Reinventing the InVenture Prize: Transforming a Year-Long Invention Program into a Week-Long, University-Based Summer Program (Evaluation)

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Abstract

In recent decades, invention education programs have been posited as a way to engage students in STEM through the hands-on process of designing their own inventions. The K-12 InVenture Prize (IP) program is an example of one such program, offering a platform for school-based invention education designed to be implemented during the academic year with Kindergarten through 12th-grade students. Previous literature has documented teachers' perspectives on the positive student outcomes associated with participating in the K-12 IP program, as well as the challenges of implementing the K-12 IP curriculum during the school year. Based on these findings, the InVenture Prize Summer Accelerator was created with the purpose of exposing a greater number of K-12 students to invention education. A week-long summer program, modelled after the year-long K-12 IP curriculum, was designed and opened to rising 6th through 8th grade students. During the program, students were guided through the steps of the Design Thinking Process as they created their own inventions. The curriculum focused on developing students' engineering knowledge, invention skills, and 21st century skills through team-based activities related to the steps in the Design Thinking Process, including empathizing, researching patents, prototyping, and pitching ideas.

This paper presents findings from an evaluation of the 2019 InVenture Prize Summer Accelerator. This paper specifically addresses calls from the existing literature to document students' self-reported outcomes of participating in InVenture programs, and is the first to describe the ways in which the K-12 IP program can be successfully adapted into a one-week summer program. Data were gathered through both qualitative and quantitative methods. Student outcomes and satisfaction were assessed using a pre- and post-survey design. Additionally, a focus group was conducted to investigate students' perspective regarding specific activities and content included in the program. Pre-survey and focus group findings indicate that students were familiar with program content knowledge and 21st century skills prior to beginning the program. Despite this, there were increases in students' confidence in program content knowledge, specifically knowledge related to the Design Thinking Process, and students' 21st century skills, such as teamwork and communication. Additionally, students' positive attitudes towards STEM and their intent to persist in STEM were maintained over the course of the week. Students were also satisfied with their Summer Accelerator experience and expressed an interest in continuing to invent after the program. These findings support the limited body of research on student outcomes associated with participation in InVenture programs, and offers unique insights into the outcomes associated with turning a school-based invention education program into a one-week summer program in an out-of-school-time context.

Introduction

In recent decades, invention education programs have been posited as a way to engage students in STEM through the hands-on process of designing their own inventions [1]. The K-12 InVenture Prize (IP) is an example of one such program, offering a platform for school-based invention education designed to be implemented during the academic year [2]. The program operates in partnership with the Georgia Institute of Technology ("Georgia Tech"), providing teachers with curriculum resources, professional development, and site visit opportunities. Additionally, the university hosts the annual statewide competition each year [3]. The goal of the K-12 IP program is to increase students' exposure to and experience with engineering and entrepreneurship, while placing a unique emphasis on student choice, collaboration, and teamwork [2]-[4]. Since the beginning of the program in 2012, teachers have adapted K-12 IP lesson plans in Kindergarten through 12th grade, implementing lessons in core classes, gifted classes, out-of-school clubs, or with students working independently outside of school [2], [3], [6]. Over 12,000 students from across the state have participated in the K-12 IP program since 2012, with over 250 students competing in the statewide K-12 IP competition in 2019.

In 2019, two K-12 IP teachers transformed the year-long K-12 IP program into the K-12 InVenture Prize Summer Accelerator ("Summer Accelerator"), a week-long summer day camp for middle grades students, taking advantage of the opportunity to deliver invention education to students without the challenges of school-year implementation. The program takes place over the course of five days (30 total hours) on the Georgia Tech campus. The format of the Summer Accelerator is similar to that of the year-long program, with students moving through a 5-step Design Thinking Process. The model of design thinking used in the K-12 IP program and the Summer Accelerator is the Design Thinking Process developed by the Hasso-Plattner Institute of Design at Stanford, in which students are encouraged to empathize, define, ideate, prototype, and test their inventions [5]. The learning objectives for students in the Summer Accelerator mirror those set out for students participating in the year-long program, including: choosing a problem and writing a problem statement about how people experience this problem; ideating solutions to that problem that are better or less expensive than devices that are currently available; sketching and making a prototype of their idea; obtaining feedback through conferencing and user surveys; and presenting their project to an audience through a "pitch."

Students in the Summer Accelerator accomplish these objectives through activities designed to support the development of invention skills, creativity, and collaboration. For example, in one activity students learn to empathize with others while thinking about the impact of their inventions. Towards this end, students are given a worksheet with an inventor (themselves) in the middle and a series of concentric circles expanding out around the inventor. In the circle closest to the inventor, the students write down problems that affect only themselves. As the circle grows, students work collaboratively to identify problems that affect their families, communities, country, and world. This activity prompts students to be mindful of issues that may affect multiple people and empathize with them as they think about the impact of their inventions. Another activity designed to promote students' social and invention skill development is the K-12 InVenture Prize Board Game. In this game, designed by the instructors of the Summer Accelerator, students practice each step in the Design Thinking Process with their peers as they think critically and creatively to solve problems in the game. The Board Game serves as an introduction to the Design Thinking Process and a way to expose students to the challenges and successes involved in the invention process.

Because the Summer Accelerator was held on the Georgia Tech campus, students were able to interact with real engineers and explore engineering facilities at the university. For example, students toured the Invention Studio at Georgia Tech and learned about engineering tools and machinery, such as 3D printers, laser cutters, and soldering equipment. Students also had the opportunity to interact with an engineering graduate student who visited the program to teach students about origami engineering. Students practiced their origami engineering skills by turning flat tubes and into rigid, three-dimensional figures, with the help of the graduate student. These experiences influenced students' invention decisions later in the week, with some teams choosing to use 3D printing or origami engineering to prototype their inventions. The Summer Accelerator's location on a university campus and the flexible schedule afforded by the out-of-school time (OST) format made these opportunities easily accessible to students.

An evaluation of the Summer Accelerator was conducted to gather information on students' perceptions of the program and outcomes of participation. Previous evaluations of the year-long K-12 IP have sought to understand students' perceptions and outcomes, but have relied heavily on teacher reports [2]-[4], [7], [8]. Furthermore, previous evaluations have focused on the implementation of the K-12 IP program in a school setting during the academic year. This paper presents findings from an evaluation of the 2019 Summer Accelerator, specifically addressing calls from the existing literature to document students' self-reported outcomes of participating in InVenture programs. It also is the first of its kind to describe the K-12 IP experience when transformed into a one-week summer program.

Background Literature

Participating in invention competitions, such as the K-12 IP, can have positive benefits for students. In past studies of the K-12 IP, teachers have reported outcomes for students including perceived growth in students' communication and teamwork skills, increased interest in engineering and entrepreneurship, increased knowledge of the Engineering Design Process, and an increased interest in STEM jobs [2]-[4], [7], [8]. In addition to documenting student outcomes reported by K-12 IP teachers, one study investigated students' self-reported outcomes of participating in the K-12 IP program [7]. The results of the study indicated that after participating in the K-12 IP program, high-school students reported slight increases in their creativity, communication skills, and interest in STEM jobs.

Though students and teachers report promising outcomes of the K-12 IP program, there are inevitable challenges to implementing the K-12 IP program in schools. K-12 IP teachers report that finding time to implement the program is a challenge [4]. This challenge is certainly not unique to the K-12 IP program and has been shown to be a barrier for implementing similar inquiry-based projects in schools [9]. Additionally, K-12 IP teachers report challenges related to a lack of funding and issues gaining access to computer labs required for the research component of the program [4]. Furthermore, teachers report that the K-12 IP needs to be a good "fit" for the school context [4].

By design, summer camps mitigate some of the challenges faced by teachers during the school year, offering a flexible format unburdened by standards or testing schedules. Furthermore, there is evidence to suggest that STEM summer camps may be especially useful for promoting STEM interest in K-12 populations. For example, participants in STEM summer camps report increased positive attitudes towards STEM, confidence in their understanding of STEM content, and an intent to continue taking classes in STEM fields or to pursue a STEM career after finishing the program [10]-[16].

Summer camps specifically related to invention have also shown positive student outcomes. For example, the Camp Invention program offers week-long summer day camps for students in Kindergarten through 6th grade [17]. The camps involve hands-on activities related to invention and focus on a range of topics, including aviation, ecosystems, and sports [18]. Evaluations of the various Camp Invention offerings indicate that participants report significant increases in creativity, STEM interest, collaboration, and problem-solving skills [19]. While Camp Invention and the Summer Accelerator share a similar focus on invention, Camp Invention differs in that students are constrained to the topic of the specific program they attend. Thus, the Summer Accelerator is unique in its emphasis on student voice and choice, with students designing inventions inspired by their own interests. Additionally, the Summer Accelerator's affiliation with a university affords participants a glimpse into the real world of engineering, with students interacting with graduate-level engineering students, touring the university Invention Studio, and working with tools used by real engineers as they prototype their designs. Despite the differences between Camp Invention and the Summer Accelerator, the positive evaluation findings from Camp Invention suggest that week-long summer programs related to invention can demonstrate positive outcomes for students that mirror those seen in other STEM summer camps, as well as in year-long invention programs. With these findings in mind, the evaluation of the 2019 Summer Accelerator was designed to understand student outcomes associated with participation in InVenture programs, and offer unique insights into the outcomes associated with transforming a school-based invention education program into a one-week summer program in an out-of-school-time (OST) context.

Methods

Participants

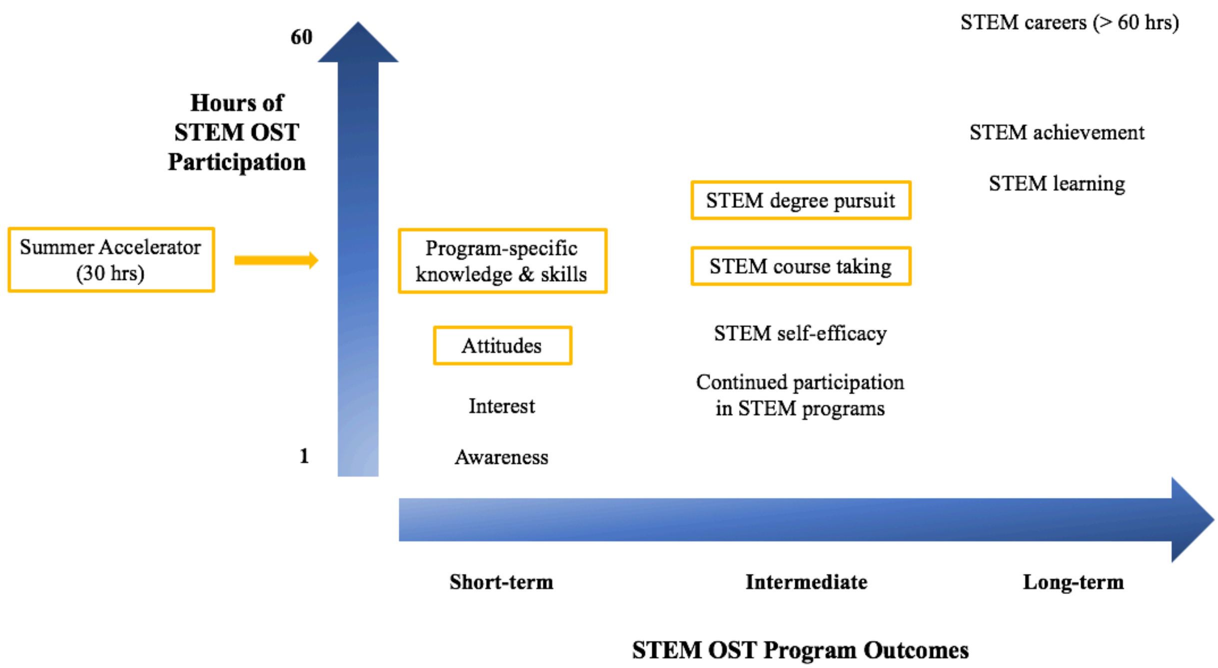
The Summer Accelerator was attended by 15 rising 6th- through 8th-grade students. The sample size for the pre-post survey is $n = 9$. Six of these students were randomly selected to participate in a focus group. Of the participants who provided self-reported demographic information on the pre-survey, 67% reported that they were male and 33% reported that they were female. The majority of participants reported that their race/ethnicity was White (44%) or Asian (44%).

Evaluation Design

A mixed-methods design was used to evaluate the Summer Accelerator, including both qualitative and quantitative data collection methods. The evaluation was guided by the following questions:

1) What are the student outcomes of participating in the Summer Accelerator?
2) What are students' perceptions of the Summer Accelerator?

Specific student outcomes were chosen based on a model for evaluating STEM OST programs developed by Wilkerson and Haden [20]. According to this model, it is appropriate to assess changes in short-term outcomes, such as attitudes and program-specific knowledge and skills, as well as intermediate outcomes, such as STEM degree pursuit and STEM course taking, for a program of moderate length, such as the Summer Accelerator (Figure 1).



Note. Outcomes measured in 2019 evaluation of Summer Accelerator are highlighted in yellow.

Figure 1. Model for evaluating STEM OST programs [20].

Accordingly, the outcomes assessed in this evaluation included students' confidence in their knowledge of specific program content, their attitudes towards STEM, intent to persist in STEM, and specific 21st century skills, including teamwork and collaboration skills, as well as presentation and communication skills. Student perceptions of the program were also assessed. These data were gathered using quantitative and qualitative methods.

Quantitative data were collected using a pre- and post-survey design. Students completed a pre-survey on the first day of the program, before any instruction began. On the final day of the program, a post-survey was administered. Each survey took approximately 15 minutes to complete. Validated constructs were used when possible. Specifically, the "teamwork and collaboration skills" and "intent to persist" constructs demonstrated good internal consistency when previously validated in middle school samples, with Cronbach's alphas of 0.88 and 0.86, respectively [7], [21]. Table 1 provides further information on the subscales used in the pre-post survey.

Table 1: Pre-Post Survey Subscales

Subscale	Source	Number of Items	Example Item(s)	Response Format
Confidence in Program Content Knowledge	Developed by authors	6	"How confident do you feel designing a prototype of an invention?" "How confident do you feel creating a survey?"	4-point Likert scale ranging from "Not at All Confident" (1) to "Very confident" (4)
STEM Attitudes	Adapted from *Student Attitudes Towards STEM Survey* [22]	13	"When I am older I think I will choose a job that uses math." "I feel good about myself when I do engineering activities."	4-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (4)
Intent to Persist in STEM	*Student Survey* [21]	9	"I would like to take more science classes in school than my school makes me." "I am eager to use my technology knowledge in my future job."	4-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (4)
Teamwork and Collaboration Skills	*Student Survey* [7]	8	"I can communicate my ideas while working with a group." "I am confident I can lead others to accomplish a goal."	4-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (4)

In addition to the items described above, the pre-survey contained a series of items assessing participants' motivation for attending the Summer Accelerator. Participants selected "yes" or "no" for each statement based on whether they felt the statement applied to them. The post-survey included fixed- and free-response questions to assess students' perceptions of the program.

A 45-minute focus group was conducted on the final day of the program to gather qualitative data on students' perspectives of the Summer Accelerator. Focus group participants were asked about their perceptions of the activities they participated in during the week, content they learned, and their interest in continuing to engage in STEM activities, coursework, or careers. Participants were also asked how the program contributed to the development of specific 21st century skills, including teamwork and collaboration skills, as well as presentation and communication skills. The focus group was audio recorded and the recording was used to analyze the findings.

Data Analysis

Quantitative survey data were analyzed using descriptive statistics. Specifically, frequencies, means, and standard deviations were conducted to provide general information on trends in participants' responses. Qualitative data provided in response to open-ended survey items and the focus group were analyzed using a general inductive approach. Thus, qualitative data were summarized, and these summaries were in turn used to draw connections between the raw data and the evaluation questions [23]. This analysis approach provided richer information on student outcomes and perceptions of the program, while triangulating survey data.

Results

Confidence in Program Content Knowledge

Qualitative and quantitative data indicate that students' confidence in their knowledge of program content increased over the course of the Summer Accelerator. The pre-post survey assessed students' confidence in their ability to complete the specific steps in the Design Thinking Process (empathize, define, ideate, prototype, and test), along with other important elements of invention, such as pitching and survey development during the testing stage. Pre-survey data indicated that participants were, on average, "somewhat confident" with all items assessing their confidence with program content at the beginning of the Summer Accelerator (Table 2).

Table 2: Participants' Confidence Before and After Program

	Mean (SD)		
How confident do you feel…	**Pre**	**Post**	**Difference**
…solving a problem in a new way?	2.67 (0.71)	3.33 (0.50)	0.67
…writing a statement about an invention problem?	2.56 (0.88)	3.11 (0.78)	0.56
…changing an invention based on survey results?	2.56 (0.88)	3.11 (0.78)	0.56
…designing a prototype of an invention?	2.89 (1.05)	3.33 (1.00)	0.44
…creating a survey?	2.89 (0.78)	3.33 (1.00)	0.44
…pitching an idea for an invention?	2.89 (1.05)	3.33 (0.71)	0.44

Note. Difference = post-survey mean – pre-survey mean. Thus, a positive difference indicates an increase in degree of agreement from pre-survey to post-survey. $n = 9$.

During the focus group, students were asked to describe their experiences using the Design Thinking Process to create and redesign their inventions. Focus group participants reported that they were already familiar with the Design Thinking Process prior to attending the program, having used it in their science classes at school or as a participant in the year-long K-12 IP program. One participant stated, "*it's kind of like a repetition of what you've already learned*." More specifically, participants described learning about the Empathy stage of the Design Thinking Process in their health classes and science classes. One participant demonstrated their understanding of this stage in the Design Thinking Process by stating:

> *It's solving a problem and for that you have to have a problem and that problem doesn't just have to apply to you and that requires empathy, but we've learned that at school multiple times.*

Even with students' previous experience with the Design Thinking Process, participants reported that they still found some steps in the process challenging. On average, survey results indicated that students were "somewhat confident" in their ability to solve a problem in a new way prior to attending the program (*M* = 2.67, *SD* = 0.71), and focus group participants reported that ideation was indeed one of the most challenging aspects of the Summer Accelerator. Participants found ideation challenging because "*the first time we were trying to come up with solutions we all were a little stumped*." Another participant stated that "*it was hard. It was annoying to have to do it*." One participant described how this process was further complicated when checking their ideas against the inventions that have been previously patented, stating, "*we got stuck because for every good idea you think of you think it's original but then when you go onto Google patents search it's already there*."

By the end of the program, students reported that they were "confident" in their ability to solve a problem in a new way (*M* = 3.33, *SD* = 0.50). Focus group participants described learning strategies to improve their ability to solve a problem in a new way and ideate on their inventions. For example, program instructors taught students the brainstorming technique, "SCAMPER." SCAMPER is a mnemonic device that prompts students to ideate through Substituting, Combining, Adapting, Modifying, Putting to Another Use, Eliminating, Rearranging or Reversing. One participant described the SCAMPER method, stating, "*I thought it was important because that's how… we looked at the product in different ways, when we came across an obstacle we could use that and then change it so that we overcome that obstacle*." Despite students' initial frustration ideating, participants reported that the SCAMPER method was an effective strategy because "*once you get past the block then… you have a ton of ideas and you can't decide which ones to choose*."

One of the smallest increases in average confidence on the pre-post survey was found for students' confidence designing a prototype of an invention. However, post-survey and focus group findings indicate that prototyping was one of the most enjoyable stages of the Design Thinking Process and the program more generally. When asked on the post-survey about the most fun thing they did or learned during the program, students commonly responded that prototyping was most fun. One focus group participant stated that they enjoyed prototyping because "*because you got to actually build something*." Another participant stated that prototyping was enjoyable because "*you can 3D print something*."

STEM Attitudes

On average, participants agreed with the majority of statements assessing their attitudes towards STEM before the program (Table 3). This finding is unsurprising given students' initial interest in STEM, with a majority of pre-survey respondents reporting that they were attending the program because they wanted to learn more about science and math (77.8%). After the program, participants agreed with all but one statement assessing their attitudes towards STEM. On average, participants disagreed that they were good at building or fixing things, with no difference in average agreement with this statement before and after the program (*M*s = 2.89). However, the positive trend in students' average agreement on the majority of items indicates that students maintained positive attitudes towards STEM over the course of the week.

Table 3: Participants' Attitudes Towards STEM Before and After Program

Item	Mean (SD)		Difference
	Pre	Post	
I feel good about myself when I do science.	3.33 (0.71)	3.56 (0.53)	0.22
I feel good about myself when I do engineering activities.	3.00 (0.50)	3.22 (0.44)	0.22
When I am older I think I will choose a job that uses math.	2.78 (0.67)	3.00 (1.00)	0.22
Engineering activities are hard for me.[a]	2.89 (1.05)	3.11 (0.93)	0.22
Science is hard for me.[a]	3.44 (0.53)	3.67 (0.50)	0.22
Science will be important to me in my future career.	3.33 (0.71)	3.44 (0.73)	0.11
Math is hard for me.[a]	3.11 (1.05)	3.22 (1.09)	0.11
Designing products or structures will be important in my future job.	2.89 (0.60)	3.00 (1.00)	0.11
I feel good about myself when I do technology activities.	3.22 (0.44)	3.22 (0.67)	0.00
I am good at building or fixing things.	2.89 (0.60)	2.89 (0.93)	0.00
I know I can do well in science.	3.67 (0.50)	3.56 (0.53)	-0.11
I am the type of student to do well in math.	3.33 (0.71)	3.11 (1.05)	-0.22
I feel good about myself when I do math.	3.22 (0.83)	3.00 (1.00)	-0.22

Note. Difference = post-survey mean – pre-survey mean. Thus, a positive difference indicates an increase in degree of agreement from pre-survey to post-survey. *n* = 9.
[a] Item was reverse coded, such that 4 = "strongly disagree," 3 = "disagree," 2 = "agree," 1 = "strongly agree"

Intent to Persist in STEM

Survey items assessing students' intent to continue taking STEM courses or pursuing a STEM career were combined to create a construct measuring students' intent to persist in STEM. There was a slight increase in students' intent to persist, rising from 3.25 (*SD* = 0.35) at the beginning of the week to 3.35 (*SD* = 0.41) at the end of the week (Table 4). When looking at individual items within this construct, the largest mean increase in agreement was for the statement "I am eager to use my science knowledge in my future job." Interestingly, this item received one of the lowest agreement ratings at the beginning of the week (*M* = 3.00, *SD* = 0.50) and one of the highest ratings at the end of the week (*M* = 3.56, *SD* = 0.53).

Table 4: Participants' Intent to Persist in STEM Before and After Program

Item	Mean (SD)		Difference
	Pre	Post	
I am eager to use my science knowledge in my future job.	3.00 (0.50)	3.56 (0.53)	0.56
I want to study hard in my math classes.	3.44 (0.53)	3.67 (0.50)	0.22
I want to study hard in my technology classes.	3.33 (0.50)	3.56 (0.53)	0.22
I would like to take more technology classes in school than my school makes me.	3.11 (0.60)	3.22 (0.67)	0.11
I am eager to use my math knowledge in my future job.	2.89 (0.93)	3.00 (1.12)	0.11
I would like to take more science classes in school than my school makes me.	3.33 (0.50)	3.33 (0.71)	0.00
I am eager to use my technology knowledge in my future job.	3.22 (0.44)	3.22 (0.67)	0.00
I want to study hard in my science classes.	3.67 (0.50)	3.56 (0.53)	-0.11
I would like to take more math classes in school than my school makes me.	3.22 (0.97)	3.00 (1.00)	-0.22

Note. Difference = post-survey mean – pre-survey mean. Thus, a positive difference indicates an increase in degree of agreement from pre-survey to post-survey. $n = 9$.

Focus group findings also demonstrated that some participants possessed an interest in a STEM career. For example, one focus group participant stated, "*I've always wanted to be an engineer*," indicating an intent to persist in STEM even before the program. Another participant explained why the Summer Accelerator is beneficial, regardless of a students' career path:

> *I think though, even if you don't want to be an engineer, it's a useful experience because you're looking at solving problems outside of the box and you're also working… with new people that you don't know so I think that's also a good part of it.*

21st Century Skills

Teamwork and collaboration skills. An important component of the Summer Accelerator was teamwork, as students worked collaboratively in groups of three to design their inventions. Teams were assigned based on students' interest in each invention idea and their self-identified strengths and weaknesses. On average, students reported strong teamwork and communication skills at the beginning of the program ($M = 3.35$, $SD = 0.48$) and at the end of the program ($M = 3.35$, $SD = 0.48$; Table 5), with no overall mean change between the pre- and post-surveys.

Table 5: Participants' Teamwork and Collaboration Before and After Program

Item	Mean (SD) Pre	Mean (SD) Post	Difference
I am confident I can encourage others to do their best.	3.00 (0.87)	3.33 (1.00)	0.33
I am confident I can lead others to accomplish a goal.	3.00 (1.00)	3.22 (0.97)	0.22
When I work with a group, I value each team member's contribution.	3.44 (0.53)	3.67 (0.50)	0.22
I can communicate my ideas while working with a group.	3.22 (0.67)	3.33 (1.00)	0.11
I am confident I can respect the differences of my peers.	3.67 (0.50)	3.67 (0.50)	0.00
I am confident I can include others' perspectives when making decisions.	3.56 (0.73)	3.56 (0.53)	0.00
I can come up with ideas and share them while working with a group.	3.33 (0.50)	3.33 (1.00)	0.00
I am confident I can work well with students from different backgrounds.	3.56 (0.53)	3.44 (0.53)	-0.11

Note. Difference = post-survey mean – pre-survey mean. Thus, a positive difference indicates an increase in degree of agreement from pre-survey to post-survey. $n = 9$.

Focus group results provided further insight into why there was no change in reported teamwork and collaboration skills on the pre-post survey. Focus group participants indicated that they frequently work in groups at school and had experience applying their teamwork and collaboration skills in academic settings. However, they also described how the Summer Accelerator challenged them to use their teamwork and collaboration skills in a new context. As one participant summarized, "*I knew how to [work with people], but I didn't really know how to make an invention with them*." Participants described needing to use teamwork and collaboration skills to mediate disagreements when students had contradictory ideas. When asked if they learned helpful teamwork and collaboration skills during the program, one participant stated:

> *I think I kind of knew it but I hadn't really had to use it yet, cause in school you already know everybody and you know how to work with them and stuff, whereas with these people you don't. You've only met them a couple days ago*.

Though there were challenges to working in teams during the Summer Accelerator, there were also benefits. Focus group participants agreed that "*it's really important to work in groups*." They described how teamwork allowed them to generate more ideas than they would have on their own:

> *We kind of like combined ideas so we wouldn't have thought of something different without bouncing it off of each other and you're more open to different ideas… when you're in groups instead of just having a narrow mind when you're by yourself.*

> *It's like easier to get past problems 'cause everyone has their own perspective of it and their own input.*

> *I probably would have no ideas right now if… I didn't have a group.*

Presentation and communication skills. During the Summer Accelerator, students were taught presentation and communication skills to help them pitch their inventions to an audience on the last day of the program. Survey participants frequently reported that these presentations were the most fun thing they did during the Summer Accelerator. Focus group participants reported that communication skills, especially those required for a formal presentation, were some of the most important skills they learned during the Summer Accelerator. Many participants stated that they practice these skills in school, either in their regular classes, public speaking class, or debate team. Because these skills were practiced in school, some felt that they were not learning new presentation skills in the InVenture program, with one stating "*with the pitching skills, I understand that those were important, but I already knew them cause public speaking is a required class at my school*."

Another participant felt that presenting frequently in school was the very reason that these skills are an important part of the Summer Accelerator: "*presentations skills and stuff, pitching, it's important for school because we do that a lot at my school. We'll get in groups together and pitch an idea*." The same participant went on to describe the new presentation strategies learned during the Summer Accelerator, stating, "*you have to stay calm, so [the program instructors]… remind the groups 'pretend you're at your table, just be calm, pretend like you're just talking to the teacher not pitching in front of a whole class or an audience.'*" Some participants indicated that they were nervous to present their final presentation, but agreed that the program helped them learn skills to communicate their ideas effectively. Taken together, these findings indicate that students recognized the importance of including presentation and communication skills in the Summer Accelerator. Students began the program with strong presentation skills developed in school and felt confident in their ability to apply these skills during their pitches, even if they were nervous to do so.

Interestingly, teamwork was brought up in the context of presenting. The program instructors required that all team members help present during the final pitch given on the last day of the program. When asked if they thought they would be able to communicate their ideas clearly during the presentations, focus group participants were confident in their own abilities but had reservations about their teammates. Participants described the challenges of presenting their inventions with other people:

> O*ne person in my group doesn't want to practice so when we pitched it was sort of a flop*.
>
> *Even if I think it's not gonna go well I still try my best cause sometimes you gotta fail to learn, but what I don't like for a presentations is when someone like, "oh I did so good," but they didn't really do anything.*

Alternatively, another participant described characteristics of their teammates that helped them feel prepared for their presentation, stating that their teammates "*are pretty good. They're good at practicing and presenting and they've helped me do it, so I'm not nervous about my friends*." These statements indicate that, though participants entered the program with strong communication and presentation skills, they learned new strategies for presenting their ideas calmly and clearly, and were challenged to apply both communication skills and teamwork skills in the context of their group presentations.

Perceptions of the Summer Accelerator

The post-survey included fixed-response and free-response questions intended to gather information on students' perceptions of the activities, instructors, and overall experience in the Summer Accelerator. With regard to program instructors, participants agreed that they understood what they were supposed to do when their teachers explained activities ($M = 3.44$, $SD = 0.53$). This finding is supported by the fact that participants disagreed that they did *not* understand what their teachers were talking about during the Summer Accelerator ($M = 2.00$, $SD = 0.87$). Participants, on average, disagreed that they were given enough time to talk with other students about what they learned ($M = 2.78$, $SD = 0.67$). However, they agreed that they had fun, enjoyed the activities, and learned a lot of new things during the Summer Accelerator (Ms > 3.11).

The majority of survey participants who replied to the question, "would you recommend this summer program to your friends?" reported that they would recommend the Summer Accelerator (89%). Focus group participants elaborated on this finding saying that they would recommend the program to "*certain friends*" who are already interested in the topics discussed in camp. Participants described the characteristics that would make someone a good fit for the program:

> *If you're looking into getting better and adding to the knowledge and what you already have then I'd say it's for them.*
>
> *I would say it's fun, but… if you're not really into building your own thing, and making a solution to a problem, finding problems, and doing research, it's probably not gonna be for you.*

Survey responses and focus group responses indicated that participants wanted to "*add some more time*" to the program. Participants suggested lengthening the program to "*two or three weeks*," or if that wasn't possible, to begin work on their projects earlier in the week. Focus group participants described the impact of the week-long program format on their inventions:

> *I think mine could have been definitely better if I had more time*.
>
> *It's gonna be a very raw product. It's not gonna be that clean*.

One participant stated, "*for the timeframe that we had I feel like I created something to the best of my abilities.*"

Many participants reported that they would continue to work on their inventions or create new inventions after the program. This was coupled with an interest in continuing to participate in the InVenture program. One focus group participant stated, "*I'm gonna tell my science teacher about it… I hope that she'll be able to do it and I think there's a lot of people that'd be interested in doing it but I have to ask her cause it's not already at my school*." All focus group participants reported that they would be interested in participating in the year-long K-12 IP program at their schools if the opportunity was available. These findings are promising, given that most focus group participants were unfamiliar with the K-12 IP program prior to attending the Summer Accelerator. Thus, the Summer Accelerator may be a good way to expose students to InVenture programs, while peaking students' interest in participating in a longer version of the program during the academic year.

Discussion

The Summer Accelerator provides a unique opportunity for students to experience a condensed version of the K-12 IP program in an OST setting. The findings from this evaluation are an important contribution to the limited literature on the student outcomes of experiencing K-12 IP lesson plans. Qualitative and quantitative findings from this evaluation demonstrate that a week-long format yields positive student outcomes similar to those that have been demonstrated in students who participate in the K-12 IP program during the academic year and students who participate in other invention summer programs across the country [9], [18]. Specifically, students in the Summer Accelerator grew their confidence in program content knowledge and 21st century skills, as well as maintained positive attitudes towards STEM and an intent to persist in STEM. This is especially encouraging given that students reported previous experience with some elements of the program, such as the Design Thinking Process, teamwork skills, and communication skills.

One limitation of this evaluation is that the findings reflect only the perspective of student participants. This was done deliberately in 2019 to allow the evaluation to focus on gathering self-reported data from students. However, future evaluations of the Summer Accelerator should include data collected from multiple sources, including students, program instructors, and parents. This will provide richer information from multiple perspectives on the outcomes for students participating in the Summer Accelerator. Additionally, program instructors can contribute information on the experience of implementing the K-12 IP program over the course of one week. This information will provide further description of the week-long program, while allowing instructors to compare their experiences guiding students through the Design Thinking Process over one week versus over an entire academic year. Another limitation of this evaluation is the small sample size. With larger sample sizes, inferential analyses can be conducted to test for statistically significant differences in pre-post survey averages. This will reveal more about the changes in students' perceptions of their abilities and attitudes from the beginning to the end of the program.

Further research is needed to continue documenting the impact that participating in the K-12 IP program in its many forms has on students, and of invention education programs more broadly. As educators continue to seek ways to engage students in STEM, it will be important to understand which specific components of programs, such as the K-12 IP program and the Summer Accelerator, support student success. Additionally, it is important to continue to understand how school-year invention education programs can be successfully transformed into OST programs, thus providing additional outlets for students to become engaged in STEM. The findings presented here offer hope that OST invention education programs can be a successful tool for promoting positive student outcomes related to STEM, developing students' 21st century skills, and ultimately, preparing the next generation of innovators and entrepreneurs.

Acknowledgements

This research was supported through CEISMC funds. We would like to thank local 5th-grade teachers, Nancy Ernstes and Julia Varnedoe, who devoted their time and energy to preparing and leading the 2019 Summer Accelerator. Lastly, this program would not be possible without the students who shared their ingenuity and creativity, as well as the support of their families.

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