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TechHive: Team-based, real-world engineering challenges for teens

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TechHive: A STEM Learning Lab for Teens

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Introduction

The Lawrence Hall of Science at University of California Berkeley's (the Hall) *TechHive: A STEM Learning Lab for Teens* program is an innovative learning program and physical studio space intended to empower high-school youth to engage in interest-driven design and creative engineering challenges while apprenticed by program leaders, museum educators, and other science center staff. The program has goals to provide youth with project-based design experiences as well as hands-on training to work in a public science center.

This paper describes the results from an evaluation of the program, conducted by outside evaluators. The central evaluation questions addressed by the evaluation were as follows:

1. What do youth learn about the design process and engineering through participation?
2. How does participation in the program influence youth attitudes towards STEM in general and engineering in particular?
3. How does participation in the program influence youth plans for future college and career?

Program Design

The TechHive program was designed to create a culture of HOMAGO (Hang Out, Mess Around & Geek Out) for participants. HOMAGO was initially developed as a theory of how youth interact with new media, using it to "hang out" and extend their friendships, "mess around" to explore their interests and tinker, and "geek out" by diving deeply into specialized interests (Ito et al., 2009), but it has expanded to be used as a way to describe informal learning experiences that seek to support these interactions.

High-school aged youth can participate in the weekend program as long a single semester to as long as four years. Each year, new teenagers are recruited to participate when other teens graduate. Each cohort of 25 interns includes five returning interns who lead a group of five new interns. At the start of a 10-week long session, youth in teams are presented with a design challenge: to imagine then create an engaging and educational visitor experience. Interns work in teams to communicate their ideas effectively with one another as they exchange information and concepts, and engage in peer-to-peer learning. While a design is being tested, interns interact with the Hall's young visitors as they design, test, re-design and implement the design project, giving them opportunities to increase their ability to communicate and comfort communicating their ideas to a wider community.

The TechHive space provides access to software, fabrication tools, engineering expertise, peers, and social media. The program starts with beginner-friendly workshops in programming, physical prototyping, and basic mechatronics.

Participants learn a new skill daily, each representing a different field in which technology and design are used to communicate ideas. Skills include: **Design** - iterative front-end design and Design Sprint; **Programming** - Scratch, Basic Arduino, and Basic C++; **Electronic** - basic circuitry, circuit diagrams, basic breadboarding, soldering, Arduino and HummingBird boards; **Mechanical** - cardboard fabrication, woodshop, 3D Printing and laser cutting; **Media** - Illustrator, Photoshop, CAD and SketchUp; **App Development** - Moqup, Sketch, App Developer, GitHub, and remote control.

During each 6-hour workshop approximately 30% of the time is spent on instruction and 70% on open-ended design, where interns experiment with each newly introduced technology and build on what they have learned, as their projects become more and more complex. Instructors work closely with interns during this process and are able to witness youths' increased fluency and comfort levels with each technology that is introduced. Youth keep a design notebook to document their ideas and progress. All projects created during the internship are also shared with the public as part of a culminating event. Through tinkering and iteration, youth discover that building in teams along with art, creativity, storytelling and humor, are essential skills in the design process.

Recruitment

TechHive has had a successful track record of recruiting and retaining participants from groups traditionally underrepresented in STEM. First, information about the program is shared with local teachers and community-based organizations such as the Boys and Girls Club or the Y. Educators and mentors in all settings are asked to share the information with youth and their families who meet the criteria. The program staff have found it is important to talk to teachers about the benefits of the programs for all youth, and to emphasize that this program should not be used as a "reward" for excellence. They also emphasize that teachers should "think outside the box" when they consider who could benefit from this program. This approach has been successful in TechHive, where 50% of participants are female and 89% are non-White (with over half Latino and African-American). Retention rates are over 95%.

Second, program staff host an information night for parents, where the goals, benefits, expectation and outcomes are all explained. Staff have discovered that parental support of participation can help youth overcome many obstacles, such as transportation or being pulled out for family needs. During this event, staff meet separately with youth to explain the norms and expectations of the program. Youth are given a document that provides these in detail, and they are asked to take it home, review it with their parents, and then return it signed before they can participate in the program.

Evaluation Questions

While the evaluation included both a formative and a summative component, this paper focuses on the findings from the summative evaluation. The goal of the evaluation was to determine how

the program was enacted, and how participation influences the attitudes and behavior of youth who complete the program. The main questions for the evaluation were:

- Who participates in TechHive and why?
- What 21st CCLC skills did youth learn from participating and what was the value-added of each component?
- What did youth learn about the design process?
- What did youth learn about the engineering process?
- How did the program influence participants' interest/knowledge of STEM and STEM careers?
- How did the program influence participants' confidence in their skills in a variety of areas (e.g. teaching others, working with the public, using media/technology, etc.)?

Evaluation Methods

The evaluation used the following methods to address the evaluation questions:

Youth Retrospective Survey:

All TechHive participants were given an annual survey at the end of the program year (in May/June 2014). Questions focus on intern's confidence in their abilities in teaching their peers and younger children, engaging visitors in conversation and exploring objects, and working with visitors from diverse backgrounds and using media/technology to express their point of view. Additionally, youth rate themselves both before and after the program on their technological familiarity and fluency in the areas of science, technology, and engineering. The evaluators utilized a retrospective post-then-pre design, where participants were asked to both provide a rating of their interest, knowledge, and confidence "now" (after they had been involved with the program for at least a year) and to reflect back to rate themselves in these same areas before they got involved with the program. Retrospective post-then-pre designs are useful to reduce problems that arise when program participants under or over-report their knowledge or abilities on pre-tests due to a lack of understanding. Retrospective post-then-pre tests are designed to reduce this "response shift bias" (University of Wisconsin-Extension, 2005).

A total of 51 retrospective surveys were collected from youth who consented to participate in the evaluation study. These included 17 TechHive participants and 34 participants from a comparison group of other interns.

Youth Interviews

TechHive youth were asked to participate in an interview at the end of the program year to gather more in-depth information about their experience. Interview questions focused on their experience in the program, their relationship with the staff and mentors, and how TechHive has affected them in terms of their interest in STEM and comfort with using technology. Interviews were conducted with 11 TechHive participants in the spring, focusing on the previous year in the program.

Personal Meaning Maps

To explore how the program has impacted participants' perceptions of technology and engineering, Personal Meaning Mapping was utilized. Personal Meaning Mapping is a technique

similar to concept mapping that uses open-ended interviews both before and after participation in an educational program to gauge how participants' understanding of concepts change as a result of their participation in that program.

At the beginning of the program year, TechHive participants who agreed to participate in the Personal Meaning Mapping exercise were presented with a blank sheet of paper with the word "Design" written on it. They were asked to write down any thoughts, feelings, or ideas that come to mind when they see the word "Design." The participants' responses were then used as the starting point for an open-ended interview where they were asked to elaborate on three things that they had written (or as many things as they had written if they wrote fewer than three things). Responses to the interviews were recorded on each participant's map. At the end of the program year (May/June 2014), participants were asked to participate in the Personal Meaning Mapping exercise again. They were given back their original map and asked to make any changes, modifications, or additions they would like. Again, an open-ended interview was conducted, with the participant being asked to expand on up to three changes they made on their map. The maps were then scored along four different dimensions:

1. **Extent**: The number of words that the participant wrote on their map in response to the prompt *before* being asked to elaborate on their responses.
2. **Breadth**: The number of different conceptual categories mentioned by the participant either in their initial written response or in the follow-up interview.
3. **Depth**: How deeply participants seemed to understand the conceptual categories that they chose to discuss in their follow-up interview.
4. **Holistic Mastery**: The overall understanding of the probe "Design" as documented in both their initial written response and the follow-up interview.

Pre-PMMs were completed by 20 TechHive interns and post-PMMs were completed by 13 interns (some interns ended up not coming to the final months of the program due to end-of-year scheduling conflicts). There were a few challenges with the Personal Meaning Mapping. Of the 13 TechHive participants who completed both pre and post maps, five (5) were returning participants (that is, they were participating in the TechHive program for the second year in a row). The remaining eight (8) were new participants this year; however they had been participating in the program for about one month prior to completing the pre-map (changes in the start date for the program were not communicated to evaluators) and thus already had some exposure to the TechHive program. As a result, the pre-PMMs do not represent true pre-data (i.e. data that is collected before any exposure to the intervention).

Evaluation Findings

Although a small number of youth (17 total) participated in the TechHive program during the year the evaluation was conducted, consistent themes emerged from the evaluation data. TechHive youth entered the program with greater interest in technology than their comparison group counterparts, appreciated working independently on projects, and gained knowledge of technology and STEM careers. These findings are explored in detail in this section.

Evaluation Question #1: Who participates in TechHive and why?

The Hall has offered TechHive since 2012 and has recruited and retained girls and youth from populations traditionally underrepresented in engineering. During the evaluation period, half of participating youth were female. In addition a variety of ethnic backgrounds were represented: 40% Latino or Hispanic; 27% Asian; 15% African-American; 12% White; and 18% other ethnicities.

TechHive participants, like the youth in the comparison group, joined the program because of a desire to do something related to science, technology, or engineering; have fun; gain work experience; and do something at the Hall. Compared to participants in the comparison group, TechHive participants were more interested in activities related to technology or engineering than were comparison group youth. TechHive youth were also more likely than comparison group youth to join because they thought the program would be fun. They did not report joining the program because their parents wanted them to participate, they needed to fulfill community service requirements, or because they knew other people in the program.

One thing that TechHive struggled with, however, was the inaccessibility of the physical location of the Institution where the program took place. Participating youth came from communities throughout a large urban area to a location with limited public transportation access. This made it difficult for participants to come to the program frequently. This lack of accessibility was something mentioned in the Year 1 staff interviews as something that inhibits a sense of community – of HOMAGO – from fully developing, because youth cannot come up to the the Hall to just "hang out." It also narrowed the pool of under-served youth who could participate in the program, as they needed regular transportation to the Hall. This barrier was somewhat mitigated by setting up carpools for students with other TechHive families as well as providing financial support for transportation costs by bus and train.

Evaluation Question #2: What 21st CCLC skills did youth learn from participating and what was the value-added of each component?

TechHive included many different components: project-based activities, working in teams, access to experts who could help youth complete projects, learning about college and STEM careers. The program team was interested in learning more about what program components were of particular benefit to participants.

The project-based activities provided excellent opportunities for youth to pursue their own interests and learn specific skills, such as programming, and about general ideas, such as engineering. The youth were divided into teams, and they were allowed to select into the team that most interested them. Youth thrived on having a specific goal and a set of team members to work with. "The valuable components that were important to me was *[sic]* having a specific group, which was the media team, because that is what I wanted more experience with. I felt more comfortable being with that team since I already had some experience as a film editor." This focus did mean, however, that youth had limited opportunities to learn skills not within their track. One said s/he wished they had the chance to work more with the general visiting public at the Hall while another wished for more time to explore computer programming.

Still, the project-based learning allowed youth to see the importance of teamwork, trial and error, patience, and creativity. Another participant added, "I was able to work on interesting projects such as building a cardboard skeeball machine and this is an experience that taught me patience and trail error." Youth also learned the importance of teamwork, "Completing the projects at TechHive, working with others, taught me that projects are a huge group effort." A number of youth expressed appreciation for the chance to be creative: "You get to do a lot of creative stuff. The staff… tutor you when you need to, and they supply you with all the supplies you need. So you can let your imagination go wild, I guess."

The project-based and team approaches were particularly successful because the program staff hosted an initial training for participants, which provided them an introduction to the work and expectations. Of the training, one youth said, "It really helped because I was told what was expected of me and the quality of work expected," while another added, "They told me what I needed to do and were clear."

Youth, however, are not always used to free-form project activities, and some struggled with this lack of structure. One participant mentioned feeling like "we could make more progress throughout the year" and that some interns have more to do than others. This youth suggested this could be addressed by having "the staff participate more in the process." Another participant suggested the program could benefit from "a set objectives for us to follow." This participant commented, "The spring semester, we had more of an objective, which was to design the curriculum for the CS playgroup camp, but the first semester, it was more like, 'Let's just go to work.'" Youth generally found some level of support was beneficial. One youth said, "[Staff members] didn't want to impose any actual directions because that usually interferes with our creativity. I wasn't used to this, but whenever we looked lost or needed help, they guided us into a possible path that we can take."

Ultimately, however, most youth found it valuable to have autonomy and agency because this helped them develop collaboration and problem-solving skills. They also recognized it mimics more closely their future work experience. One youth said that s/he wished, at the start of the program, for "more guidance" from the staff. But, by the end, s/he realized it was important to solve problems on their own because they had to figure things out as a team. Another realized how much they benefited from the open-ended approach, saying, "As far as expectations go, I thought there would be more direct explanation on how to approach problems or solve them. Instead, problems have been left open-ended, which ended up being more helpful in developing my own critical thinking and problem-solving skills." Another participant commented that it is sometime difficult to balance the work for the individual project with the group projects and suggested that it would help if the individual project were more clearly defined in terms of deadlines, although he also said that setting deadlines for yourself is a "good experience since that's what happens in the real world."

Access to supportive staff members was crucial throughout the program. Youth described the staff as friendly and easy to talk to and truly seem to see the staff as people that they could connect with on a personal as well as a professional level. Youth commented that staff were available and offered help. As one youth said, "All the staff members were always there to help. [Staff members] have always supported all the interns and a lot of the projects we made and

things we accomplished wouldn't have been possible without them." Another youth added that the staff "helped me dream and understand the projects at hand."

In addition, the fact that the program staff themselves are young, and only recently completed high school or college, seemed to have enhanced the connection between staff and youth. A typical comment from one youth was, "They are really easy-going, and they connect a lot with the students, whether it's talking about college or what we're doing in TechHive. They don't act like teens, but they don't act like these really strict people…. When I came here I thought they were going to be like pretty strict on us, like, 'You're gonna do this, this, this.' Then I found out they were like … easy to talk to. It wasn't hard to connect to them." The comparison group programs were staffed by older educators, and this might explain why TechHive participants gave notably higher ratings (i.e., mean difference ≥ 0.5) for the opportunity to interact with the program leaders than did comparison group youth.

Youth also felt part of a community of teens. In TechHive, staff have placed an emphasis on community building where interns and facilitators have lunch together. The flip side of this means that the program was less successful on days with low attendance. One person commented that the program can be "boring" on days where there is a lower turnout of teen interns.

The community emphasizes both the shared goals and interests of youth, but also the importance of diverse ways of thinking and diverse skills. Youth appreciated being with others with similar interests, saying, "They're pretty cool people, who, just like me, like engineering. That's why they're here. So it's cool to talk to people like that, because outside of this, at my school, there aren't many people who are interested in this. If they are, it's like robotics. People at my school got the art side. And people here, they have a balance." But youth also acknowledged the benefits of working with a diverse group: "I think one thing that I've really enjoyed is that, to some extent, we have different skill sets and different attitudes and approaches. And it's nice being able to see that different perspective on a project that you might not be able to see."

The program gave youth opportunities to practice interacting with the public. One youth said, "I definitely feel more comfortable talking with people about science and engineering and, just in general, being able to articulate my ideas with people I might not know. And feeling more comfortable engaging them."

Finally, throughout the project-process, youth learned to persevere. One said, "I think every part of me improved, *as a person*. I understand better, thinking logically, and so definitely a big part is I – I definitely challenge myself to go over my limit and do things. I was, back then, 'Ahhh if I can't do this, I'll just stop,' but now [I think], 'Maybe I can try a different way, and maybe I could make it.'" Another said, "I've learned to be more confident in… everything, basically. And I'm not scared of… stating my ideas, because I know that everybody else is there to help you, not put you down or anything."

Evaluation Question #3: What did youth learn about the design process?

TechHive emphasizes the design process as part of the project-based learning. Participants as a whole started the program year with a strong understanding of the design process as measured by the Personal Meaning Map exercise. This may be because almost half of the participants had

participated for one year in the program before the baseline was collected, and thus had been exposed to the design concepts before.

At the beginning of the program year, participants were able to use a fairly large number of words to describe design, focused on design as an iterative and creative process, demonstrated a fairly high depth of knowledge about specific categories related to design, and showed accurate understanding of the design process as a whole. Not surprisingly, returning TechHive interns used more words on their pre-maps, indicating that they started the year with a higher verbal ability to discuss design, and had fewer words to add on their post-map as compared to new participants.

Because of this high baseline, shifts in participants' perception of design/engineering were subtle from pre to post. However, at the end of the program year, participants were able to use more words to describe the design/engineering process and did show a more expert understanding of the design process as a whole. For example, there was a significant increase in the number of words used from pre to post, indicating that participants increased their verbal ability to discuss design.

Youth focused on design as an iterative process, although other aspects of design were mentioned. Overall, researchers identified 14 distinct conceptual categories mentioned by participants are listed below, as explained in the table below.

Table 1. The Design Process – Conceptual Categories identified by researchers from Personal Meaning Maps

Conceptual Category	**Examples from PMMs**
People/professions/places/companies associated with design	Engineer, Architect, Silicon Valley, Ideo
Tools associated with design	CAD, blueprints, software, Adobe, cardboard, physical models, computer, coding
Design as visual product	Painting, "a way something would look," "a wave of colors," "arranging things/layout," "aesthetically pleasing," "decorate it"
Design as a physical product	Robots, flying cars, web design, Ferris wheel
Design as an iterative process	Ideas, brainstorm, create, plan, build, drawing
Design as a creative process	"Thinking outside the box," "Creativity" "No right or wrong," artistic
Design for societal good/societal need/solving problems/meeting users' needs	"My idea of designing is to make life better."
Failure as a component of design	Mistakes, starting over, problems, trial and error
Teamwork, interpersonal relationships	"Working together to design something," Collaboration, Mentors, Teaching
Skills/dispositions associated with design	Intelligence, confidence, right brain, persistence, commitment
Time pressures	Deadlines, "budget lots of extra time"

Personal experiences with design	"[I] didn't think about it before. Thought about it in [my] individual project."
Emotions associated with design	Fun, "New & Exciting," Joy, Disappointment
Connections between design and other STEAM fields	"Science & art both use design," Interdisciplinary
Miscellaneous	Participant comments that did not fit were coded as miscellaneous

There were some shifts in the specific categories mentioned between the pre-maps and the post-maps. Overall, participants were focused on design as an iterative process on their pre-maps (mentioned on 77% of pre-maps) and remained focused on this on their post maps (mentioned on 69% of post-maps). This is a core focus of the program and participants had a sense of this in the beginning of the program year and it remained in the forefront of their minds at the end of the program year. Another category that came up very frequently on the pre-maps is the idea that design is a creative process (mentioned on 77% of pre-maps). This came up much less frequently on the post-maps (31% of post-maps). However, participants are obviously aware of this idea; they simply focused on it somewhat less on their post-maps. Other categories that were mentioned more frequently on the pre-maps were people/professions/places/companies associated with design; design as a visual product; design as a physical/final product; skills/dispositions associated with design; and emotions associated with design. Other shifts in categories were fairly subtle.

New interns showed similar shifts to the overall group: design as an iterative process is a key idea on both the pre-maps and post-maps and there are declines from pre to post in the frequency with which participants mention design as a creative process; people/professions/places/ companies associated with design; design as a visual product; design as a physical/final product; skills/dispositions associated with design; and emotions associated with design. New interns were also less likely to discuss failure as a component of design on their post-maps. However, new interns showed an increase from pre to post in the frequency with which they mentioned tools associated with design, design as having a role in improving society; teamwork/interpersonal relationships; time pressures; and personal experiences with design. Many of the categories that increased for new interns seem to be able to be directly tied to gaining new experiences in design (e.g. introduction to new tools, working with teams, time pressures, personal experiences).

Evaluation Question #4: What did participants learn about engineering process?

In addition to emphasizing the design process, TechHive also exposes participants to engineering. In interviews, some participants mentioned that participating in the program increased their awareness of soft skills associated with engineering and helped them recognize the complexity of the engineering design process. All interviewees recognized that what they do in TechHive is engineering and several said participating in the program helped shape their own identity as engineers.

There were two key ways in which participants mentioned that the program affected how they think about engineering. First, several participants mentioned that they recognized more of the

soft skills associated with engineering (e.g. communication skills, ability to work as part of team). There was a consistent shift from seeing engineering as a solitary, stationary activity, to one that involves teamwork, communicating, and thinking about how tools will be used by others. This is consistent with the increased frequency of mentioning teamwork among new TechHive interns on their Personal Meaning Maps. As one youth said, "I used to think that engineering… was just sitting behind a computer and all that kind of stuff, but I also learned it's also about… communication skills, interacting with your peers. It's not just the actual hardware, sitting behind the computer, coding. It's about how you use the stuff you've made, either to show the public, or to teach others." Similarly, another youth said, "Before I used to think that engineers are just working by themselves in like an underground basement, and just cutting stuff out, and mak[ing] evil stuff. But nowadays I know engineer[ing] is not just working by yourself, but also working with a team."

The second change participants mentioned was understanding the process of engineering was more complex than they had originally understood it to be. "At first, I was like, 'Oh yeah, let's *build*.' But then after we went through the TechHive program, I realized there's a lot of planning, making sure, 'What's your goal?' or, 'What do you want to do next?' Or, 'What's the plan that you need to take to accomplish your design,' or whatever that might be." Another youth said, "TechHive has made me realize that engineering – it's not simple. It's very complicated."

The experience in TechHive also appeared to shape participants' identity as engineers. Of the 11 interviewees, only three said they would have considered themselves as an engineer or doing engineering before participating in TechHive. By the end of the program, seven said they considered themselves as engineers or doing engineering, three were unsure or somewhat hesitant in their response, and only one said s/he would still not consider herself an engineer or doing engineering (note that s/he was primarily involved in the video production projects).

Evaluation Question #5: How did the program influence participants' interest/knowledge of STEM and STEM careers?

Most youth participating in TechHive entered with a strong interest in STEM – it is a self-selected group, who opted to spend their weekends devoted to technology project. That said, TechHive participants reported that the program had a strong impact on them in terms of their knowledge and interest in STEM and STEM careers, with greater growth reported in terms of knowledge compared to interest, which was already very high even before beginning the program. TechHive participants reported that participation in the program has introduced them to specific STEM fields and helped them narrow down their choices for college majors or careers. Several TechHive participants have begun to engage in STEM-related projects independently (outside of school or TechHive).

Participants showed the greatest growth from pre to post in terms of their knowledge of STEM and STEM careers. Interest in STEM in general, studying STEM in college, and pursuing STEM careers showed less growth from pre to post because participants already rated themselves fairly high in these areas prior to joining the program, however the growth was still noteworthy.

When comparing the TechHive participants to the comparison group participants, TechHive participants tended to rate themselves higher in almost all areas prior to beginning the program.

However, both groups gave themselves similar post ratings in these areas regardless of track. As such, participants in the comparison group showed slightly larger gains from pre to post in terms of their knowledge and interest in STEM. However, growth for both groups was high and there were no notable differences in gains (i.e., mean difference ≥ 0.5) between the two groups for any of the survey items.

In an open-ended item on the survey, all TechHive participants emphasized that the program has influenced their interest in STEM by increasing their awareness of and interest in specific STEM fields (e.g. video production, technology, engineering). For example, one youth said, "The program influenced my interest in technology, because I have been more exposed to it," while another specified, "When I had the chance to work with the video-editing group I found a new interest in video production."

TechHive youth also indicated the program influenced their life or future plans by helping narrow down their choices for college majors or careers. Even though many were already interested in pursuing STEM careers, TechHive helped them focus in on areas of particular interest to them. Interestingly, some shifted from being most interested in computer science to engineering, and others went the opposite direction. For example, while one youth said, "I want to be an engineer. I used to think that I want to do computer science but I'm starting to like mechanical more," another said, "I know I will major in computer science!"

Because TechHive also includes elements of science education and science communication, some participants saw themselves moving in that direction. For example, two participants also expressed interest in public service careers, which they indicated were influenced by their experience in TechHive. One was particularly interested in communication, saying, "I want to teach and keep doing video production on the side of scientific research." Another was not specific about what they wanted to do, but knew that TechHive "reinforced my goal to give back to the community as much a possible through what I create."

Beyond interview and survey results, youth provided additional evidence that they are more interested in STEM. Several participants described how they now engaged in STEM-related projects on their own time (not through school or structured extracurricular activities) as a result of their experience in TechHive. One youth indicated s/he has independently developed games using Scratch and posted them on the Scratch website, while another said s/he is writing an app for Android with a friend. S/he stated, "Before… I had ideas for projects that I wanted to pursue, but I would be a lot less likely to go out and start them and just make it happen. But now that I've been forced to kind of make it happen, I feel much more confident in my ability to start a project and follow through with it."

Other participants described how participation in the program exposed them to new STEM fields and increased their interest in areas that they would not otherwise have considered. One participant commented, "Before I came to TechHive I was already a very science-y person. But TechHive has instigated more interest in, I guess, technology, because I've worked so much on the making-related projects, and sometimes they give us snippets of what is going on in the tech world, and that was really cool. It's cool to learn more about them." Another participant indicated that he was not previously interested in STEM, but now was thinking about ways to

bring his interests in business together with what he learned in TechHive. This youth commented, "I'm actually into business, management, and stuff like that. And now after I enter TechHive, I think a lot of stuff is about technology nowadays, and I'd really like to mix up business and technology together at the same time, and that could be really interesting."

Finally, some youth expressed awareness that there are challenges in the technology field for people from populations traditionally underrepresented in STEM. TechHive was designed to give this population access to skills and a network that can support them through difficult years. One female participant also described that she feels very comfortable in what is a traditionally male-dominated field. She stated: "It doesn't feel like a barrier, girls and boys. Because you know how there's not a lot of girls in engineering? But it doesn't feel like that in the TechHive. We're like equals."

Evaluation Question #6: How did the program influence participants' confidence in their skills in a variety of areas (e.g. teaching others, working with the public, using media/technology, etc.)?

TechHive participants reported large gains in their confidence in their job-related skills, with larger gains in job-related skills compared to the gains related to interest in STEM. Not surprisingly, TechHive participants reported notably larger gains than participants in the comparison group, which offered internships less based on technology. There were two areas where TechHive participants showed notably larger gains compared to the comparison group participants: using media/technology to "express my point of view" and using many different types of technology. TechHive participants showed larger gains in these areas despite having given themselves higher ratings in these areas before beginning the program. In interviews and open-ended survey items, TechHive youth reported feeling more skilled in specific engineering and technology skills and the design process as a whole. They also described having gained leadership, teamwork, and project management skills and strengthened their ability to communicate and interact with the public.

TechHive participants reported that the program also had a strong impact on them in terms of their confidence in their job-related skills. TechHive program participants indicated that they had made large gains (mean gain ≥ 1.0) from before beginning the program to after in the following job skills: developing activities for visitors; explaining and communicating my ideas to others; engaging visitors on the museum floor and in the public spaces; engaging visitors in engineering design challenges; using many different types of technology; and teaching younger children. They reported more modest gains in working with visitors from diverse backgrounds, engaging visitors in exploring objects, engaging visitors in conversation without using a script, and teaching their peers. Participants gave themselves the highest pre-ratings on these items, thus resulting in smaller gains. (Note that there were two job-related skills related to working with animals that were included on the survey but are excluded from analysis because they are not directly connected with the TechHive track). In general, the gains in job-related skills were larger than the gains related to interest in STEM, again because participants' interest in STEM was typically very high before beginning the program.

When comparing the TechHive participants to the comparison group, TechHive participants typically gave themselves higher ratings in their confidence levels before beginning the program,

but similar ratings for after the program, resulting in notably larger gains (mean difference ≥ 0.5) for the comparison group on several items. TechHive participants showed smaller gains compared to comparison group participants on the following items: engaging visitors in conversation without using a script; engaging visitors in exploring objects, and working with visitors from diverse backgrounds.

During the interviews, youth also indicated that they feel more comfortable using technology and have been introduced to and learned a variety of different software programs such as Adobe After Effects, Adobe Photoshop, Adobe Premiere, Autodesk Inventor, Makey-Makey, Scratch, SketchUp, and how to properly handle technological equipment and tools. One youth commented, "Last year, when I was [in a different program], I wasn't comfortable with holding all this very expensive equipment. I didn't want to touch them; I thought I would break them. Coming here, they gave me so much privilege and freedom. They really trusted me. And I'm glad that they did, but I'm like, 'How do they trust me? I'm new. I could break one of these.' But I've been more comfortable recording and stuff like that."

Conclusion

The TechHive program appears to have a powerful impact on participating youth. Participants are highly satisfied with their experience in the program, and the program seems to have fostered an environment where participants are engaged in interesting work, enjoy spending time, and are able to engage with peers and mentors with shared interests and passions. Participants felt that the program had strong impacts on them in terms of their confidence in their job-related skills and their knowledge and, to a lesser degree, interest in STEM and STEM careers.

Despite specific challenges associated with the physical location of this institution, situating a youth STEM learning program within a public science center such as the Hall has several benefits. First, it provides the opportunity for authentic project-based learning experiences, as participants create exhibits and activities that will be integrated into museum programming. Second, it allows youth to have access to the expertise and support of engineers, scientists, and science-communicators who also have a background in youth development. This provides a stronger support system and results in stronger connections between youth and mentors. Third, by drawing youth from across a wide geographic area, it enables them to build their networks and support systems beyond their own school or afterschool program settings. For these reasons, informal science centers can play a role in creating an ecosystem for pathways to engineering and other STEM careers.

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