AC 2007-2858: ARCHIMEDES PROJECT HAWAII INVENTION FACTORY: REAL-LIFE AND HANDS-ON PROJECTS FOR MIDDLE SCHOOL AND HIGH SCHOOL STUDENTS

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Archimedes Project - Hawaii Invention Factory: Real-life and hands-on projects for middle and high school students

Abstract

The Archimedes Project, Hawaii, under the auspices of the Research & Development of the University of Hawaii, hosts introductory programs for middle, high school and college students to stimulate their interests in science, technology and math through hands-on, inquiry-led, project-based activities.

Recently, the Archimedes Hawaii Project was awarded a National Science Foundation grant to develop a concept called The Invention Factory. This project is an after school program that introduces fundamental technical skills and concepts to middle and high school students through a series of fun projects as budding inventors. The engaging platform aligns pre-engineering concepts with the Hawaiian community values of giving. This paper will profile the first year where the initial recruitment goal of 150 students was exceeded by recruiting 161. Electronic toys were modified for disabled children and donated to local charitable organizations for distribution (like Easter Seals and Shriners Hospital). Participating students not only fulfilled service project requirements but enjoyed the activities, with several students returning as peer mentors in subsequent sessions. Workshops provide reinforcement of math and science concepts through relevance and application. Curriculum is also tied to the Hawaii DOE standards for level 8^{th} grade through 12^{th}.

Facilitators, curriculum, supplies and tools are all provided by The Invention Factory staff. Workshops are conducted in 2 sessions: one during the Fall and the other during Spring. Each session includes 6-8 workshops, one every other week for the duration of each session. Maximum number of students per workshop is 15-20. Program partners include the Women in Technology Project and isisHawaii (a local organization devoted to providing mentors—*"i"* for "internet", *"sis"* for "sisters"—to high school girls interested in STEM), who have provided recruitment and gender and cultural equity counsel. This has assured strong female and minority enrollments. The paper will discuss the formative program evaluation results, findings and recommendations for further implementation and replication.

Introduction

The Archimedes Project, Hawaii, under the auspices of the Research & Development of the University of Hawaii, hosts introductory programs for middle, high school and college students to stimulate their interests in science, technology and math through hands-on inquiry-led project-based activities. The programs proved so popular that students wanted to return. Returning students were able to continue their learning and get into more complex electrical engineering skills.

Monthly workshops begun in 2004 continued into 2005 with electrical engineering students from UH Manoa serving as mentors to student teams. Based on this success, the Archimedes Hawaii Project was awarded a National Science Foundation grant to develop a concept called The

Invention Factory. This project is an after school program that introduces fundamental technical skills and concepts to middle and high school students through a series of fun projects as budding inventors. The engaging platform aligns pre-engineering concepts with the Hawaiian community values of giving.

The Invention Factory (IF) is a 3-year program (2005–2008) developed to provide an informal, hands-on learning environment that teaches teenagers electrical engineering and invention concepts through projects creating technology-based, quality-of-life improvements for the disabled and elderly. Such assistive technology is one way to stimulate student interest in engineering concepts by connecting them to real-life applications[1]. The IF targets specific outreach to girls, Native Hawaiians, and those from families with low incomes. The aim is to stimulate interest in future study and careers in science, technology, engineering, and mathematics (STEM) among those less likely to pursue these fields.

Combining engineering instruction with hands-on "tinkering" addresses both the lack of representation of these populations in engineering programs and the lack of confidence in tinkering skills in those who do participate[2]. Workshops provide reinforcement of math and science concepts by providing a context for their application. Curriculum is also tied to the Hawaii DOE standards for 8th through 12th grade levels.

At the IF, electronic toys were modified for disabled children and donated to local charitable organizations (e.g. Easter Seals and Shriners' Hospital) for distribution. Participating students not only fulfilled service project requirements but enjoyed the activities so much that many kept returning and eventually became peer mentors.

For the most part, projects were presented at an introductory level, building on the concept of circuits and how circuits could control lights, run sirens, motors, speech amplifiers and voice activated relays. The students apply their knowledge by taking apart and modifying electronic toys to allow children with disabilities to play with them (i.e., assistive technology). First, students learn basic electronics and soldering skills by building a lamp circuit and then progress to toy modification. Students also learn about battery interrupters: a standard and very simple method of providing a remote switch for a toy that has an accessible battery compartment and is typically turned on with a slider or toggle switch. Battery interrupter production teaches skills such as soldering, stripping wire, and use of heat shrink.

Students then learn how to insert a "socket" cable into a stuffed dancing and singing toy that typically has a tactile switch in its hand or foot. To accomplish this, students typically cut the seam under the toys arm to access wires that lead to the switch. Students then solder 2 wires in series with the switch and cover the modification with heat shrink. The same sort of modification is accomplished on a hard plastic toy by drilling a hole and soldering wires directly onto the traces of the interior switch by scratching off the solder mask on the toy's printed circuit board. More advanced students are presented with toys with unique switch devices that require them to identify how the exterior switch is activated and locate where the interior connection occurs. Each of these unique switches is photographed and students are challenged to determine how to connect a socket cable in a way that will not interfere with the switch activation.

Facilitators, curriculum, supplies and tools are all provided by The Invention Factory staff. Program partners include the Women in Technology Project and isisHawaii who have provided recruitment and gender and cultural equity counsel to support the goal of strong female and minority enrollments. The IF approach--inquiry based, hands-on projects with real-world helping applications—is exactly what research indicates works in drawing females to STEM[2, 3].

The goal of the IF is to increase by several hundred the number of students in Hawai‘i who study STEM and who intend to pursue a career in STEM. The associated objectives are to: (a) create student confidence and ability to come up with innovative solutions to human-computer interface problems, (b) stimulate student interest in STEM study and careers, and (c) increase enrollment in STEM courses.

The guiding assumption for the IF is that by using engineering and inventing to improve the quality of life of others, students will gain skill and confidence in STEM-related activities, will develop interest and motivation to pursue study and careers in STEM, and, as a consequence, will enroll in STEM courses in high school and college (see Figure 1).

During its 3-year implementation, the IF intends to serve approximately 400 students in three activity levels: 8th graders in Level 1, 9th–11th graders in Level 2, and 10th–12th graders in Level 3. In Year 1, 100 Level 1 participants and 50 Level 2 participants were to begin, with an additional 100 Level 1 participants and 20 Level 2 participants targeted in each of Years 2 and 3.

Although attrition was anticipated, the intention is for some Year 1 - 8th graders to participate for all 3 years. The IF proposed to recruit small groups of participants from several local public high schools and associated intermediate schools. The program was designed as a weekly out-of-school voluntary activity to include mentors, monthly midweek face-to-face tutorials, workshops, and an interactive online component. Level 1 students are to participate in 21 hours of programming and Level 2 and 3 students 140 hours of programming.

During the 2005–2006 school year, the IF was implemented at eight sites: five were Level 1 8th graders and three were Level 2 high schoolers. The IF Level 1, intended for 8th grade students, comprised eight learning modules. Five groups of 8th grade students from three schools participated. In order to accommodate school schedules, the number and duration of sessions and the time span of the program varied. The total number of hours allocated for completion of Level 1 ranged from 12.5 to 20 hours. However, all eight Level 1 modules were provided to all groups. For half of the eight Level 1 groups, participation was voluntary and after school. For one group, the program was conducted during required mathematics and science classes. At one school, students from 6th through 8th grade participated.

The IF Level 2, intended for high school students, comprised all Level 1 modules and additional Level 2 modules. Three groups participated in Level 2. For all three groups, the Level 2 program was administered over 12 sessions, each lasting 2.5 hours, for a total of 30 hours. Two of the groups participated in an extra session, during which the participants worked on group and individual projects. Circumstances of participation varied for the three Level 2 groups. For one group, the program was a voluntary, after school program, comprising 9th through 11th grade students. The second was a group of home schooled children who met at the Invention Factory site during regular school hours. In order to accommodate younger siblings of high school students, participations in this group ranged from the 5th through 11th grades. The third group was conducted during a required 11th grade science course. A fourth group of high school students attended one session of the program, but, due to a low turnout, the program was terminated after two sessions.

Evaluation

For the first implementation year of the IF (2005–2006), the evaluation addressed 4 evaluation questions:

1. Does student confidence and ability in instructional activities, inventing, and STEM improve?

2. Do student interest in, study of, and intention to pursue careers in STEM increase?

3. Do recruitment procedures produce and maintain adequate enrollment levels? (What are reasons for attrition?)

4. Do the instructional activities, interactions, quality, and role models—that is, the learning environment—maintain interest, and produce learning?

The overall approach of the evaluation was to phase in different aspects of the evaluation over the 3-year duration of the project. Therefore, the first year was intended to provide feedback on selected aspects of the program and to try out some of the measures. By the third year, it is expected the evaluation will focus on outcomes. This approach is reflected in the evaluation design for the IF.

Two questionnaires were developed for the evaluation. One measured student attitudes and behavior toward various aspects of STEM, the other their satisfaction with the IF learning environment. Also, interviews were conducted with the recruitment manager and the supervising teachers. Finally, project attendance records and demographic data supplied data relevant to evaluation question 3.

Limitations

The following limitations characterized the first-year (2005–2006) evaluation of the Invention Factory. The scope of the evaluation was limited because of resource constraints and design. The funding level for the evaluation put limits on what could be done. In some cases, though, these limits on what parts of the evaluation were conducted were intentional. For instance, increased selection of STEM courses in school was intended to be evaluated in the final year of the project, after possible program effects had time to manifest as course selection.

Records used for the evaluation in the first year (2005–2006) (e.g., attendance, school lists, student lists) arrived late. When received, further cleaning was required. One effect of this tardy delivery of data was those who dropped out of the program were not interviewed regarding their reasons. However, relevant information about causes for attrition were obtained from interviews with the recruitment coordinator and the supervising teachers.

Not all students who attended the IF completed a posttest—some dropped out, others might not have been present on the day the posttest was administered, and the IF did not administer the posttest to some groups. This attrition caused both a loss of data and raised a question about the possible representativeness of the final sample of posttest takers.

Because it is believed the effects on achievement and career choice will occur after some exposure to the program, no attempt was made this year to monitor more deeply than participants' feelings (that is, their affect) about these outcomes.

Results

1. Does student confidence and ability in instructional activities, inventing, and STEM improve?

Participants in the IF program entered with fairly high confidence and interest in doing the activities that characterize the IF experience, in inventing, and in performing STEM activities. On a 5-point scale, average means hovered around 3.5. By the end of the program, their opinions were largely unchanged. Accordingly, the first evaluation question was not sustained—it did not appear that student confidence and ability in instructional activities, inventing, and STEM improved.

2. Does student interest in, study of, and intention to pursue careers in STEM increase?

Participants in the IF program entered with fairly high levels of interest in participating in STEM activities outside of school and choosing STEM careers. On a 5-point scale, average means were around 3.5. To a lesser extent, participants were interested in taking STEM courses in school. Both at the beginning and at the end of the 2005–2006 IF program, about 40% of participants were actually participating in extracurricular STEM-related activities.

Another indication of participants' interest in STEM was their motivation for joining the IF. When asked why they joined the IF, one–third of participants mentioned a specific interest in STEM or inventing. This regard for STEM and inventing, combined with general interest and excitement, accounted for almost two-thirds of responses.

These tendencies (e.g., interest and confidence in STEM courses and careers) did not seem to grow during the year. Thus, the second evaluation question may not have been positively answered: student interest in, study of, and intention to pursue careers in STEM did not appear to increase. Nevertheless, the IF participants began and ended the IF experience with positive attitudes toward STEM.

3. Do recruitment procedures produce and maintain adequate enrollment levels? What are the reasons for attrition?

This evaluation question considers whether enrollment numbers are met, how well enrollment reflects the target population. Assuming that attrition would be an issue for the program, a secondary question explored reasons for attrition. We answered these questions both quantitatively (attendance records and demographic data) and qualitatively (interviews with the recruitment manager and teacher supervisors from the school sites). This section first provides descriptive statistics on enrollment and retention. Second, the results of interviews with the recruitment manager and supervising teachers provide background on the recruitment procedures, describe barriers to enrollment and retention, and provide recommendations for improvement.

The quantitative analysis of enrollment and retention relied on three data sources: (1) an Attitudes Toward STEM pretest, which included demographic questions; (2) the IF's record of participants' attendance for each session; and (3) an IF participant information database that included participants' contact information and other personal information collected by the IF.

The IF proposed for the first year to reach 150 participants: 100 Level 1 8th grade students, and in Level 2, 30 9th graders, 10 10th graders, and 10 11th graders. The target population was girls, Native Hawaiians, those from families with low incomes, and disabled children. It was intended that all students would participate in the program after school on a voluntary basis.

Responsibility for recruitment was contracted to a consultant, who was charged with finding public schools to host the program. When selecting possible schools, the consultant considered the demographic targets for the IF and the need to facilitate 8th graders' ability to continue the program in high school. Therefore, many of the seven middle schools and eight high schools approached had relatively higher concentrations of low income and Native Hawaiian populations compared to typical public schools and included high schools and their feeder schools.

The recruitment manager presented the program concept to STEM faculty at potential school participants. Six schools ultimately participated, and some others expressed interest but could not attract enough students to participate. The recruiting manager felt that schools that did participate were attracted to the program in part because they were not meeting performance standards for mathematics and science. Another attraction of the program was the link to community service it provided.

Schools interested in the program were charged with recruiting students to attend. The IF originally required groups to be comprised of at least 50% girls, however, due to a lack of response from girls, this requirement was dropped. Among the 5 participating schools, a variety of methods were used to recruit students, according to the supervising teachers at the schools. Two groups requested the IF to present the program as part of a required class during the school day. In these cases, students were assigned to participate in the IF. For a voluntary, after-school program, one supervising teacher hand picked students who had expressed interest in engineering at a career fair. For another after-school group, the program was offered as one among many options in a new school-wide, after-school program. At another school, the program was advertised during science classes. In one instance, the IF conducted an in-class demonstration of the program to spur interest in it. A home schooled group was recruited by IF staff.

According to IF program records, the IF enrolled 161 students in its program, and 150 attended at least 1 session. The IF collected the Attitudes Toward STEM pretests and attendance data was matched from 132 participants (88% of the 150 who attended at least 1 session). The database of 132 participants was used to analyze the program's enrollment and retention record.

The evaluation defines “course completion” as attending at least 75% of the sessions offered. Under this definition, 72 students completed the IF in its inaugural year. This was equivalent to 45% of the initial enrollment (72/161). Participation in IF sessions ranged from 8% (1 of 12 sessions) to 100%, with the average participant attending 65% of sessions. Just over half (55%) of participants attended at least 75% of the sessions.

The IF was particularly focused on recruiting girls, Native Hawaiians, and children from low income families. During the first year, 32% of those recruited and retained were female, 21% were Hawaiian and 40% were from neighborhoods where most children live below the poverty level.

The recruitment manager and supervising teachers reflected on the problems faced with recruiting both schools and students, and provided suggestions to remedy these problems.

• Timing: Contact with the schools began in December with the intention of starting the program in January. According to the recruiting manager, it was difficult for schools to organize in just a few weeks. Additionally, halfway through the year, some schools had already committed to other math/science programs. For Year 2, school recruitment was well underway by the end of the first school year.

• The “treatment” was not well-defined: The program structure was not prepackaged (e.g., how many sessions, over what time frame); therefore, schools were unclear about what they would get from the program. With the program better defined, the recruiting manager did not believe this would be a problem for Year 2 recruiting.

• Application process: The recruitment manager felt the application forms/process might have been intimidating and onerous. More students might have been interested in attending the IF, but did not follow through with the forms.

• Competition, Scheduling Conflicts: The IF was competing with many other after-school programs. Supervising teachers felt that a reason for not enrolling more students was that students had already committed to after-school activities. For Year 2, the program will be promoted at the beginning of the school year.

• Lack of Advertising: Several school supervisors mentioned that they could have used more assistance from the IF to publicize the program to students. They said that showing students what the program would do would have been an important recruiting tool. The teachers suggested providing in-class demonstrations or presenting a marketing video. For Year 2, one school requested a lunchtime demonstration in the school library. Other suggestions were to disseminate “kid friendly” information about the program, provide a presentation to the faculty, and put information in the school newsletters that go home to parents.

• Parental Buy-In: One teacher felt that parents needed to be better informed about the program, particularly because middle school parents wanted their children home after school. The recruiting manager also felt that parental buy-in needed to be a bigger priority. One attempt to reach parents in 2005–2006 was a “Parent’s Day” to demonstrate the program; however, it was organized in only a few days and there was not enough publicity for it.

• Not Matching Girls’ Interests: The recruitment manager suggested that the projects might attract more girls if the connection with helping the disabled was stronger, and the end products were more relevant. Also, the IF is considering targeting groups that work specifically with girls, such as the YWCA or the Girl Scouts.

• Too Academic: The recruitment manager felt that students might be turned off if the program seems like a classroom or academic activity. An 8th grade teacher similarly said that 8th graders “are in school for 7 hours and after school want to play.”

Regarding retention, maintaining student participation was an issue for the voluntary after-school groups. According to the supervising teachers, the main problem was that students had scheduling conflicts (e.g., band, basketball, tutoring). At one school where the IF was one offering of a school-wide after-school program, one problem was that the school-wide program was new, and the procedures for signing up for and sticking with programs were not well-established. Two teachers felt that it was generally difficult to retain 8th grade students in an after-school program, because 8th graders do not have a strong sense of commitment, and because their parents were not involved enough to make sure they attended. Supervising teachers did not believe the reason why some students did not attend regularly was a lack of interest. (See evaluation question 4 for discussion.)

The following were suggestions for maintaining enrollment.

• Conduct the IF during academic class periods.

• Recruit students at the beginning of the school year before they are involved with other programs.

• Screen potential participants for interest and commitment in the program.

• Offer a small incentive for participation.

4. Do the instructional activities, interactions, quality, and role models—that is, the learning environment—maintain interest, and produce learning?

A total of 58 Learning Environment Surveys were collected from 6 project sites between May 19 and May 25. For each item on the survey, a mean score was calculated. Missing data (i.e., those who chose the “don’t know” response or none at all) ranged from 0% to 14%. For all but two items (#10 and #18), the amount of missing data was below 10%. Response frequencies and means for items, sorted by magnitude of the mean, are given in Table 1.

Overall, participants reported positive views of the IF program, particularly regarding learning. The five items with the largest means (3.4 to 3.5) referred to what (i.e., inventing, engineering, helping disabled and elderly) or how (through instructor's lessons and hands-on activities) participants were learning. The item with the lowest mean (2.7) asked whether participants paid attention during the instructor's lessons. Even though this was the lowest of the means recorded, few strongly agreed that they were bored during the sessions overall (2.8).
It should be noted that positive responses to the questionnaire items (i.e., responses of agreement) ranged from 51% to 94%. In other words, for no item did as many as half of the respondents have negative responses.

With an overall mean of 3.2 on a 4-point Likert scale, it is reasonable to conclude that, in general, students were satisfied with their IF instructional experience. It seemed they were quite satisfied with the hands-on activities that are a main feature of the IF. They said they were learning new things from instruction, were learning to help the disabled, and were learning about inventing and engineering. They were not always able to maintain attention during instruction and sometimes felt bored during the session.

Table 1. Item Frequencies and Means for Satisfaction Scale

How much do you agree with each statement about your experience at the Invention Factory?	Strongly Disagree (1)	Somewhat Disagree (2)	Somewhat Agree (3)	Strongly Agree (4)	Mean
I am learning new skills doing the hands-on activities.(7)a	2%	4%	33%	61%	3.5
I am learning new things from instructor's lessons.(6)	4%	9%	33%	55%	3.4
I am learning ways to help disabled and elderly people.(13)	3%	4%	44%	51%	3.4
I am learning about inventing.(15)	2%	7%	45%	46%	3.4
I am learning about engineering.(4)	0%	7%	44%	49%	3.4
I am interested in the IF activities that we do.(1)	2%	13%	46%	40%	3.2
The IF activities are fun to do.(3)	0%	16%	51%	33%	3.2
I put a lot of effort into doing the IF activities.(5)	5%	9%	50%	36%	3.2
The IF staff are fun to work with.(8)	6%	15%	40%	40%	3.2
Now I know what it is like to be an engineer.(17)	4%	13%	54%	30%	3.1

IF is better than other classes I have in school.(16)	4%	24%	35%	38%	3.1
I can usually follow the math and science we do.(2)	6%	19%	44%	32%	3.0
I look forward to attending the next IF session.(10)	10%	24%	34%	32%	2.9
*Sometimes I am bored during the IF sessions.(12)	13%	19%	47%	21%	2.8
I always pay attention to the instructor's lessons.(9)	5%	43%	23%	28%	2.7

a Numbers in parentheses refer to the item number on the questionnaire.

The IF staff requested participant feedback on some aspects of the program that might be modified for the future. The mean scores of these 3 items demonstrate that ownership of the gadgets created seemed fairly important (54% strongly agreed they would like to keep completed IF projects and 32% somewhat agreed). Working on projects at home strongly appealed to 22% and somewhat appealed to 31%. Using the IF Web site to learn more at home strongly appealed to 24% and somewhat to 22%.

Teachers who supervised the school groups were asked for their perspective on the IF's ability to maintain interest and produce student learning. Four of the five supervising teachers felt the program was very successful in maintaining participants' interest in the program. The teachers commented most about students' interest and engagement in the hands-on aspects of the program. One teacher said, "Even kids who stopped in to see what we were doing, they would come in and join and start soldering. It was a kid magnet."

According to one teacher, the program seemed to spark an interest in students who would not generally be interested in STEM. "We saw some kids who were so disenfranchised from school taking an interest. One little boy who was staying after school for detention…a Samoan girl who starting talking about an interest in medicine…we were reaching kids who don't see the connection between what we teach in school and real life."

At the same time, there was discussion across all programs about balancing the hands-on learning and lecturing. Three of the teachers said that students lost interest during the lectures. One teacher said, "It was evident that kids were losing interest when the lecture was at the beginning of the session."

Four of the supervising teachers said the program was very successful in "producing learning," though two of these teachers cautioned that this was a judgment they might not be qualified to make. Nevertheless, the teachers spoke about participants' exposure to science concepts, "very detailed skills," and hands-on projects they would not typically get in school. Two teachers emphasized the skills that students acquired. One teacher said the "value of the skills were so high of what you can do with it later." Another commented on "the new skills they can take with them after high school." Two teachers mentioned the importance of students' learning about connections between science and "real life." Other positive comments from two teachers were that the projects related to each other and built upon each other—important for producing learning.

Teachers provided some suggestions for improving students' interest and learning. Some of the comments were specific to individual teachers, while others were shared by a few teachers.

• Limit the lecture time. As mentioned above, nearly all teachers felt the lectures did not fully engage students. One who felt that the IF lectures were a reasonable length explained the importance of keeping the lectures brief. "The lecture would be brief, 15 to 20 minutes, the rest was hands-on…. This program can go far in middle school because for 15 or 20 minutes the kids will stay focused, but not longer."

• Make a stronger connection between the toys and how they will help the disabled and elderly. "Put a face on the individual that will be using the toys—how it will improve their quality of life, how it will make a life-changing difference for them." Another teacher said, "Have the products [that the participants make] featured more. Sometimes the kids didn't really know where they were going with the project." A third teacher commented on the value the projects' had to students: "They felt like they were not just doing it for nothing, but someone is going to use something they built."

• Start sessions with hands-on activities to engage students. One teacher said, "I would suggest more hands-on activities early in the session, rather than lecture-based information to grab the students' interest first."

• Allow more time for brainstorming and toy building. A teacher explained, "To me, this is where the most relevant learning and application would have taken place."

• Cover the basics: Speaking about the module on electricity, a middle school teacher suggested spending more time on the basics of parallel and series circuits.

• Relate the program to standards: The same middle school teacher suggested it might be helpful for students and teachers to link the projects with the DOE science standards that students were learning.

The interviews with teachers confirmed the idea that the lectures may have been too long, dense, or both, and may have turned off some students. There seemed to be general agreement that the learning environment provided by the IF was powerful and valuable. Suggestions were made to start IF sessions with activities; limit lecture time; make clearer how toys help the elderly and disabled; allow more time for brainstorming and toy building; cover the basics, for instance, on circuits; and relate the program to state standards.

Although we did not directly measure learning, students who completed the program felt they were learning. They were also generally satisfied with the learning environment. With the possible exception regarding instruction, we concluded the IF was maintaining interest and probably producing learning.

We want to be very cautious about our interpretation of student sentiment regarding the lectures they received. Only one item measured student feelings about the instructor's lessons (#9). Because the mean on this item was the smallest on the questionnaire, we think it necessary to draw attention to it. However, a mean of 2.7 on a 4-point scale is still above the midpoint of 2.5. Similarly, half (51%) of students gave positive responses. Having registered this caveat about the student data, it should be noted that teachers expressed reservations about the lectures. Not that they weren't valuable, but that they might have been overextended. So, in the interest of possible program improvement, we want to draw attention to this matter, but, in the interest of being accurate, we don't want our suggestion about instruction to be over-interpreted.

Conclusion

Raising student interest in STEM education and careers via a voluntary afterschool program may be a much longer-term proposition than anticipated. Currently, it appears that the program mainly attracts those students who already have high interest in STEM. The validity of the conclusion that there was no statistically relevant change is hampered by the inherent weakness of the pretest-posttest design. Because an equivalent comparison group was not used to calibrate the amount and direction of change typical for students like these, an accurate gauge of the direction and magnitude of change for such a group was lacking. Consequently, attribution of change—or lack thereof—to the influence of the IF is tentative.

Nevertheless, if the results are valid—that is, if the Invention Factory had no effect on improving participants' attitudes toward STEM it was not due to students' lack of interest for or appreciation of the program. By all accounts, the program was valued by those who completed it. It is possible ceiling effects on the pretest prevented posttest increases. As the program matures, the evidence collected for evaluation questions 1–4 will include measures of intended outcomes more direct than those used in 2005–2006, such as STEM courses taken in school and learning acquired from the IF.

Based on the sample of 132 participants with valid ID numbers, the IF enrollment effort was most successful in targeting those from lower-income areas, and also garnered some participation from girls and Native Hawaiians. One-third of participants were girls, one in six were Native Hawaiian, and half were from geographic areas with higher than average concentrations of children in poverty. Additionally, IF records showed that 3 participants of the 132 identified themselves as having a disability.

Half of the 132 participants were enrolled in the IF through voluntary, after-school programs and were split between high school and middle school students. Not unexpectedly, participants from the two groups that were conducted in class and those who were part of the home-school group comprised the majority of participants whose attendance remained high. Participants of in-class groups did not have the option of skipping the class or dropping out. Parental involvement in the home-schooled group also made it less likely that students would discontinue attendance. Therefore, the demographics of the retained participants largely reflected these groups.

It should be noted that, although their numbers were low relative to males and non-Hawaiians, participating Native Hawaiians and girls were no more likely than other groups to drop out of the program. It makes sense, then, that if these groups are recruited in larger numbers than they have been, they are likely to maintain their levels of representation in the program.

According to program participants, the IF was successfully producing student learning and reaching participants with information on engineering, inventing, and how to help disabled and elderly people. Some items related to maintaining students' interest (interest in IF activities, IF activities are fun, put effort into IF activities) ranked slightly lower. The highest and lowest rated items point to two main components of the program: hands-on activities and instructor's lessons (i.e. lectures). These ratings provide empirical evidence of what some supervising teachers and IF staff had supposed about students' learning styles and experience in the IF. The program's strength was engaging participants in hands-on activities, while the instructor's lessons were less successful in maintaining students' interest.

Based on these results, the IF is considering ways to increase the number of girls, Native Hawaiians, and those from lower-income backgrounds among program participants who complete the curriculum by increasing their proportion in those initially contacted. The IF is reviewing the thoughts and suggestions for improving recruitment and retention made by the recruitment manager and collaborating teachers. Finally, the IF recognizes that the program goal of improving students' interests, confidence, and career choice in STEM may require attracting more students to the program who have no or low pre-existing interest in STEM.

The IF has already implemented two modifications based on the feedback obtained through this review. The IF was prompted to reconsider the length, content, and placement of lecture components. As a result, the IF has actually virtually eliminated all lecture format delivery of instruction to the students and streamlined its workshop presentations into entirely hands-on instruction. In addition, beginning in February 2007, the students now have the opportunity to participate in the delivery and presentation of the modified toys to the disabled children who receive them. Anecdotally, both the hands-on instruction style and the opportunity to meet the actual users of the products of their work have resulted in increased engagement and investment in the IF project for the participating students. In fact, the attrition rate between Fall 2006 and Spring 2007 dropped to zero: every student wanted to continue participating.

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