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Diversifying the STEM pipeline

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Structured Abstract

Purpose—The current paper focuses on the description and evaluation of a two-year STEM intervention targeting underserved middle schools students from minority and low SES backgrounds.

Design/methodology/approach—Middle school students from low-income and minority backgrounds ($n = 166$) were targeted to participate in a two-year, intensive, hands-on science and technology intervention to increase their interest in biomedical and health sciences. Quantitative and qualitative data were collected from TRY-IT! Students as well as a control group that did not participate in the intervention, teachers, and parents to assess changes in attitudes and knowledge with respect to a variety of STEM-related topics.

Findings—Quantitative analyses did not reveal significant long-lasting differences between the TRY-IT! and the control group, thus providing a mixed assessment of the effectiveness of the intervention. However, qualitative student responses collected during the second year of participation revealed positive attitudes toward the program experience and benefits of their exposure to science. In light of these findings, insights drawn from reflecting on successes and challenges experienced during the course of planning and implementing the study are provided to guide future programs and research.

Originality/value—The intervention was developed in response to the continued under representation of minority and lower SES individuals in STEM careers. An effort to boost positive attitudes toward science and math, as well as confidence in the accessibility of STEM careers

among this population is important given the promising outlook of this career field compared to others for future generations.

Keywords

evaluation; middle school science; STEM interventions; underserved populations

The under representation of people from minority and economically disadvantaged backgrounds in science careers continues to be a n issue(NSF, 2012; Oscos-Sanchez et al., 2008). Students from these backgrounds do not lack interest in science (Ong et al., 2011), but institutionalized and socio-cultural factors can work to undermine interest and/or future success in science careers (Ferguson, 2000; Kozol, 1991). Specific issues include conscious and unconscious stereotypes, stereotype threat, fewer role models (Oscos-Sanchez et al., 2008), and less exposure to science and math (Museus et al., 2011; Peng and Hill, 1995) can affect future participation in science careers by students from minority backgrounds. Similarly, students from low-income families often attend schools that do not adequately prepare them for careers in science (Hamrick and Stage, 2004) with challenges such as unprepared teachers and limited funding for the equipment and personnel needed for higher level courses. Consequently, identification as a minority from a low-income background may result in increased risk for academic failure and decreased chances for science careers. Beyond race and socioeconomic status(SES) issues, declines in science interest are observed among all students in middle school years (Javidi and Sheybani, 2010)making this a n ideal time for science interventions.

In response to these issues, the Translating Research to Youth through Information Technology (TRY-IT!) project was developed for students in minority and lower SES groups at a pivotal point in their educational trajectory. The goal of TRY-IT! was to increase knowledge of and participation in biomedical science and clinical trials. The project incorporated novel 3D modeling with science education enrichment activities. Throughout TRY-IT!, there was structured, positive feedback from parents and student participants about gains in student knowledge and program enthusiasm. However, quantitative evaluation data suggested limited positive outcomes. Subsequent discussion among project staff resulted in “lessons learned.”

Consequently, the goals of this paper are to provide an overview of study findings and to discuss the major lessons learned to inform future initiatives.

Project Description

The overall goal of TRY-IT! was to increase knowledge and interest in biomedical science, which included the following objectives:

1. Increase the interest and knowledge of middle school students from minority and underrepresented backgrounds in biomedical science, clinical trials, and scientific uses of technology.

2. Expand the biomedical science, technology skills, and biomedical science career knowledge of middle school teachers serving students from minority and underrepresented backgrounds.
3. Evaluate changes in student interest, knowledge, skills, and changes in career paths in biomedical science.

TRY-IT! activities

TRY-IT! objectives were met with planned activities to involve students, teachers, educational personnel, scientists, and technology specialists. Students who participated in TRY-IT! attended a no cost, two-week Summer Institute for two consecutive years on a University campus. The Summer Institute involved full-day enrichment activities, transportation, meals, and supplies. The curriculum focused on topics related to heart anatomy and physiology, neuroscience, the mouth and teeth, research, clinical trials, and technology. Sessions involved a combination of lecture, hands-on activities, dissection, games, and cooperative learning activities. Participants engaged in extra-curricular activities such as visiting science museums to expand their view of science.

A major feature was the use of 3D modeling software called EON Reality. This software allowed students to develop stereo presentations. Students received training on the use of this technology. These skills, in conjunction with science content knowledge, were used to program 3D models of the heart and the brain. Students also learned how to program their models to show the name of a structure when the student rolled over it with the mouse. Then, that structure moved away from the rest of the model to highlight it. The act of programming these models required knowledge of learned material and was thus, simultaneously building students' technology skills and reinforcing scientific content from instructional sessions. In addition to the summer institute, monthly Saturday Academies were scheduled during the academic year to supplement students' learning about the heart, mouth, brain, and the technology.¹ These activities were similar in format and content to summer activities.

Additionally, students were teamed up with science mentors. We attempted to pair mentors and mentees based on their interests when possible. Mentors included university faculty, researchers, physicians, medical students, and other university health staff. Mentors were required to maintain contact with mentees a minimum of twice a month. This contact could include phone calls, email, or face-to-face visits. Furthermore, one mentor-mentee activity was set to facilitate mentor-mentee contact; however, the activity was not well attended. With the exception of an online training and the twice-a-month contact, there was no formal proscription for the mentoring relationship. The pairs were given the freedom to design their contact and activities based on their availability and interests, and contacts ranged from phone conversations to shadowing to meeting informally for ice cream.

Teachers who participated in TRY-IT! received a laptop with the EON Reality Software and participated in training sessions. Interactive, 3D health science exhibits were developed by

¹The Saturday academies were not mandatory and often conflicted with other student activities or parents' schedules.

students with project staff and the local children's museum. These museum exhibits focused on the heart and brain and operated with the EON software. (For further information, visit the TRY-IT! website at <http://www.mc.uky.edu/behavioralscience/research/tryit/>).

Participants, recruitment, and selection

TRY-IT! targeted middle schools in a metropolitan city with high percentages of both low-income and minority students. All sixth graders from six schools with a high proportion of students qualifying for free or reduced-price lunches were sent applications inviting them to participate in the project. Six schools participated in TRY-IT!. Students were recruited by a staff person who conducted a brief presentation to 6th grade students during their homeroom period. This presentation included a description of TRY-IT! and a demonstration of the capabilities of the EON Reality modeling software. Every 6th grade student in the participating schools was mailed an informational packet that included program details, application materials, and a postage paid return envelope. For the later cohorts, every 6th grader was sent an application packet with permission from the principal.

In the application review process, the two primary selection criteria for participation were income level and academic performance². Students from low-income and minority households were given priority. To select teachers in the participating schools applied for and were selected on the following: (a) teaching math, science, or technology; (b) at least two years of teaching experience; and (c) letter of interest. Participating teachers received stipends, as well as professional development credits.

Methods

Sample

A longitudinal design with a treatment and a control group was used to evaluate participants' attitudes toward science, technology, and related careers. Measures were obtained at the time of program application and were repeated post-intervention and at one and two-year follow-ups.

Three cohorts of students were selected in successive years, beginning in 2007. Students were randomly assigned to either the participant or control group. After dropping cases with missing data on socio-demographic measures ($n = 20$), the sample was 166 children, 97 who received the TRY-IT! intervention and 69 who did not receive the intervention and served as a control group. Data was provided up to four times over the study period, for a total of 534 observations.

Descriptive statistics for the TRY-IT! participants and the control group are presented in Table 1. Specifically, about 53% of the TRY-IT! group and 57% of the control group were girls. Both groups ranged in age from 11 to 13, and all were sixth graders when they began participation in TRY-IT!. Racial/ethnic minorities are over-represented in the treatment

²The original academic performance criteria of selecting higher performing students could not be enforced due to several issues: First, the number of applicants was much lower than expected. Second, some schools either did not provide the requested test data or did so only after the recruitment was completed. In addition, different middle schools supplied different test information, thus making the data not comparable. It is possible that the lack of enforcement of this criterium washed out some of the significance in our analysis.

group, with 24% White, 43% African American, and 33% of some other race or multiracial. In contrast, significantly fewer children in the control group were racial or ethnic minorities (29% African American and 10% some other race). Also, the treatment group had significantly lower socioeconomic characteristics than the control group. In addition, more students in the treatment group were in the free or reduced lunch program compared to the control group (79% versus 25%). Moreover, household income ($M=\$30,160$ versus $M=\$52,060$) and mother's years of schooling ($M=13.99$ versus $M=15.27$) were significantly lower in the TRY-IT! group. These racial and socioeconomic differences are a function of a recruitment strategy which selected those children most underrepresented in science, technology, engineering, and math (STEM) careers to receive the intervention.

Measures

Two sets of evaluation measures were used in the study. One group of measures was administered to both the treatment and control groups at baseline and follow-ups. Another set of measures was administered only to TRY-IT! participants and their parents to provide feedback about the most and least successful aspects of the intervention. Measures reported by TRY-IT! and control groups for the purposes of comparing them included:

Socio-demographic characteristics—Gender was measured using a dichotomous variable (1=female). Race was measured using a series of dichotomous variables created from an item asking respondents to self-report which category best describes their race. Options were “White,” “African American,” “Hispanic/Latino,” “Native American,” “Asian,” and “Other.” The latter four categories were combined into “other” race because low frequencies in these categories caused small cell size problems in regression analyses. Participation in the free or reduced lunch program was measured using a dichotomous variable (1=yes). Mother's education was measured in years using a question asking how many years of schooling the child's mother had received. The addition of other variables measuring socioeconomic status did not alter the substantive findings presented here and were omitted from final models.

Educational aspirations—Three items measured children's, parents', and friends' aspirations for educational attainment, respectively. Response categories were “Middle School,” “High School,” “Trade School,” “2-Year College or Community College,” or “4-Year College.” The parent item asked children about the level of education their parents/guardians expected them to complete, and the friend item asked about their friends' educational aspirations. These were recoded to years of schooling, giving a potential range of 8–16 years. Students', parents', and peers' educational aspirations are an important predictor of future educational attainment, and may contribute to the intergenerational persistence of socioeconomic inequality (Davis-Kean, 2005).

School-related self-esteem—A ten-item subscale of the Hare Self-Esteem Scale (HSS; Hare, 1996) measured self-worth or self-pride in the school domain. It included such items as “School is harder for me than most other people.” Each item was measured on a four-point scale ranging from “strongly disagree” to “strongly agree.” The scale was computed by taking the mean of all non-missing items, and ranged from 1–4 ($\alpha=0.79$). High values

indicated more positive attitudes. The HSS is valid, highly reliable, and comprehensive in that it measures the major areas of interaction in which youth develop a sense of self-worth. School-related self-esteem is a critical component of academic success, educational aspirations, and interest in STEM careers (Marsh et al., 2005).

Persistence—This 18-item scale was an abbreviated version of a 40-item instrument developed by Lufi and Cohen (1987), and is designed to measure persistence, or the ability to continue to work at a difficult or even insoluble task. Items include “I usually persist in what I am doing.” Potential responses were “yes” (coded 1) and “no” (coded 0). Factor analyses strongly suggested a one-factor solution with 11 items loading on that factor. The scale was computed by taking the mean of those 11 items, and ranged from 0–1 ($\alpha=0.67$). Higher values were indicative of a greater level of persistence. Persistence is an important characteristic in the pursuit of higher education and personality development. As such, this valid and reliable construct is important in the developmental stages of young people where biomedical and technological careers hinge on advanced degrees (Busato et al., 2000).

Cooperative learning—Seven items from the Classroom Life Instrument were used to assess children’s orientation toward cooperative learning (Johnson et al., 1983). It included items such as “I like to share my ideas and materials with other students,” and responses were measured on a five-point scale anchored by “strongly disagree” and “strongly agree.” A scale was computed by taking the mean of all non-missing items, and ranged from 1–5 ($\alpha=0.87$). Higher scores indicated more positive attitudes toward cooperative learning. Research suggests that cooperative learning is an important element of strategies to increase the participation of women and minorities in STEM education and careers (Burke and Mattis, 2007).

Self-efficacy in science education—A scale adapted from the work of Lent and colleagues (1984) measured self-efficacy in science education. Children were asked to rate their confidence in their ability to successfully complete a list of nine science and math courses. Responses were measured on a ten-point scale ranging from “completely unsure” to “completely sure.” The scale was computed by taking the mean of all non-missing items, and ranged from 1–10, with higher values signifying more confidence ($\alpha=0.95$). Possessing a high degree of confidence in one’s ability to complete difficult math and science courses is an important determinant of students’ decisions to train for science and technology careers (Eccles & Wigfield, 2002).

Attitudes toward science—A series of subscales from the Attitude Toward Science Inventory (ATSI; Weinburgh and Steele, 2000) was employed to assess five factors: Attitudes toward science teachers (three items; $\alpha=0.69$; e.g., “Science teachers make science interesting”); Anxiety toward science (five items; $\alpha=0.84$; e.g., “It scares me to have to take a science class”); Value of science in society (five items; $\alpha=0.80$; e.g., “Science is helpful in understanding today’s world”); Science self-concept (five items; $\alpha=0.84$; e.g., “Science is easy for me”); and Desire to do science (seven items; $\alpha=0.89$; e.g., “Science is something that I enjoy very much”). Responses were measured

on a five-point scale ranging from “strongly disagree” to “strongly agree.” The scales were computed by taking the mean of all non-missing items, and ranged from 1–5. Higher scores indicated more positive attitudes, except in the case of anxiety toward science, where higher values signified negative (anxious) attitudes.

Self-efficacy in science occupations was measured by asking children whether they felt they could complete the education and/or training for seven STEM careers (Betz and Hackett, 1981). Responses were measured on a ten-point scale anchored by “completely unsure” and “completely sure.” A scale was computed by taking the mean of all non-missing items, and ranged from 1–10 ($\alpha=0.91$). Higher scores indicated more self-efficacy. Research suggests that higher self-efficacy to complete job training is associated with occupational interest, perceived viability of careers, and career choice, even above more objective measures of achievement (Betz and Hackett, 1981; Hackett, 1995).

Attitudes toward computing—Three measures of attitudes toward computing were collected. Two subscales of the Self-Efficacy in Technology and Science Survey (Ketelhut, 2007) were used to assess self-efficacy on general computer use ($\alpha=0.90$; e.g. “Learning how to use a computer is not hard for me”) and problem solving computer use ($\alpha=0.83$; e.g. “I can find information on the web by using a search engine”). These scales contained 11 and 5 items, respectively. In addition, the Computer Attitude Questionnaire (Knezek and Miyashita, 1994) containing 20 items was employed to measure computer importance and enjoyment ($\alpha=0.90$; e.g. “I can learn many things when I use a computer”). All items were measured on a five-point scale. The scales were computed by taking the mean of all non-missing items, and ranged from 1–5. Higher scores indicated more self-efficacy and/or positive attitudes.

Science activities—Two measures were included to gauge access to and interest in science and technology outside of school. A count outcome asked children to report whether the following items are available in their home: a daily newspaper, a computer, internet access, an atlas or globe, a calculator, more than 50 books, a microscope, and a telescope. Similarly, a count outcome indexed the number of science related activities in which had children engaged in the past year: participated in science, math or computer club, visited a science museum, watched science or math TV shows, read science or math magazines or news articles, and collected information about careers in science or mathematics. Higher levels of engagement and exposure to science, math, and technology-related activities outside of school are presumed to signify or to lead to increasing interest in STEM education and careers.

Science and technology knowledge—A measure of knowledge pertaining to science and technology curriculum taught during the Summer Institute was developed for the purposes of this intervention. It contained 25 multiple choice questions with content such as, “If a patient has a heart attack that kills the heart muscle in the left ventricle, which vessel is probably blocked?” The score for the scale was the percentage correct, and was intended to measure whether TRY-IT participants acquired and retained biomedical and computer knowledge as a result of the intervention.

Subjective rating and feedback—In addition to the above measures, a feed back questionnaire was administered only to TRY-IT! participants at the conclusion of the Summer Institutes as part of a formative evaluation of specific aspects of the intervention. These measures were primarily open-ended, but did include a subjective rating of the intervention on a scale from 1 to 10. Responses ranged from 1 (poor) to 10 (excellent). Also, students were asked to respond in writing to four open -ended questions about the TRY-IT! program. These include: 1) What do you believe are the three most helpful aspects of the TRY-IT! program?; 2) What do you believe are the three things about TRY-IT that could be improved?; 3) What would you tell your friends about the TRY-IT! program?; and 4) How do you believe the TRY-IT! program has changed or developed your career goals?

Analytic strategy

Analyses examined the effectiveness of TRY-IT!. More specifically, this evaluation examined changes over time in attitudes and perceptions relating to education, science, and technology that could be associated with a likelihood of pursuing higher education in STEM and entering STEM careers. Findings supported the effectiveness of the TRY-IT! intervention if there was structurally significant improvement over time in the treatment group, or if the magnitude of the improvement was greater in the treatment group relative to the control group. All analyses were conducted in Stata 12.

Multivariate regression was conducted using two-level variance components models that account for within-subject heterogeneity. These random-effects models reflect time points (level-1) nested in respondents (level-2), and contain respondent-level (i.e. cluster-specific) random intercepts (Rabe-Hesketh and Skrondal, 2008). For example, the two-level model with two covariates predicting outcome y_{jk} in time point i for respondent j can be written as:

$$y_{jk} = \beta_1 + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \zeta_j + \varepsilon_{ij}$$

In this model, i corresponds to the time point (i.e. level-1) identifier, j to the respondent (i.e. level-2) identifier, ζ_j to the random intercepts, and ε_{ij} to the level-1 residual. Together, ζ_j and ε_{ij} represent the random part of the model, while the other components are the fixed part of the model.

To assess whether the effect of time on outcomes varied for children in the treatment and control groups, a series of models were used with a pooled sample. These included socio-demographic control variables, a treatment variable (i.e. participation in the TRY-IT! intervention), and a set of dichotomous variables representing time (i.e., posttest, one-year follow-up, and two-year follow-up compared to pretest, or baseline). Then, interaction terms multiplying the three dichotomous time variables by the treatment variable were added to the base model. A significant interaction term was indicative of treatment and control group differences in change across time in outcome measures. Predicted values from regression models are presented for significant interactions, which account for socio-demographic differences across groups, in tables. Full regression results are available upon request.

For the open-ended feedback responses, coding recommendations from Bogdan and Biklen (1998) were employed to analyze qualitative data from the two-year follow-up. The written responses were read item-by-item and were open-coded. During open-coding, tentative themes were developed. These themes were then used to code the remaining sets of responses. If the data did not fit an already identified code, a new one was created to reach saturation. Once all of the data were coded, the codes were examined to identify any patterns or overarching themes that emerged. These are presented following the quantitative results to enrich our understanding of the strengths and weaknesses of the TRY-IT! intervention.

Results

Overall, sixth-graders in this sample reported positive attitudes toward education and science at baseline. Mean school self-esteem and cooperative learning were reported in the “agree” to “strongly agree” range for positive items, and the “disagree” to “strongly disagree” range for negative items, and persistence was also high (see Table 1). In addition, 97% of participants reported aspiring to some higher education, and most expressed a desire to obtain a four-year college degree. Parents’ perceived aspirations for their children were similarly high. Students in the sample reported confidence in their ability to complete science courses, low anxiety toward science, positive science self-concepts, and “fairly” affirmative attitudes toward science teachers. In addition, participants indicated a strong belief in the value of science in society, but a moderate desire to do science. Attitudes toward computing were very high, on average. With regard to science exposure and interest outside of school, children reported a mean of about 5 of 8 possible science and technology materials available in the home, and engaged in about 3 of 5 science-related pursuits in their free time. However, knowledge of the specific biomedical and technological curriculum in the TRY-IT intervention was low at baseline.

Treatment and control group differences at baseline

In general, the analyses revealed socio-demographic differences between the group that participated in the TRY-IT! intervention and the control group, with racial minorities and children of low socioeconomic status disproportionately represented in the treatment group³. However, few baseline differences in measures were identified (see Table 1). Children in the control group did report significantly higher school self-esteem ($M=3.30$) relative to the TRY-IT! group ($M=3.14$). In addition, consistent with their higher socioeconomic status, children in the control group identified significantly more science and technology materials in the home compared to the TRY-IT! group ($M=5.36$ vs. $M=4.72$).

Treatment and control group differences in changes in attitudes and interests over time

There were significant interactions ($p<.05$) between group (i.e. TRY-IT! or control) and time for eight outcomes, controlling for gender, race, and socioeconomic status. As shown in

³This disparity was based on the numbers of application we received. We anticipated a significantly larger pool of applicants. Given our target population for TRY-IT!, combined with the fact that most of the non-minority applicants had a higher SES background, the study ended up with an unanticipated difference with regard to race and SES. The proposed recruitment strategy had project personnel going into the schools and presenting project opportunities to homeroom classes. Students were distributed application materials via mail. Later in the grant, personnel went and talked with principals for permission and sent every sixth grader in each school home with an application packet because many of the mailed application packets were not returned.

Table 2 predicted values from these models suggest greater or exclusive improvement over time in the TRY-IT! group compared to the control group for three outcomes. First, general computing self-esteem increased significantly between the baseline pretest measure and the two-year follow-up for TRY-IT! participants ($b=0.29$), but remained stable for the control group ($b=-0.02$). Second, attitudes toward computing improved at the two-year follow-up for the TRY-IT! group ($b=0.11$), and decreased for the control group ($b=-0.10$). Third, knowledge of the TRY-IT! curriculum (i.e., heart and brain physiology and anatomy and technology) increased significantly for those in the TRY-IT! group at posttest ($b=0.09$), but little increase was recorded in the control group ($b=0.02$).

As shown in Table 3, there were significant differences ($p<.05$) between groups on five outcome measures that indicated advantages for the control group relative to the TRY-IT! group. Among children in the control group, educational aspirations increased between the pretest and the one-year follow-up ($b=0.14$), but decreased in the treatment group ($b=-0.16$). However, predicted values for educational aspirations were very similar in both groups at two-year follow-up. Also, self-efficacy in science education ($b=0.67$) increased substantially between the baseline pretest and the one-year follow-up for the control group, but decreased slightly in the treatment group ($b=-0.04$). However, at two-year follow-up, TRY-IT participants' self-efficacy in science education increased so that the predicted value exceeded the control group.

In addition, self-efficacy in science occupations increased substantially over time in the control group at two-year follow-up ($b=0.98$). In contrast, self-efficacy was fairly consistent over time in the TRY-IT! group ($b=0.02$). The predicted value for self-efficacy in science occupations was higher in the control group than in the TRY-IT! group at the two-year follow-up. Likewise, attitudes toward sciences teachers became significantly worse over time in the treatment group ($b=-0.39$), but decreased only slightly in the control group ($b=-0.10$). Finally, desire to do science remained about the same over time for the control group ($b=0.01$), but decreased over time ($b=-0.36$) for the TRY-IT! group, controlling for socio-demographic variables.

Feedback from TRY-IT! participants

Despite mixed results from the quantitative evaluation component of the study, the quality of the programming and curriculum of the TRY-IT! intervention was underscored by student ratings following the Summer Institute. In 2008, Cohort 1's average rating on a scale from 1 to 10 was 8.7 ($n=9$). Similarly, in 2009, Cohort 2's average rating was 8.6 ($n=26$). In 2010, Cohort 3's average rating was 8.75 ($n=24$). These ratings suggest that participants were very satisfied with their participation in the two-year science enrichment program.

Three major themes emerged from open-ended responses ($n=55$) to a question about helpful aspects of the TRY-IT! program. The most commonly reported responses pertained to the TRY-IT! curriculum. 47 students (87%) indicated that the information on STEM subjects and technology was helpful. They made comments such as, "(this curriculum) gives us access to knowledge that advances us into the learning experience." They also found the challenge of the material, their opportunities to learn, as well as the preparation for the future to be most helpful. The second most frequently reported theme highlighted the

valuable relationships participants developed in the program. Many participants (N=35; 65%) reported that having opportunities for meaningful interactions with teachers and counselors was one of the most rewarding aspects of the program. They also reported positive reactions to meeting new people, seeing their friends from school over the summer, and collaborating with others their own age on challenging projects. Additionally, 18 participants (33 %) also indicated that the program was enjoyable. They reported “having fun” and said that the engaging and hands-on nature of the projects and lessons were important to the success of the program.

When asked what participants thought could be improved about the TRY-IT! program (n= 55), the most commonly reported response (N=13; 24%) was “nothing.” Beyond this, a second theme that emerged was a request for improvements related to the curriculum (N=11; 20%). Responses varied, but included suggestions such as focusing on different material, reducing the amount of didactic instruction, and increasing the number of activities. Another theme that emerged pertained to the logistics of the Summer Institute schedule. Some students (N=20; 37%) wanted longer breaks, shorter class periods, staying overnight in the dorms, no dress code, and starting later in the day. Finally, some participants (N=8; 15%) also reported dissatisfaction involving personnel and other students. They suggested changes such as allowing the girls and boys to have classes together, involving more kids in the program, and recruiting better staff members.

TRY-IT! participants were also asked what they would tell their friends about the program (n= 54). The most commonly reported response (N=37; 69%) was that the program was an enjoyable and rewarding experience. One participant reported that she would tell her friends “that it’s a blast!” Likewise, youth noted, “The people there are awesome!” and “Neat staff and professors.” Others said, “fun education,” “great quality ideas,” and “my time here is now a treasured memory.” Participants often commented about how much they learned during the program (N=10; 19%). Examples include “it is an awesome way to learn about the body and that it may help you choose your career,” and “it’s a great program to learn about brain, heart, and teeth.” Similarly, some participants (N=5; 9%) connected their experiences to their interest in STEM: “fun and educational...related to your education and if interested in science and technology like, it’s really good for you.”

Finally, participants also described how the TRY-IT! program changed or developed their career goals (n = 54). Some respondents (N=9; 12%) indicated that they did not experience a change in their career goals as a result of participating in TRY-IT!. Additionally, other participants (N=17; 32%) indicated that the program had a positive impact on their educational aspirations or attitudes overall rather than specifically affecting their career goals. For instance, participants indicated that the program affected “my learning and it just gave me more stuff about science,” and that TRY-IT! “enriched the science aspect of it, helped out in socializing, it’s done so much it’s hard to put in words.” Another participant reported that “the TRY-IT camp has always pushed me to go for my goals and has been a very positive influence.” Finally, many of the youth (N=13; 24%) involved in TRY-IT! reported that the program had influenced their career considerations. For example, one participant said, “Since I learned about the heart and a lot of other stuff it makes me want to be a doctor more and I learned about teeth so maybe I’ll be a dentist.” Others noted that

TRY-IT! “has introduced me to new professions and opened me up to more options,” and “since it has talked about the body and I want to be a medical researcher I think that it has pushed me toward that instead of a lawyer.” In these cases, the TRY-IT! program reinforced prior STEM career choices or inspired expansion of career considerations into new areas.

Discussion

The goal of the TRY-IT! project was to increase knowledge of and interest in biomedical topics and careers through a multi-year intervention program. Positive effects of the TRY-IT! intervention were largely in the area of computing rather than science. However, participants in the TRY-IT! project reported positive attitudes towards science and technology at the pre-intervention baseline assessment, before receiving the TRY-IT! intervention. As mentioned above, we noticed significant differences between the quantitative evaluation component of the study and the qualitative assessment of the programming and curriculum of the TRY-IT! Intervention. Due to unforeseeable difficulties in recruitment, curriculum changes, and turnover of project personnel, the final project was significantly different in important aspects from what was originally proposed. Therefore, some of the quantitative measures were no longer ideal for what the project evolved into. We learned along the way and made changes and adjustments to the project, the curriculum, as well as the student experience; however, minimal changes were made in regard to measurement.

In addition, there were significant socioeconomic and racial and ethnic differences between the treatment and control groups that could have attenuated gains made from the intervention. After reviewing and discussing the outcome data and participant feedback with project staff and investigators, we discuss the limitations of the current study and offer recommendations for future projects like TRY-IT!.

Balancing evaluation measurement continuity and flexibility

It is not uncommon for projects to evolve and change over time to respond to challenges experienced during implementation. Differences between the proposed and implemented project can range from minor to major, which can shift expected outcomes and/or lead to unexpected outcomes. At times, responses to unanticipated challenges must be made “in the moment” and appropriate adjustments to data collection procedures can become lost in project implementation. However, good researchers know the critical need for implementation fidelity and the need for the consideration of changes to a research design when analyzing impact. TRY-IT! faced several fidelity issues. The original plan encompassed the formation of teacher, student and researcher teams to work on a project together using the technology taught in TRY-IT!. However, we ran into several issues, such as lack of participating teachers and teachers’ struggles with the software, which shifted the focus to support the teachers and resulted in the abandonment of the team work. In addition, Saturday academies that were proposed to take place bi-monthly were actually only realized on a monthly basis. Furthermore, the mentoring portion of the grant was not evaluated due to the small number of participants and the fact that many of the mentoring relationships were not sustained over time as planned. The biggest issue would likely be the repeated changes of several key staff. Documenting such changes is important for interpreting findings with

instrumentation adjustment. One of the issues that TRY-IT! faced involved the challenge of adequately accounting for the evolution of the project across time.

Project personnel can ensure that the measures capture changes in attitudes, knowledge, and behavior. If data have already been collected prior to these changes, altering instrumentation will have implications for longitudinal data analyses. Determining the best approach to this issue depends on the project changes. Minor changes can and should be addressed by including additional items or subscales to the selected measures which allows for comparison across time. Qualitative methods should also be considered for participant feedback on changes.

TRY-IT could have addressed this issue more effectively with a concrete and detailed formative evaluation plan. According to Guskey (2005), failure to conduct formative evaluation is a common mistake in the field of education as many educators think about evaluation as only addressing summative data. Formative evaluation is useful because it provides feedback throughout implementation on what is working and what is not working to guide program improvement (Guskey, 2005; Rossi, et al., 1999). Summative evaluation at the end of the project provides information on outcomes. Formative evaluation data can inform summative outcome data (Guskey, 2005), improved the implementation of TRY-IT! and provided data about the utility of selected measures.

Summative data analyses revealed greater improvement in computer attitudes than in science attitudes. In review of the project measures, we surmise that the items assessing interest in science may have been too broad. In contrast, the technology items were more specific. Use of a logic model, another tool regularly used in evaluation, which shows the relationship between major project components (e.g., goals, objectives, resources, activities, outcome measures) as well as a formative evaluation plan could have helped to mitigate this issue (McLaughlin and Jordan, 2004). Logic models are useful for planning and assuring components connect in a logical, feasible way and can be used to help guide the selection of questions and measures (McLaughlin and Jordan, 2004).

School and program curriculum continuity

Based upon our experience with TRY-IT!, lack of continuity between the program and school-based instruction may have impacted the project's efficacy. The TRY-IT! project had resources to facilitate curriculum and science experience that is challenging, engaging, heavily hands-on, and incorporated authentic learning activities, such as working with patient simulators in the university medical facility. As mentioned earlier, research has shown that schools serving larger proportions of students from disadvantaged backgrounds face issues such as limited resources and a disproportionate number of unqualified teachers (Museusv et al., 2011) which could limit the ability to maintain the same intensity as TRY-IT!. This reality was echoed in student and parent feedback, as well as the comment of one principal who said that "science had to take a back seat to math and reading." Consequently, although TRY-IT! participant interest might have been piqued during the Summer Institutes and monthly Saturday Academies, the impact became "watered down" later. Therefore, it is critical to tailor evaluation measures specifically to the program (e.g., "To what degree did your experiences this summer in TRY-IT! increase your interest in biomedical careers?").

The quality of the programming and curriculum of the TRY-IT! intervention was captured by participant evaluation feedback on measures such as these.

More importantly, on-going relationships between science departments in colleges and universities and schools to provide regular hands-on, engaging science outreach experiences are key. These relationships can help sustain more intense science curriculum implementation and improve learning outcomes. Also, project materials (i.e., curricular materials) made available to targeted schools need to be compatible with the financial and personnel limitations in low-income and minority community schools.

Generational differences and the digital divide

A major part of the TRY-IT! project was EON Reality 3D modeling software. The intention was for both students and teachers to work together using the software. We learned that generational differences were not taken into consideration. Student participants quickly learned the software, while most teachers found the software frustrating and complicated. Consequently, several teachers dropped out. For those who continued, more frequent trainings than proposed were needed. Overall, teachers indicated they were not prepared and uncomfortable with the software and reported discomfort of working with students while they were learning the software. Others reported feeling uneasy about working with students who were more knowledgeable about the software than they were. As the project continued, regular issues with scheduled training conflicts and continuous reports of feeling frustrated and overwhelmed with the software occurred.

Through our experiences with TRY-IT!, we learned that careful technological consideration should be made. The TRY-IT! staff included a technology expert on the project who was involved in the selection of the technology and planning and implementation of training. However, we learned that because technology experts possess high levels of knowledge and facility with technology, they may be unaware of the challenges that non-experts may face. In other words, ratings of “user friendly” by technologically advanced professionals may not extend to teachers. It is crucial that project staff ensure that the technology be straight forward and easy to use. If possible, a small pilot study can facilitate understanding about the ease of use. Conducting a pre-assessment of teacher’s technology knowledge and skills should provide direction about the best type of technology to use or the ways that the training can best meet the needs of teachers.

Maximizing program implementation success

Although selection of support staff is a priority, especially when children are involved, we learned that this can be difficult. Though support staff was not responsible for teaching the science curriculum, we came to realize that one of the most important roles were the Summer Institute counselor staff. Each summer, TRY-IT! hired counselors who were responsible for behavior management, informal mentoring, escorting students to and from scheduled activities, planning for down-time, taking students on field trips, supporting instructors, and facilitating learning. The significance of this role to success became clearer over the years, as we observed how differences in counselor personalities could either enhance or undermine participant experiences each summer.

One particular Summer Institute was fraught with counselor discord and negativity which seemed to impact the overall experience. Several of the counselors struggled to maintain the training for positive encouragement and respect for others. According to Rhodes and colleagues (2005), in the early stages of relationship building, youth may be particularly sensitive to slights or difficulties and potential negative aspects of relationships have the potential to over shadow or cancel out positive aspects. Since the Summer Institutes were the first substantive exposure to the program for participants, this early relationship building is critical to creating an optimal learning environment. Students from disadvantaged backgrounds may be especially vulnerable to negative experiences because they are often the targets of lower academic expectations in science and math and may face anxiety from that stereotype threat (Museus et al., 2011). Creating an environment where expectations for learning were high and the adults were warm, supportive, and fostered confidence was as important as the science content.

The staffing, including class room instructors, was important. Unfortunately, interviews and background checks did not always help us select counselors that best fit the program. In our experience, a person working with children in a science intervention should: (a) have a genuine commitment to the success of the program, (b) have the ability to connect with children, (c) demonstrate warmth, compassion, and positivity (d) hold high expectations of child behavior and learning, (e) effectively manage behavior, and (f) demonstrate enthusiasm. It is a challenge to assess whether a candidate can sustain these characteristics. Carefully asked questions that required candidates to indicate how they would respond to various difficult situations were useful in our later interviews.

Those who TRY-IT! found to be particularly effective as counselors were student and full-time teachers, especially those experienced working with students from low-income and minority backgrounds. Full-time teachers often look for income during the summer months, and have engaging and creative ways to support classroom instruction. Teachers can also facilitate activities with minimal direction and have skills in managing behavior. An additional approach is to incorporate a staff training curriculum which incorporates discussion of the unique needs of at-risk children and associated interactions. Staff expectations should always be clearly and concretely communicated. Modeling is also effective in demonstrating expected approaches.

Creating an environment conducive to sustainable mentoring

The TRY-IT!'s project design included a mentoring component in which all participants were to participate in university mentoring in science. Unfortunately, this component was not as effectively sustained. First, we were unable to secure sufficient interest in mentoring by both TRY-IT! participants and mentors. Families were not responsive when attempts were made to match students with a mentor. In hindsight it seems that this was not clearly communicated that mentoring was not optional. TRY-IT! had a large number of highly qualified, interested mentors, including researchers, faculty, and professionals in the medical field. Nevertheless, many of our candidates indicated that they did not have the time to commit to mentoring. Ultimately, the lack of requests for mentors by students became less of a problem, but it limited our ability for implementation.

Overall, there was substantial heterogeneity in the mentorship experiences of students, with some being successful and others practically nonexistent. This is a problem for program evaluation because the mentorship was not consistent and there was limited control for variation. Moreover, the overall lack of strong, continuous mentoring relationships could have contributed to the lack of improvements in science attitudes or undermined findings. For example, Rhodes and Grossman (2002) reported that youth in mentoring relationships that ended within three months reported drops in self-worth and perceived scholastic competence. Consequently, no mentorship program could be better than one that is poorly executed.

DuBois and colleagues' (2002) meta-analysis found that successful mentoring programs conducted careful screening of mentors, employed ongoing supervision, monitored program implementation, and communicated clear expectations for regular, long term contact in the mentoring relationship. Spencer (2007) also found that unmet expectations were a theme among failed mentoring relationships. She advised that mentoring programs help mentors and mentees clarify their goals and objectives for participation and to use these expectations in match decisions. Also, there is some evidence to suggest that cultural differences can impact the quality of the relationship (see Spencer, 2007) which may have been a barrier in TRY-IT!.

Self-selection and non-random assignment

TRY-IT! targeted students with varying levels of initial science interest to balance goals. Given the significance of technology in the lives of young people, TRY-IT! anticipated that technology would attract applicants with varying levels of interest in science. However, evaluation measures revealed a low ceiling given the measures of attitudes about science and technology that were high at the baseline data collection point. It was clear that participants had a general interest in science which limited the possibility for significant increases in attitudes. Ultimately, TRY-IT! did not minimize self-selection bias⁴. Future projects should work with science teachers and school counselors to identify, recruit, and balance students who have general academic aptitude, with little to no or a lot of interest in science. It could be helpful to work with Parent Teacher Associations (PTA) and parent representatives.

Random assignment is the optimal approach to examine control or intervention group outcomes. Since every 6th grader in each school was a potential applicant, TRY-IT! expected a large applicant pool. However, the applicant pool was smaller than anticipated, even after multiple attempts were made to recruit interested students. As a result, TRY-IT! modified its plans to randomly assign participants to the control and intervention groups in order to maximize participation of students from low-income and minority backgrounds.

Although we were able to control for socio-demographic variables, statistical modeling cannot adequately address the differences between the treatment and control groups. However, because of the limited number of interested participants, we were unable to match individuals in the control and intervention groups on socio-demographic characteristics. In retrospect, TRY-IT! could have worked more closely with school personnel during

⁴This was largely due to recruitment issues (see explanation in footnote 3).

recruitment because school personnel have established relationships with students and families. The involvement of school staff should not be underestimated and can ultimately aid in securing the sustainability of program interventions.

Conclusion

Given the natural diversity in interests and skills across individuals, it is unrealistic to expect that every participant would experience an increase in science knowledge and interest. Thus, even though not unequivocally reflected by the results of our quantitative analysis of the data, overall, it is believed that TRY-IT! was implemented successfully. Quantitative data captured some improvements over time in comparison to the control group, including increases in computing self-esteem, attitudes toward computing, and science knowledge. These gains were consistent with TRY-IT!'s focus on enhancing interest in science and related careers. Also, there was consistent student participation across years of the study, with the majority of students returning for a second Summer Institute and even requesting an extension of the program. In addition, feedback from participants indicated that they rated their experiences positively, reported engagement and high levels of satisfaction with the program, as well as confirmation of career interests and expansion of career considerations.

While the project was deemed successful overall, there were challenges that limited the project's efficacy. Consequently, several suggestions to improve future projects with goals similar to those of TRY-IT! were presented. We concluded that the development of logic models and formative evaluation plans would be extremely useful in providing on-going feedback about project implementation fidelity and success. Forging ongoing, collaborative relationships with schools during the recruitment and formative project stages can aid in recruitment and building enhanced science education sustainability. In projects involving technology, it may be useful to pilot selected technology with the target population in order to ensure its feasibility or use the feedback to tailor future trainings. Additionally, the inclusion of program-specific items in instrumentation is important to gathering data that provides a fuller picture of project success. Finally, programs with mentoring components should ensure that both parties are clear on the goals and expectations and should consider incorporating mentor training on cultural diversity that includes acknowledging and addressing biases, and facilitation of cross-cultural relationship building.

One of the important lessons learned regarding research on informal STEM programs was the importance of a thorough evaluation that is flexible enough to adjust to unforeseen changes and complications. This can only be accomplished if the evaluation is an integral part of the planning and not merely an afterthought in the overall project. Furthermore, with respect to the implementation of informal STEM programs, we learned that while the academic culture of grants certainly emphasizes evaluation, and this is emphasized by the researchers on the project, this component might not yet be fully embraced by key project personnel. Some of the personnel involved 'on the ground' tend to think of evaluation as a mandated nuisance that adds word or takes away funds from the implementation of other project components. It is essential that there be a shift in the perception of the value of formal evaluations; this could be accomplished by education on how a solid evaluation in fact increases program success and strong data. Evaluation goes beyond looking at outcome

data. It is an on-going, feedback mechanism that helps to minimize ineffectiveness in the program; ensure project fidelity; and to be more confident in the cause-effect relationship of our program and our outcomes. Strong evaluation throughout the project is key to a strong program implementation. It assists in being able to more quickly and proactively deal with the many challenges one face throughout the implementation of a new program as well as to account for the impact of these challenges on project outcomes.

There is a sense of urgency to enhance STEM education and preparation in order to increase the competitiveness of the United States in global markets. Given structural and systemic inequalities, it is even more imperative that we understand how to reach students that are at-risk for academic failure due to their environments. TRY-IT!'s aim was to create a high-quality, engaging science experience that gave disadvantaged students an opportunity to learn challenging material and experience success with science. It is hoped that similar projects can use some of the insights from TRY-IT! to improve overall project effectiveness and the ability to capture evidence of improvements in order to meet the increasing accountability demands of funding agencies.

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Table 1

Comparison of children in TRY-IT! (n=97) and control groups (n=69) at baseline.

	Range	TRY-IT! Mean (SD)	Control Mean (SD)	χ^2 or t
Socio-demographic characteristics				
Female		0.53	0.57	0.25
Free/reduced lunch program		0.79	0.25	49.20 ***
Mother's education (yrs)	4–16	13.99 (2.96)	15.27 (2.86)	2.80 **
Household income (thousands of dollars)	8–68	30.16 (18.85)	52.06 (22.52)	6.94 ***
White		0.24	0.61	25.39 ***
African American		0.43	0.29	
Other race		0.33	0.10	
Education and learning				
School self-esteem	1–4	3.14 (0.47)	3.30 (0.45)	2.21 *
Persistence	0–1	0.56 (0.14)	0.54 (0.12)	–0.70
Cooperative learning	1–5	4.02 (0.62)	4.16 (0.57)	1.38
Child's educational aspirations (yrs)	12–16	15.83 (0.64)	15.64 (0.92)	–1.55
Parents' educational aspirations for child (yrs)	8–16	15.65 (1.01)	15.70 (0.88)	0.29
Friends' educational aspirations (yrs)	8–16	15.00 (1.42)	15.14 (1.33)	0.63
Science attitudes				
Self-efficacy in science education	1–10	6.77 (2.33)	6.71 (2.45)	–0.16
Self-efficacy in science occupations	1–10	5.70 (2.56)	5.88 (2.72)	0.40
Anxiety toward science	1–5	2.08 (0.76)	2.06 (0.86)	–0.21
Attitudes toward science teachers	1–5	3.89 (0.71)	3.84 (0.80)	–0.41
Value of science in society	1–5	3.95 (0.66)	4.11 (0.57)	1.57
Science self-concept	1–5	3.85 (0.79)	3.99 (0.80)	1.11
Desire to do science	1–5	3.57 (0.81)	3.40 (0.92)	–1.21
Technology attitudes				
Computing self-esteem	1–5	4.37 (0.59)	4.52 (0.50)	1.71
Computer problem-solving self-esteem	1–5	4.10 (0.73)	4.26 (0.75)	1.38
Attitudes toward computing	1–5	4.18 (0.53)	4.27 (0.53)	0.99
Science in the home	0–8	4.72 (1.51)	5.36 (1.47)	2.73 **
Science engagement	0–5	3.05 (1.16)	3.04 (1.34)	–0.04
Science and technology knowledge	0–1	0.33 (0.09)	0.34 (0.10)	0.20

* = $p < .05$;** = $p < .01$;*** = $p < .001$;

Two-tailed tests

Table 2

Evidence supporting the TRY-IT! intervention: Predicted values and confidence intervals on outcomes with significant^a differences between TRY-IT! and control groups in change over time.

	Pre-test	Post-test	1-year follow-up	2-year follow-up
General computing self-esteem				
TRY-IT!	4.42 (4.30–4.55)	4.41 (4.29–4.53)	4.42 (4.28–4.55)	4.71 (4.56–4.86)
Control	4.44 (4.30–4.59)	4.45 (4.30–4.61)	4.41 (4.25–4.56)	4.43 (4.27–4.59)
Attitudes toward computing				
TRY-IT!	4.21 (4.09–4.34)	4.29 (4.17–4.42)	4.13 (4.00–4.27)	4.33 (4.18–4.48)
Control	4.23 (4.08–4.38)	4.28 (4.12–4.43)	4.17 (4.01–4.33)	4.14 (3.97–4.30)
Science and technology knowledge				
TRY-IT!	0.34 (0.32–0.36)	0.44 (0.42–0.46)	0.40 (0.38–0.42)	0.38 (0.35–0.41)
Control	0.32 (0.30–0.35)	0.34 (0.32–0.37)	0.34 (0.32–0.37)	0.37 (0.34–0.40)

^aPredicted values are based on a random-effects regression with a statistically significant ($p < .05$) interaction term (TRY-IT group*time point), controlling for gender, race, mother's education, and participation in free/reduced lunch program (held at means)

Table 3

Evidence controverting the TRY-IT¹ intervention: Predicted values and confidence intervals on outcomes with significant^a differences between TRY-IT¹ and control groups in change over time.

	Pre-test	Post-test	1-year follow-up	2-year follow-up
Child's educational aspirations (yrs)				
TRY-IT ¹	15.88 (15.71–16.04)	15.72 (15.53–15.91)	15.71 (15.52–15.91)	15.71 (15.49–15.92)
Control	15.56 (15.36–15.77)	15.60 (15.39–15.81)	15.70 (15.48–15.92)	15.68 (15.46–15.90)
Self-efficacy in science education				
TRY-IT ¹	7.04 (6.59–7.48)	7.18 (6.73–7.63)	6.99 (6.50–7.49)	7.65 (7.11–8.20)
Control	6.40 (5.86–6.94)	6.78 (6.23–7.34)	7.07 (6.50–7.64)	7.12 (6.53–7.71)
Self-efficacy in science occupations				
TRY-IT ¹	5.78 (5.23–6.33)	5.88 (5.32–6.44)	5.53 (4.90–6.15)	5.80 (5.11–6.49)
Control	5.58 (4.92–6.24)	6.32 (5.64–7.01)	6.65 (5.95–7.34)	6.56 (5.85–7.28)
Attitudes toward science teachers				
TRY-IT ¹	3.87 (3.70–4.05)	3.76 (3.58–3.93)	3.48 (3.29–3.68)	3.53 (3.31–3.75)
Control	3.85 (3.65–4.06)	3.72 (3.50–3.93)	3.75 (3.53–3.97)	3.70 (3.47–3.93)
Desire to do science				
TRY-IT ¹	3.54 (3.36–3.73)	3.40 (3.21–3.58)	3.18 (2.98–3.38)	3.28 (3.06–3.50)
Control	3.44 (3.22–3.66)	3.42 (3.19–3.65)	3.45 (3.21–3.68)	3.38 (3.15–3.62)

^aPredicted values are based on a random-effects regression with a statistically significant ($p < .05$) interaction term (TRY-IT group*time point), controlling for gender, race, mother's education, and participation in free/reduced lunch program (held at means)