S 221 P	221 S 221 P

The ChiS&E Curriculum- *Little Engineers*

A unique curriculum aligned with science learning objectives and design and engineering learning standards was designed as the instructional program for each year.[25] Each of the sessions had a grade level focus: kindergarten, civil engineer; first grade, chemical engineer; second grade, electrical engineer; third grade, mechanical engineer, and fourth grade, structural engineer. The curriculum was designed using Wiggins and McTighe backwards design methodology.[26] Activities were enhanced using other established curricula and curriculum development frameworks.[27, 28] In addition, parents were required to participate in a parent orientation prior to the start of each session, a parent symposium during each session, and one cyber-learning seminar after each fall and summer session. Additional activities for parents included early child development support strategies, digital technology training, and career and community support program awareness. The CHiS&E program has served over 200 students and their parents, and 30 teachers. Forty-seven students completed a full 4 years of programming (Kinder- 4th Grade) in 2013. Families from seven schools attended four Saturday morning sessions in each semester of fall, spring, and summer at the Chicago Museum of Science and Industry.

Teacher professional development for CHiS&E

Program teachers received background content and instruction, STEM pedagogy and direct guidance in the facilitation of each engineering activity. Upon completion of the professional development, teachers were able to a) to identify K-12 learning opportunities and challenges, b) describe engineering careers and K-12 engineering activities, c) relate the connectedness of mathematics and science in the context of engineering design through hands-on practice, d) emphasize for students the role of mathematics and science in collecting, recording, analyzing, and communicating observations, e) demonstrate the use of inquiry instructional techniques when leading a STEM academic lesson, and f) practice classroom management skills when leading inquiry activities.

The research program

Research questions

At the crux of ChiS&E's theory of action has been the belief that all students can rise to the challenge of high achievement in STEM education and career. However, not all students are afforded the strong early foundational experiences that can strengthen the odds of their success in such pursuits. Therefore, early community involvement is critical to support in the creation of formal and informal development experiences for parents and children. Parents can be supported by facilitating early opportunities for them to work side-by-side with their children as well as with educators who model strategies of appropriate interaction between educator and child in support of the youth's academic success (e.g. conflict resolution, inquiry in learning, science and engineering processes, etc.). The ChiS&E program model was designed to deliver such a research-based informal learning experience in a sustained manner. In addition, the cyber learning sessions for parents emphasized the competencies needed to disseminate information learned at ChiS&E and taught them how to use digital equipment and hardware as an educational tool. While external evaluation reports attest to CHiS&E meeting its objectives, additional research questions have guided this work and have to potential to contribute new knowledge.

Research question 1: What factors motivate parents to participate in time intensive programs STEM programs like CHiS&E?

Research question 2: To what extent has ChiS&E affected low SES parents' understanding of engineering and technology?

Research question 3: To what extent has ChiS&E affected low SES parents' patterns of performance and engagement in guiding and supporting students to succeed academically in STEM?

Methods
A mixed methods research design was utilized in order to capitalize on the respective strengths of both quantitative and qualitative approaches. Quantitative data was collected through surveys and basic concept inventories in order to efficiently report on results. Qualitative data was collected through in-depth interviews, focus groups, and classroom observations. The data collection and analysis methods addressed the above research questions with the use of parent surveys, engineering and technology concept inventories[29,30,31], and through observation using protocol such as the culturally responsive Sheltered Instruction Observation Protocol (SIOP) model. [31] Parents and children were observed at least once during each 4-week program session per cohort. The qualitative and quantitative components were performed concurrently. In order to enhance the validity of inter-rater reliability, only one observer recorded data. The observer was a trained researcher serving as an external evaluator.

In year 2, parents completed a 45 item online questionnaire designed to measure their attitudes towards technology. The questionnaire included 37 items designed to measure parent attitudes towards technology at a global level. These items measured parents' likes, use, and confidence with computers. Also, parents were asked about their proficiency in the usage of a number of software packages used in the technology strand. Eight background questions, such as gender, grade level of child, and race/ethnicity were also asked.

Face-to-face interviews and focus groups were conducted with parents at least once per year with small groups of participating parents guided by one facilitator asking questions using a general script aimed at discovering in-depth information about parents' experiences and perceptions.

Data sources

Data sources included two parent questionnaires, one on engineering and one on technology, and session observations. Both the engineering and technology questionnaires are research-based instruments developed by the Museum of Science [33] for use with elementary aged students. The modified engineering questionnaire consisted of 20 multiple-choice items and 4 short answers. The technology questionnaire included a table with 16 images and descriptions of people at work and asks the participant to circle the kinds of work that engineers do. Both questionnaires were provided in English and Spanish. Short answers were translated and coded using emergent coding. Corellated t-test scores of pre-test and post-test responses were calculated using Excel. Observations were coded using emergent coding.

Results

Research question 1: What factors motivate parents to participate in time intensive programs STEM programs like CHiS&E?

In Year 1, parents reported that ChiS&E has provided an opportunity for them to become more involved in their children's education and gave them a unique opportunity to interact with their children. In particular it helped parents support their child's learning. This continued in Year 2.

> *Parent 1: I would not say it's personally advantageous to me, but anything that's advantageous for my child is advantageous for me. Basically what I'm trying to do is produce someone, who is able to compete in the global community, you know, kids of all races. I want her to be able to compete in the job world, the economy, and for her to be familiar with those kinds of things.*

Focus group parents noted that programs that serve people of color and those who seek to provide educational opportunities for their children are scarce. Parents pointed out that ChiS&E provided them access to a unique opportunity. Focus group parents who sought out other similar programs for their children, were unable to enroll them due to the cost

of the program, lack of information, and/or programs being filled to capacity. Here are three parents' comments from the focus group:

Parent 1: Museum of Science and Industry, they have a club, a science thing, and you can't get in. It's not accessible. I don't know if it's an inner club or what but you can't get in. I don't know how to get in it, I've tried. I hear of it, but because they reached out to the schools, but the program was almost full. The Museum of Science and Industry itself sent a message to them, they are inside and I think we always feel like we are outside and we always get leftovers, crumbs. Those are the opportunities, and they are failing opportunities. We are not really in the mix of things. ChiS&E comes across as in the mix.

Parent 2: Because the planetarium has one, it's 6 weeks, but it's like 700 and something dollars for the summer.

Parent 3: Yeah because the program you were talking about they start scouting for people in like January and by the time March came, when I tried to call the Museum of Science and Industry, they were completely full and that's just something for the summer. And that was $1100.

In addition to having access to a quality program for families with multiple children, ChiS&E offered participants one-on-one time with their child and, according to parents, this sent their child a message on the importance of education. Parents believed ChiS&E was one of the programs that will encourage their child to move along further.

Research question 2: To what extent has ChiS&E affected low SES parents' understanding of engineering and technology?

One hundred thirty two parents completed the questionnaire in the fall and fifty-one parents in the spring. One hundred eight African American parents completed the questionnaire in the fall and forty-two in the spring. Twenty-two Latino parents completed the survey in the fall and 9 in the spring. Two parents did not indicate their race/ethnicity, thus the n =130. Both of the questionnaires were administered online at the technology sessions. It is important to note that there are sample differences between each administration. Some parents may have participated in both data collections, but many did not. Because the group of parents were not the same across time points, it is possible that some changes observed over program years may result from these group differences. This issue is also important to consider when interpreting questionnaire responses because the group of participating parents were not identical at each time point. Findings from parents' proficiency with software, use of technology, parents' likes towards technology, and their confidence with using technology will be discussed.

Parents indicated, at every opportunity, that they were very satisfied with the technology strand. However, there were stark differences between parents that completed the questionnaire in the fall and the spring as it related to their knowledge about the Internet, PowerPoint, and Windows Movie Maker (See Table 2). One possible explanation is that

parents who attended the sessions in the spring needed the technology training more than those who attended in the fall, thus highlighting the individual differences between parents at the programs. From observations of these sessions, it was apparent that there were different levels of proficiency among parents on how to use PowerPoint, or iMovie. Three parents in the focus group commented that because the sessions did not account for the varying degrees of parents' experience with technology, the extent to which they grasped the material shared was limited.

Table 2. Parents' proficiency use with computer software

Please indicate your knowledge of the following:	"Basic" or "Excellent" Knowledge Fall 2011 (n=132)	"Basic" or "Excellent" Knowledge Spring 2012 (n=51)
• Internet	91%	57%
• Power Point	98%	72%
• Photo Editing programs	73%	85%
• Video Making	63%	79%
• Windows Media Creator	46%	64%
• I-Movie	48%	35%

Note: A five point Likert Scale was used: 1 - I do not use and am not interested; 2 - I do not use them, but I'd like to learn; 3- Basic Knowledge; 4- Intermediate Knowledge; 5- Excellent Knowledge.

Parents used technology in multiple ways such as by using tablet computers to record data and observations in word document, through internet searches and by using digital cameras to record evidence of home engineering and science work with their children. Parents in the spring and fall remained consistent in their use of technology as part of their search for education resources. This was encouraged in ChiS&E's technology sessions as parents were given a number of websites for student learning about engineering, science, and math. There was an increase in the number of parents that reported using computers to upload and download pictures and music, which could be attributed to them creating their video essays at ChiS&E (See Table 3).

Table 3. Parents Use of the Computers

How often do you use computers to:	"Often" or "Very Often" Fall 2011 (n=132)	"Often" or "Very Often" Spring 2012 (N=51)
• Search for educational resources	79%	76%
• Check Electronic Mail (E-mail)	19%	55%
• Play Games	92%	48%
• Shop Online	45%	60%
• Talk in Chat Rooms	65%	68%
• Upload Pictures	48%	85%
• Upload Music	51%	80%
• Download Music	41%	74%
• Download Pictures	45%	81%
• Entertain yourself (e.g., watch movies; listen to music; read articles)	78%	76%
• Complete work for you job	94%	81%

Note: A five point Likert Scale was used: 1-Very Rarely; 2- Rarely; 3- Sometimes; 4- Often; 5- Very Often; 6- Don't Know

Parents' attitudes and confidence towards technology was high. The majorities of the parents had a positive attitude towards technology and were confident in their use of computers, although the percentage of parents who "agreed" or "strongly agreed" with the items in the spring were lower. The questionnaire data (see Table 4) indicate that the parents were open to learning about computers and how they can be used to support multiple areas in their life. Therefore, parents were open to the use of computers in daily routines, to support their child's learning, and to seek additional resources, which are goals of the technology strand of ChiS&E. Also, parents' positive attitude towards computers motivated parents to increase their knowledge about computers, thus further highlighting the need for additional technology training at ChiS&E.

Table 4. Parents' attitude towards technology.

What is your general attitude about Technology?	"Agreed" or "Strongly Agreed" Fall 2011 (n=132)	"Agreed" or "Strongly Agreed" Spring 2012 (N=51)
• I like using computers	96%	86%
• I generally have positive attitudes towards computers	92%	89%
• Using computers makes me more efficient in my life	88%	84%
• Using computers makes me more efficient at my work	91%	73%
• Using computers makes completing tasks easier	95%	73%
• I like searching the internet for general interest	92%	84%
• I dislike using computers to learn	86%	79%
• I perceive computers as an educational tool	91%	73%
• I like searching the internet for educational resources for my child	96%	88%
• Computers can be a good supplement to support learning	92%	83%

Note: A five point Likert Scale was used: 1 Strongly Agree; 2- Agree; 3 -Undecided; 4 - Agree; 5- Strongly Agree-.

While the majority of the parents "agreed" or "strongly agreed" with the items designed to measure their confidence in using computers, the percentage in the spring was lower than the percentage in the fall. This can be attributed to members in the Latino group rating themselves lower on these items in the spring. Parents that reported feeling confident using computers might be more likely to encourage their children to use them, [36] versus those who reported that they were not confident.

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Table 5. Parents' confidence with using computers.

What is your comfort level with using computers?	"Agreed" or "Strongly Agreed" Fall 2011	"Agreed" or "Strongly Agreed" Spring 2012
	(n=132)	(N=51)
• I am not the type to do well with computers	87%	76%
• I do not feel comfortable using computers	87%	71%
• I feel confident about using a computer	86%	76%
• I feel confident learning terms relating to computer software (e.g., word; excel; movie maker)	96%	81%
• I feel confident learning terms relating to computer hardware (e.g., external hard-drive; memory stick)	89%	74%

Note: A five point Likert Scale was used: 1- Strongly Agree; 2- Agree; 3- Undecided; 4- Agree; 5- Strongly Agree.

Observational evidence indicated that participation in ChiS&E improved parents' capacities to support their child's development in STEM. As one ChiS&E teacher observed during her Saturday session:

Parent 4: *Parents are learning that they can ask their child questions about how things work and also lead their kids to ask those types of questions. I definitely hear and see that a lot of parents are learning new content as well.*

I mean obviously parents are learning some content and some of them have said in their evaluations that they were excited to learn some new things that they didn't know about science content. I think that watching teachers interact with kids helps to model what parents can do that with their kids when they're doing learning activities at home.

Another parent shared this:

Parent 5: *Ever since I've been in the ChiS&E program I've found it less stressful working with my daughter because just doing the work refreshes your mind, having patience with them, and having methods to work with them. It just kind of improves things, on classwork and outside classwork.*

During each of the four-week sessions, teachers and ChiS&E staff continued to provide scaffolding for parents to support their children's learning. Interview and observational data indicate that parents benefitted from the training and participation with their children in both organized sessions and at-home activities. According to two parents in the focus group:

Parent 6: *We're learning just like the kids are learning. I learned a lot of stuff too, like how to make the simple machines and a chemical change.*

Parent 7: The activities kind of show you that even though we're adults, our focus kind of gets off, like I was looking someplace else and then I missed the directions. I learned a lesson, you know sometimes with your kids you say to them "you went to school today but you didn't hear the lesson?" I think sometimes it gives you a little bit more sympathy and it makes you work with your child as a team.

Another area in which ChiS&E helped parents develop was in their understanding of what an engineer does. In Year 1, parents were asked the different types of work that engineers do, parents were able to tie common examples of the kids' work together with work that engineers do. However, with regards to tasks that are not directly related to engineering, they were more discriminate as to which sort of task they would attribute to engineers and which they would attribute to other support personnel such as laborers, drivers, and technicians. The questionnaire was not administered to parents in Year 2 in-order to prevent taking away from programming. However, in the focus group, parents were asked to share their understanding of an engineer. Below are the comments of two parents:

Parent 8: I didn't understand how important an engineer was, how hard it would be, how it's part of my life, like every time I take the train I kind of look at how they got stuff made, how they got the little bathrooms and they made all of it portable.

Parent 9: I thought engineering was construction. I just didn't really explore the idea of engineering. I was always thinking that it had something to do with construction. So ChiS&E broadened my knowledge of what an engineer does. And we've learned more since being in the program, but that's just one example.

Research question 3: To what extent has CHiS&E increased parents'/guardians' capacity to support their children in pursing education and careers in STEM fields?

Overall, parents reported being satisfied with the ChiS&E program. Parents continue to exhibit a high level of engagement, which is indicative of their overall satisfaction with the program. In interviews, parents reported that they were thankful for the opportunity to participate and were extremely pleased with the content of the Saturday sessions. In addition, parents recognized the value of enrolling their children at such an early age. A number of parents viewed ChiS&E as a unique opportunity for them and their child. A majority of parents rated the ChiS&E weekly sessions an average overall rating of 4.67 to 4.98 on surveys administered by the program. The majority of parents in first (96%) and second grade (92%) reported that they would return to ChiS&E in spring 2011. All of the kindergarten and 3rd grade parents reported they would be returning to the program in the fall.

Table 6. First, second, third, and K parents overall rating for ChiS&E by Day in Years 1 and 2

Day	Fall Year 1		Spring Year 1		Fall Year 2			Spring Year 2			Summer Year 2
	1st	2nd	1st	2nd	1st	2nd	3rd	1st	2nd	3rd	K
Day 1	4.86	4.94	4.89	4.75	4.75	4.87	4.83	4.85	4.88	4.83	4.83
Day 2	4.86	4.97	4.83	4.82	4.83	4.84	4.63	4.76	4.72	4.85	4.87
Day 3	4.88	4.97	4.86	4.97	4.83	4.67	4.94	4.98	4.89	4.97	4.98
Day 4	4.96	4.89	4.85	4.97	NA*	NA	NA	NA	NA	NA	NA

Note: 5 point scale, 1 = lowest.
*NA: Program questionnaires were not administered on the last day of the program due to parents and students engaging in independent museum exploration activities.

Parents also expressed satisfaction with the program in written comments on the weekly parent questionnaires. Year 2 parents who had children enrolled in multiple grades in the program wrote:

Parent 10: *This is my second child going throng the ChiS&E program. I'm still pleased with the organization and professionalism of the staff. Nothing had gone down, the program has only continued to excel.*

Parent 11: *Todo muy bien, muy satisfecha "Felicitaciones" (All very good, very satisfied "Congratulations")*

Third grade parents wrote:

Parent 12: *I have enjoyed this 3rd year experience. ChiS&E is a valuable program for children and parents. I have learned so much about science and my child continues to succeed in math and science (A's). I have two other children and I cannot wait for them to be a part of ChiS&E.*

Parent 13: *This is by far a great program; I hope they incorporate something like this in the school system.*

The commitment of parents to the program was evidenced in their actions. Many discussed having made special arrangements to ensure that their children could participate. Some of their comments follow:

Part 14: *For me, sometimes we've had to bring my younger two girls and either my wife will monitor them or I'll monitor them while we work with our son.*

Parent 15: *I bring my grandson, the only reason why his parents are not here is because of their job, they gotta work. You make a way when the program is good, you find a way, and your family sees what's happening and they don't mind chipping*

in and helping. It's just amazing and I'm so thankful that I'm able to assist them with their son as their child grows the way they want him to grow.

Parent engagement was high across all grade levels and during each program activity it continued to be quite high. Based on the observation data, parents and students gravitated to a work style that was best for them. Some of the parents worked collaboratively with their children, while others let their child work independently, providing support and encouragement when needed. This difference in style might also be related to the parents' confidence in the content. Less confident parents may hold back. In addition, a number of parents in both grade levels were observed asking their child questions that helped them further explore the activity, draw conclusions about what they were doing, and reinforce the vocabulary being used. Three parents shared these thoughts:

Parent 16: *Just having the opportunity to observe my child in a setting where they are learning is priceless. I'm encouraged to work with him differently just from observing him.*

Parent 17*: I had an opportunity to show my son how I totally trust his common sense today. The project today, I could have figured it out, but I really did not want to do that. So I said you're smart enough, you can do it yourself and he did it. So I was able to instill that confidence in him, and when I peeked over he had it.*

Parent 18: *Se me hace muy divertido compar el trabajo con mi niña; le gusta mucho explorar con el agua (I find it really fun to share the work with my daughter, [we] explore much with water)*

Discussion

A report from the National Research Council (NRC) reveals that informal science environments and experiences play a crucial role in learning. [34] The Committee on Science and Learning in Informal Environments, which contributed to the development of the report, found "abundant evidence" that individuals of all ages learn science across a variety of venues (museum, science centers, zoos, aquariums, etc.) and everyday experiences. "These experiences can kick-start and sustain long-term interests that involve sophisticated learning," according to Philip Bell, co-chair of the committee and associate professor of learning sciences at the University of Washington, Seattle. Evaluations of museum-based and after-school programs suggest that these programs may also support academic gains for children and youth in these groups. Moreover, there is mounting evidence that structured, non-school science programs may positively influence academic achievement for students and may expand participants' sense of future science career options.[35] These findings are particularly relevant to ChiS&E as the program used an informal science institution, the Museum of Science and Industry, to create fun and exciting experiences for its participants. Scientists often cite their experiences outside of school as significant influences in shaping their careers. The program strengthened parents' capacity to support their children's development. In Year 2, ChiS& E continued to build parents' capacity to support their children's development, creating opportunities for parents and family members to become more

involved with their children's education. In particular, the program helped to support and promote student learning by modeling instructional strategies for parents and providing parents with educational activities to be used at home.

ChiS&E prepared students to begin building an awareness of career opportunities and skills needed to participate in the STEM fields. The activities at ChiS&E had students use a number of process skills that have helped them to think through and solve problems. Also the use of process skills is helping ChiS&E students develop an understanding about scientific inquiry. In Year 2, student ideas of an engineer have become more consistent with description of an engineer. By building parents' confidence in their ability to understand and use technology, and subsequently improving their attitude towards technology, ChiS&E has been shown as playing an important role in influencing how parents use technology with their child.

Proven parent engagement model
During the teacher-directed activities, parent engagement in both grade levels was quite high. Some of the parents worked collaboratively with their children, while others let their children work independently, providing support and encouragement when needed. Even though there were some instances where it was noticeable that a few parents dominated a particular activity, this occurred much less frequently as the cohort progressed in their cohort program. In addition, a number of parents in both grade levels were observed asking their children questions that helped them further explore the activity and draw conclusions about what they were doing. The high level of parents' engagement can be attributed to their overall satisfaction with the program. In interviews parents continued to report that they were thankful for the opportunity to participate and were extremely pleased with the material shared during the Saturday sessions. Satisfaction was also evidenced by the fact that the majority of parents gave ChiS&E an overall rating of 5/5 on weekly surveys administered by the program.

Strengthened a parent network to support children's learning
Parent training has given parents an opportunity to become acquainted with their counterparts from different schools, which enabled the development of a peer network for parents of ChiS&E students. In addition, a handful of parents took on informal leadership roles and a number of other parents have responded positively. The organic nature of this development increased the likelihood of parents accepting those who stepped forward as leaders, proving that programs such as ChiS&E can encourage parents to become program leaders in their children's education.

Limitations and future research
The data reviewed begins to provide insight as to how informal STEM programs can support parents to be better prepared and more involved in their children's early introduction to engineering careers and academic content. Further investigation of the long-term impact upon the collaborating teams of parents, educators and students is needed. A longitudinal study that will investigate the impact of the learning experiences that have been provided to students- especially those that have completed the 3-4 year

cycle is critical. The impact of the training that has been provided to parents can also be further expanded and a comparison to a control group of parents not involved in such a program would be highly revealing. Future research will continue to follow and collect data from these cohorts of students, educators and parents.

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