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Program Evaluation • Consultation • Market Research

Internet Community of Design Engineers (iCODE) Final Evaluation Report

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EXECUTIVE SUMMARY

Internet Community of Design Engineers (iCODE) program, which took an innovative approach to structuring self-directed learning – using a collaborative on-line environment to facilitate hands-on activities, was a three year program led by the University of Massachusetts Lowell and Machine Science Inc., Cambridge. The overall objective of this program, which involved after-school and summer sessions and was funded by NSF's Innovative Technology Experiences for Students and Teachers (ITEST) Program, was to increase the likelihood that participating middle school and high school students will pursue Information Technology (IT) and Science-Technology-Engineering-Math (STEM) careers, by engaging them in intensive, hands-on IT learning experiences.

Goodman Research Group, Inc. (GRG), a research firm in Cambridge, MA that specializes in the evaluation of educational programs and materials, conducted the external process and summative evaluation of the iCODE project. GRG's evaluation involved collecting data over the three years of the program. During each year of the program, GRG collected data from various sources to examine iCODE implementation and to relate program processes to outcomes. These data collection procedures included pre and post surveys, focus groups, and content quizzes for students, interviews and surveys of educators, and site observations conducted by GRG researchers.

KEY FINDINGS

Overall, the iCODE program successfully met the ITEST project goals.

iCODE program successfully met all the requirements of ITSET project goals (based on ITEST Program Solicitation NSF 07-514) mentioned below.

- Programs should aim at middle- and high-school students, particularly those from disadvantaged urban and rural communities.
- Programs should provide year-round IT enrichment experiences and opportunities through curriculum models for use in after school, weekend, and/or summer settings.
- Programs should include hands-on, inquiry-based activities.

Students showed substantial gains in engineering process and workforce skills.

- The specific projects created both during the school year and at the summer camps greatly increased student understanding of computer programming and electronic devices.
- The program offered students ample opportunities to exercise and practice their teamwork, problem solving, and creativity skills.

Students learned about STEM-related careers

- Student ratings indicated that the second year of iCODE was successful at increasing the students' knowledge about careers in science, engineering, and technology. During the third year, the students perceived a significant increase in their knowledge about preparations required for a career in Information Technology.

Students entered iCODE with positive attitudes toward STEM subjects and these attitudes were maintained through the program.

- The students did not show increase in their ratings about their attitudes toward STEM subjects on the pre-post surveys during the three years. Students started the program with positive attitudes towards STEM and these attitudes were maintained every year.

Overall, the iCODE project had high appeal among the students and educators.

- The iCODE students greatly enjoyed the unique hands-on experiences while working on their computer-based projects.

- The educators enjoyed learning engineering concepts themselves and watching students get excited throughout the program as they completed their projects.

Hands on activities, outside the classroom events, and teamwork components of the program held high appeal.

- Throughout the three years, students enjoyed working directly with the technology.

- The online guides, hands-on projects, the collaboration among students, as well as with the mentor, were the most successful aspects of the program.

- The summer camps, because of their intensive nature, were highly successful at achieving the program's student learning goals.

- The events occurring outside of iCODE sessions, such as Robot Sumo competition, also received a high appeal.

The mentors played significant roles in the iCODE program

- A component of the program that was considered highly successful by both the students and the educators was the role of the undergraduate mentor. During the third year, two schools had veteran iCODE students function as mentors for the newer students.

- The undergraduate mentors played various roles from teaching the actual iCODE content to the students to troubleshooting with hands-on projects. They were capable of challenging students depending on their capabilities and providing programming expertise to the educators.

Implementation of the program occurred, for most part, according to the proposed plan.

- Starting with 5 sites in Year 1, the iCODE after-school program involved up to 14 sites through the three years, wherein it served closed to 300 students. Successful one and two-week summer-camps ran in two locations each summer.

- The program had a high retention rate from after school program to summer program every year.

- The program retained some students and most of its educators across multiple years.

- Each year, the program was highly successful at attracting students from diverse racial backgrounds.

- Training sessions, which allowed the educators to practice the hands-on aspects of the program themselves, were held every year.

The most successful year of the program in terms of student gains was year 2.

The second year was the most successful year in the program for various reasons:

- During the second year, the students showed most gains in their knowledge about STEM careers.

- Also, only during the second year, the program appeared to have contributed to an increase in positive attitudes of the female students toward STEM and IT subjects and careers.

- Finally, student performance on the programming quizzes was better during the second year than the third year.

RECOMMENDATIONS

Throughout the iCODE program, GRG's annual evaluation reports offered specific recommendations for improving program process and outcomes for the following years. Given that the program is drawing to a close, we offer the following broad lessons learned in consideration of any future iterations or replications of the program.

- Continue to incorporate the successful role of a mentor into future programs. Increase the accessibility of the mentors by making their services available through student or educator online modules.

- Make newer learning challenges available to returning students in the program to sustain their interest and motivation in the program.

- Increase measures to encourage females into the program through strategies such as making the projects female-friendly and using female mentors/role models in promoting the program.

- Take the educator training beyond what the students will learn so that the educators will be better equipped to answer student questions and address any programming difficulties.

- To provide new educators scaffolding throughout the program year, include resources such as an online educational module or a Facebook page where educators can discuss issues and implementation strategies.

- Extend the community building aspect of the program to include more outside-the-school-walls experiences for the students, such as guest lectures and field trips.

- Encourage parent involvement in the program through take-home activities that require parental feedback, like technology questionnaires and interactive games.

- Work with the school authorities and/or the educators to help avoid technical difficulties such as issues with the Internet, network, or computers. An expert could be assigned at the beginning of the program with the task of setting up the computer and internet systems at the program sites.

In summary, the iCODE program can serve as a model for other ITEST initiatives that feature programmatic efforts to make hands-on, inquiry-based engineering and programming experiences available to underrepresented groups in the middle and high schools.

INTRODUCTION

Building an Internet Community of Design Engineers (iCODE) was a project of the National Science Foundation Innovative Technology Experiences for Students and Teachers (ITEST) program. The ITEST program began in 2003 and the iCODE project, funded in 2006, was among the fourth cohort of funded projects. The overarching aim of ITEST is to strengthen the STEM workforce. iCODE was one of more than 135 ITEST projects nationwide and was among the 29% of ITEST projects with a primary focus on engineering.

The project was a university-non-profit collaboration between the University of Massachusetts Lowell (UML) and Machine Science, Inc. The UML team represented the departments of Computer Science and Science Education and the UML Future Engineers Center, a provider of informal K-12 science and engineering education programs.

Machine Science, a Cambridge-based non-profit organization, is also a provider of informal engineering programs through the use of project/curriculum kits, on-line resources, and educator professional development and support (via workshops and undergraduate and graduate student mentors).

iCODE's primary target audience was middle and high school students from geographic areas around the collaborating institutions in Lowell and Boston, with program instructors (afterschool educators) as a secondary audience. Although the Machine Science (MS) and the UML's Tech Creation (TC) program followed different curricula, the core concepts such as electric circuits and programming were common to both. The three program goals were to:

1. enhance participating students' technology fluency;

2. increase their awareness of IT and STEM educational and career opportunities; and

3. connect them to a community of like-minded peers and adults.

iCODE featured four key components:

1. a weekly after-school program, modeled on Machine Science's existing programs and using resources from UML's existing DESIGNLAB program in the Future Engineers Center;

2. two annual career events;

3. an annual exhibition/competition, building off of UML's and Machine Science's existing Botfest and Robot Sumo events, respectively; and

4. an annual summer camp, modeled on UML's existing DESIGNCAMP program, also in the Future Engineers Center.

In addition, the project offered an annual training for program instructors.

EXTERNAL EVALUATION

Goodman Research Group, Inc. (GRG), a firm specializing in the evaluation of educational programs, materials, and services, conducted the external formative and summative evaluation of the iCODE project. GRG collected data over the three years of the project from multiple sources: youth participants and afterschool educators at participating organizations.

The purpose of GRG's evaluation was to provide a comprehensive formative assessment of project processes and a summative assessment of project outcomes. GRG evaluated the implementation of the program at the classroom (group) level and outcomes at the individual (student) level.

Formative Evaluation

The formative evaluation of iCODE focused on project processes. Each year, GRG examined how the project implementation proceeded and the extent to which the project was implemented as planned.

Formative evaluation research questions included:

1. How was the project implemented across various sites in Boston and Lowell, and what modifications were made to the planned activities?

2. What successes and challenges were experienced regarding site recruitment and retention? What proportions of recruited students were from racial minority groups and/or from low-income households? What proportion of sites and/or students continued for a second and third year of participation?

3. To what extent did educators perceive the iCODE materials and delivery system to be effective and high quality? How can the materials and delivery system be improved?

4. What project components were perceived by educators and participants as most and least effective?

5. What lessons were learned to improve and/or streamline project implementation?

Summative Evaluation

The goal of the summative evaluation was to assess the influence of the project on participating students' IT attitudes, career aspirations, and skills. Summative evaluation research questions were:

1. To what extent did participation in iCODE change participating students' engineering and programming skills and workforce skills (e.g., teamwork, problem solving)?

2. To what project components did students and educators primarily attribute gains in skill?

3. How effective were the in-person visits and on-line resources in increasing participants' awareness of educational and career opportunities in IT and STEM?

4. To what extent did participants' attitudes about STEM subjects and their aspirations for future IT educational and career endeavors change as a result of program involvement?

5. To what extent did students feel connected to a larger IT community, through project involvement? How effective were in-person interactions with undergraduate mentors, Internet-based interactions with industry mentors, and the use of a national invention database for developing this sense of community?

6. What were the perceptions about the project's success among educators and mentors? What were their perceptions about student gains?

METHODS

Over the three years program, multiple data collection instruments were used to collect implementation, appeal, and outcomes data. All of these protocols were approved by the Institutional Review Board of the University of Massachusetts Lowell. Table 1 provides the overall data collection activities and schedule. Each data collection instrument is then described in detail.

Table 1
Data Collection Activities carried out by GRG over the Three Year Project

	Year 1 (2006-2007)	**Year 2 (2007-2008)**	**Year 3 (2008-2009)**
Winter /Fall	Student pre-survey	Student pre-survey	Student pre-survey
Spring	Student post-survey	Student post-survey	Student post-survey
	Site visits	Site visits	Site visits
		Online quizzes	Online quizzes
Summer	Student survey	Student survey	Student survey
	Student journals	Site visits	Site visits
	Site visits	Educator survey	Educator survey
	Educator survey		

STUDENT PRE-POST SURVEYS

Students completed pre-surveys at the beginning of the spring semester in early January 2007 and at the beginning of each school year for the following two years (September 2008 and September 2009). Post surveys were completed at the end of each school year in May 2007, 2008, and 2009 (See Appendices A and B). These surveys focused on the student's attitudes towards STEM courses and careers, their educational and career aspirations, and their feelings of connectedness to a larger STEM community.

Closed- and open-ended questions included in the surveys addressed the following areas:

- Background and demographic information (*pre-survey only*)
- IT and STEM attitudes
- Education and career plans
- Awareness of IT tools
- Program-related information (*post-surveys only*).

STUDENT SUMMER JOURNALS

For the first year, GRG developed reflection questions to be administered to participating students during the summer camp (See Appendix C). Educators administered these questions to students at appropriate intervals during the summer camp (i.e., timed to correspond to the summer camp activities and content). These questions focused on the processes underlying the building projects that the students undertook during the camp, processes such as conceptualizing problems that require solutions; designing, building, and testing solutions; and working in teams. The students answered these questions periodically during the summer camps. They used diagrams and figures along with text to answer the questions. A rubric, to score the student answers to the reflection questions, was also developed (See Appendix D).

The journals were piloted during the first summer of the program. However, following discussions between GRG and program developers, it was jointly decided that the journals would be replaced by a quantitative assessment. Hence online quizzes were administered to the students in the later two years of the program.

ONLINE CONTENT QUIZZES

In the second year of the project, the iCODE collaborators developed online content quizzes for the students. Three such quizzes, each with an increasing level of difficulty, were taken by the students during the academic year and the summer. The basic premise was to develop a scheme whereby students will understand the progression of knowledge and skills-based competence as they progress in the iCODE program. The core concepts common to both MS and TC programs, such as electric circuits and programming, were assessed by the quizzes. The students took the quizzes during both the second and the third year. For an example of a quiz see Appendix E.

SUMMER CAMP STUDENT SURVEYS

A one-page (front and back) survey was administered to the students at the end of the summer camp (See Appendices F and G). The questions on this survey focused on student experiences and student learning during the camp. These were collected in all three years of the program. All students enrolled in the summer camps, regardless of whether they were involved during the academic year, took the summer survey.

END-OF-YEAR SURVEY OF ICODE EDUCATORS

At the end of the summer camp, the educators completed surveys that assessed program implementation to date (See Appendix H). These surveys collected basic information regarding the number of students involved, the extent and duration of their participation, the type of activities conducted, and the collaborative and applied nature of their activities. Educators' feedback about program implementation, including challenges they encountered and suggestions for modifications, was also collected in order to inform on-going program improvements. Specific feedback about the iCODE materials and delivery system was collected, in addition to feedback on how well the translation of these materials into hands-on projects worked for their students. Finally, educator surveys included assessment of their perception of student gains.

SITE VISITS

GRG evaluators conducted site visits to multiple program sites in Boston and in Lowell during all three iCODE years. The key purpose of these site visits was to address more comprehensively the process goals of the evaluation and to see the curriculum "in action." The following tools and methods were used to collect data during the site visits:

- An observation protocol to document youth behavior and task engagement during iCODE participation (See Appendix I);
- A group interview with the youth focusing on questions about the real-world relevance of the activities, and student engagement with the materials (See Appendix J); and
- An educator interview to learn how the observed sessions resembled or differed from prior sessions, and to discuss in more detail the effectiveness of program components and features for their particular group of youth (See Appendix K).

In Year 2, a Teaching Assistant from the UMass Lowell Graduate School of Education observed 12 sessions at the TC and MS sites and used the observation protocol developed by GRG to record her observations.

Along with these visits during the school year, GRG researchers also visited the summer camp organized by the Machine Science and Tech Creation during their summer camps. Some examples of projects observed during these visits over the three years are rocket launches, text message machines, LED artwork and various robots. Table 2 indicates the number of site visits conducted by the GRG researchers over the three years.

Table 2
Site Visits Conducted over the Three Years

Year	**School Year Visits**		**Summer Visits**	
	Machine Science	Tech Creation	Machine Science	Tech Creation
Year 1	1 visit	1 visit	1 visit	1 visit
Year 2	6 visits	14 visits	1 visit	1 visit
Year 3	2 visits	2 visits	1 visit	1 visit

RESULTS

The results are organized by formative and summative evaluation and draw on all the data sources.

FORMATIVE EVALUATION

The following paragraph outlines the ITEST project goals in Program Solicitation NSF 07-514[1]:

"The goal of ITEST youth-based programming is to provide middle- and high-school students, particularly those from disadvantaged urban and rural communities, access to year-round IT enrichment experiences and opportunities to explore related education and career pathways. Projects should create high-quality learning strategies and curriculum models for use in after school, weekend, and/or summer settings. Youth-based projects should include hands-on, inquiry-based activities with a strong emphasis on non-traditional approaches to learning and the intensive use of information technologies."

The iCODE program successfully met the ITEST project goals, the division of NSF, under which it is funded, as outlined in Program Solicitation NSF 07-514

Overall, the iCODE program successfully met these ITEST project goals. The following section provides detailed information about the implementation of the program, organized by the formative research questions.

[1] See http://www.nsf.gov/pubs/2007/nsf07514/nsf07514.htm#pgm_desc_txt

Program Implementation

Highlights of Program Implementation

- The implementation of the iCODE program went according to the original plan. The two program collaborators developed parallel curricula using the iCODE programming system, Tech Creation (TC) for grades 6-8 and Machine Science (MS) for grades 7-12.

- Both the school-year and summer camp components of the program grew in terms of the number of sites and students involved during each of the three years, as planned.

- Students used the iCODE system to create a range of projects, including a variety of robotic creatures, electronic games, and tools such as stopwatches.

- The educator training was successful in equipping the instructors with sufficient knowledge of the iCODE design process and tools to assist students. For the new educators, more intensive training would have helped them feel greater content mastery as well as reducing their need for scaffolding and assistance throughout the year.

The two program collaborators – UMass Lowell and Machine Science – developed different projects under the larger umbrella project of iCODE. The curriculum developed by UMass Lowell, called Tech Creation (TC), catered to middle school students (grades 6-8), whereas the curriculum developed by Machine Science (MS) catered to high school youth (grades 7-12). Both curricula, although developed for different age-groups, were based on the iCODE system, an online system that provided a way to program educational and hobby microcontrollers. It included project tutorials, space to showcase completed projects, and forums for communicating with other users.

The actual projects created by the students of TC and MS differed based on their curricula. Machine Science's projects are based on breadboard-based XBoard technology, which involved physically wiring components to a PIC microcontroller and programming the chip in C. TC's projects are based on Super Cricket microcontroller, a printed circuit board controller programmed in Logo (See figure 1 below). Examples of some of the projects created over the three years are included in Table 3.

Figure 1
Super Cricket (left) and Machine Science breadboard kit (right).

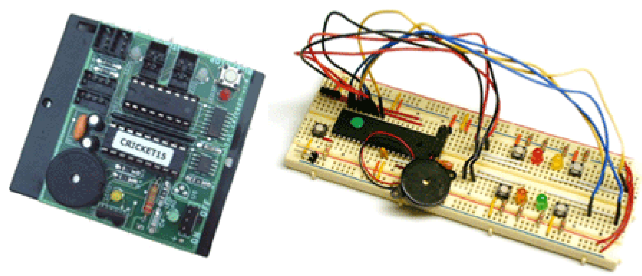


Table 3
Examples of Projects Created by Students over the Three Years

TC projects **http://techcreation.cs.uml.edu/icode/**	**MS projects** **http://guides.machinescience.org/course/view.php?id=29**
Electronic Frisbee	Digital stopwatch
Halloween project	Remote control robot
Robotic bug	Sumo robot
Fortune teller	Water rocket
Arcade game	Electronic games
Food factory	

The program grew from six sites during Year 1 to 12 sites in Year 3 as planned (See Table 4). Four of the sites were retained across all three years of the program and newer sites were added each Year. Overall, the program served a total of 14 unique sites. Table 5 describes these 14 sites.

Table 4
Growth of iCODE Sites across the Three Years of the Program

	Year 1	**Year 2**	**Year 3**
Total sites	6	11	12
MS sites (Boston)	4	6	5
TC sites (Lowell)	2	5	7
	The program began at 5 sites as planned, but one MS site had to be replaced (because of medical reasons on part of the educator)	Some sites overlapped between Years 1 and 2.	Some sites overlapped between Years 1, 2, and 3.

iCODE program:

2 curricula

3 years

14 sites

294 students!

Table 5
Description of the 14 Program Sites Over the Three Years

	Number out of 14
Schools	8
Girls only schools	1
Charter schools	2
Co-ed after school programs	2
Girls-only after school programs	1

Participation in the iCODE program required the students to apply for the program. Teachers were also asked to nominate students. Teachers typically chose students who they believed would gain from being in the program (e.g., students that were not being fully challenged by regular school) and who could make the commitment.

Summer camps were held every year through the MS and TC projects. The total number of students attending the summer camps, as well as the number of summer camps offered, differed each year (See Table 6). Student participation grew from a total of 22 in Year 1's summer camp to 49 in Year 3's camp. When a student signed up for the iCODE program, he or she would also commit to the summer program. Hence, most of the summer camp students every year also had attended the after-school program.

Table 6
Number of Students Attending the Summer Camps through the Two Programs

	Year 1		**Year 2**		**Year 3**	
	MS	TC	MS	TC	MS	TC
Total number of students in summer camp	11	11	13	38	7	42
Total number of camp sessions	1	1	1	3	1	3

Each iCODE site was staffed with an iCODE educator. Educators involved in iCODE were generally secondary school science/engineering teachers or had some science/engineering background. Often times, in addition to the educator, a mentor would be present during the sessions. These mentors were typically undergraduate and graduate students in fields of engineering at UML. On rare occasion, a veteran iCODE student served as mentor to the new students.

Training of the educators

At the beginning of each year, both MS and TC conducted separate training sessions with the iCODE educators. The training sessions gave the educators general background about the content in the program and set the context for educators to learn as they went along.

"Since my experience in engineering is limited, I would like help with ways to teach my students more about the field, and to challenge them more deeply with the engineering skills involved with the projects."

An iCODE educator

The training sessions followed a workshop pattern, in which the educators read over the online iCODE materials and tinkered with the coding to try to find problems that the students might encounter. During training, they had opportunities to go through the sessions the exact same way that the students would do so during the program. The practical aspect of the training gave the educators the necessary knowledge about the design process and the other tools such as the online modules, which were an integral part of iCODE program.

The technical assistance provided by the iCODE collaborators through the training was especially beneficial to the new educators each year. The new educators, in spite of the training, found the content of iCODE difficult to teach and needed constant assistance and scaffolding throughout the year. In the words of a new educator in Year 3, *"I'd never really heard of it [the iCODE content] until I first came here, I didn't know how it worked, so as the kids were learning I was trying to learn with them, and that was tough because those kids need help, and I barely understand it myself, so I really wasn't able to help them too much."*

Site and Student Recruitment and Retention

Successes in Recruitment and Retention

- The iCODE program reached 284 students over the course of the three years, which is beyond the target number of 250 students projected in the original proposal.

- The program retained large numbers of students from the after-school program to the summer camp program every year, indicating that the hands-on activities and competitive nature of the iCODE program were engaging for students.

- The program succeeded in retaining some students and most of its educators across multiple years. Some 22% of the students in Year 2 and 15% of the students in Year 3 were "veterans," and more than half of the educators were involved with the program for more than one year.

- The program was very successful in reaching students from racially diverse groups: Approximately three-quarters described themselves as Black or African American, Spanish/Hispanic or Latino, Asian, and/or American Indian or Alaska Native.

The project collaborators had projected to serve a total of 250 students during the three years (50 during Year 1 and 100 each during Year 2). Table 7 indicates the total number of students enrolled in at least some part of the iCODE program over the three years. Some students returned for a second year of the program. In all, five students participated in the program for all three years. A number of educators (8 out of the 14) also worked for multiple years on the project.

Table 7
Changes in the Number of Students through the Years

Number of students across all sites who …	**Total number**		
	Year 1	**Year 2**	**Year 3**
… attended some part of the program	69	110	152
…who completed both pre and post surveys	27	25-45	26-61
…were returning students	--	24	23

Most of the students involved in the year-long after school program continued with the summer program every year. This indicated that, overall, the students enjoyed the program, as they were not required to attend. The educators reported that the unique nature of the hands-on activities of the iCODE program and its competitive nature allowed for the students to remain excited about their projects. As mentioned earlier, the teachers recruited those students they thought would benefit from participation in the program. Thus, additionally, this recruitment process could have also ensured that the students were a dedicated group.

The iCODE program successfully reached the target population of racially diverse students.

The iCODE program was highly successful at achieving its target of reaching students from racially diverse groups. As Table 8 indicates, across all three years only between 22%- 26% of the students reported their race as White; all others categorized themselves as belonging to some other racial or ethnic group.

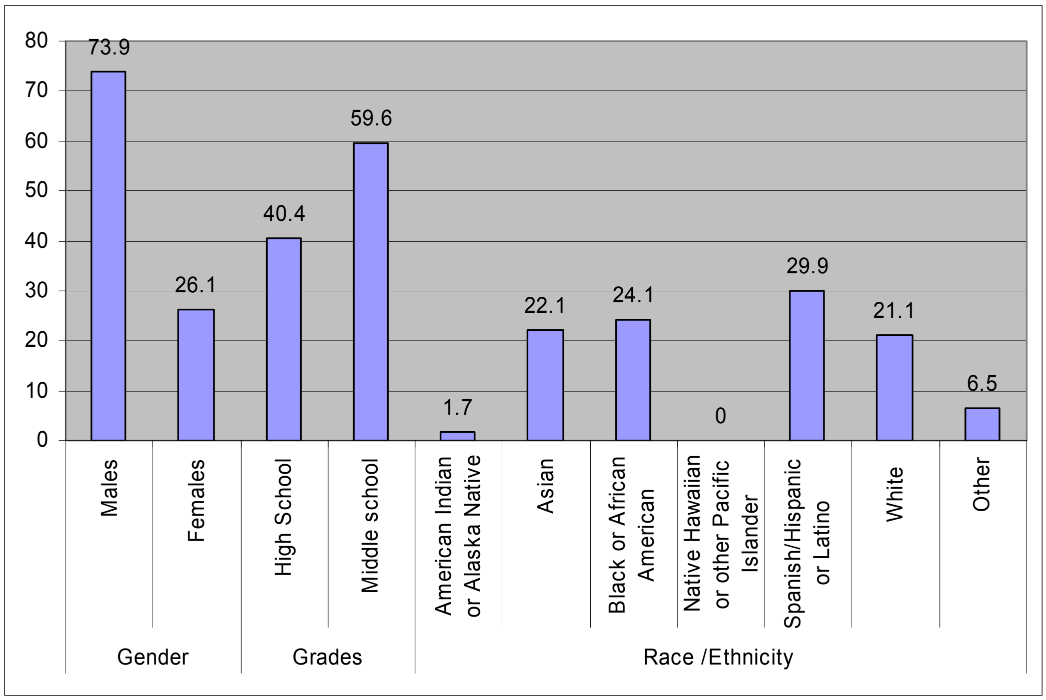
Table 8
Demographic Characteristics of the Students Across the Three Years

		Percentages		
		Year 1	Year 2	Year 3
Gender	Females	32%	18%	21%
	Males	68%	82%	79%
Grade level	6th	6%	2%	7%
	7th	27%	35%	37%
	8th	12%	13%	23%
	9th	17%	10%	10%
	10th	25%	14%	3%
	11th	8%	19%	0
	12th	6%	8%	11%
Ethnic and racial background	American Indian or Alaska Native	3%	2%	0
	Asian	19%	20%	25%
	Black or African American	35%	23%	24%
	Native Hawaiian or Other Pacific Islander	0	0	0
	Spanish/Hispanic or Latino	19%	31%	37%
	White	26%	26%	22%
	Other	8%	7%	6%

*N varies from 69 - 152
*Percentages may not add to 100% because of rounding and multiple responses.

Figure 2, which provides a graphical presentation of the demographic characteristics of the all the students across the three years, also indicates that the program was successful at attracting students from diverse racial backgrounds. Overall, the percentages of Whites, African American, Asian, and Hispanic students were in close vicinity of one another.

Figure 2: Graphical Representation of Demographic Characteristics of the Students Across the Three Years.



Challenges in Recruitment and Retention:

- The iCODE program experienced stiff competition from other after school activities. This was true throughout the year and especially toward the end of the school year.

- Sustaining the interest of the students, especially that of the returning students – was a difficult because these veterans felt the activities were a repeat from the previous year.

Throughout the three years, girls constituted only about a fifth to a third of the group; recruiting larger numbers of female program participants proved to be a continuing challenge.

During the interviews over the years, the iCODE educators addressed the topics of student recruitment and retention. Although the educators felt that recruitment and retention in the program were generally successful, they also brought up certain challenges. According to the educators, because iCODE was an after school program, it was in competition with other extracurricular activities, such as sports. Some students who were involved in sports dropped out of the program, missed many sessions, or arrived late after their sports practice.

One strategy that helped a school to tackle these issues was that, during the second year, it held sessions during the school day so that students could attend iCODE more consistently. Another strategy implemented by UMass was to over-recruit during the third year, so that even with attrition they ended with the expected number of students at the end of year.

Another issue was sustaining the interest in the program toward the end of the school year. Since the program only met once a week and because there were school vacations, it was hard to maintain the interest of the students toward the end of the program. The students were also always facing competing demands in terms of extra-curricular activities.

Sustaining interest of the returning students was also a challenge. Discussions with educators and with students indicated that returning students were often working on projects similar to the ones that they had worked on during the earlier years. This would lead them to believe that they were not learning anything new during the subsequent years and would result in lack of motivation to some extent.

In terms of the gender breakdown, many more males were enrolled in the program than females during each of the three years (Refer back to Table 8). The highest percentage of female recruit was during the first year. Overall, the gender ratio was approximately three males to one female (Refer back to Figure 1). This gender ratio is slightly lower than the current gender divide in science and engineering occupations, which is two males to one female.[2]

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[2] SOURCES:
National Science Foundation, Division of Science Resources Statistics, Scientist and Engineers Statistical Data System (SESTAT): http://www.nsf.gov/statistics/wmpd/
Engineering Conferences International Presentation Abstract:
http://www.engconfintl.org/8axabstracts/Session%201A/rees08_submission_91.pdf

Educator Perceptions of iCODE and Suggestions for Improvement

Highlights of Educator Perceptions and Suggestions

- The educators rated the online iCODE materials as of high quality and extremely helpful in implementing the program; at most, they made only minor changes in using the material.
- In response to student feedback, iCODE staff were able to successfully enhance the navigability and user-friendliness of the online modules for students in successive years of the program.
- One improvement suggested by students was to have more materials and supplies readily available to be used in projects. This perceived shortage may have been at least partially due to over-recruitment to the TC project during Year 3.

Throughout the three years, the educators made extensive use of the online iCODE materials. These materials included online modules with elaborate instructions for successful completion of each project. Each module included information about programming, graphical representation of supplies used etc.

Qualitative data collected by GRG over the three years indicated that the educators were extremely satisfied with the online materials and found them to be of high quality and extremely helpful in implementing the iCODE program. The educators needed to make only minor changes while using these materials. The novice teachers tended to use the materials as they were presented. As the educators taught for more than one year, their use of the materials differed from the new teachers. The veteran teachers were able to adapt their teaching style. For example, they made certain additions, such as worksheets, to help scaffold the student's learning when needed.

"The online guides allow the students to be very independent (learn without a teacher), and also encourage them to work with their peers."

-an iCODE educator

During the first year, students had expressed difficulty in navigating through the online modules and wanted the modules to be more user-friendly. These students had indicated that although the online modules were helpful, finding what they needed through these modules was hard. The iCODE staff responded to this criticism by simplifying the modules during the second year. As a result, students reacted more positively to online tools in the later years of the program.

Students also requested ready availability of more supplies from year one to year two. In Year 3, this trend continued and students, once again, mentioned the need for more supplies for their projects. However, knowing that the TC project had over-recruited during the third year, it is difficult to say whether this was due to the increase in demand or because the materials were really low in quantity.

"The iCODE program is a total package of designing, building, coding, testing, documenting, and assessment.

This approach is very effective in accomplishing the program objectives."

-an iCODE educator

Most and Least Successful Program Components

- The hand-on-activities, the gradual progression in the complexity of the projects, the opportunities for individual as well as collaborative work, and events such as Robot Sumo were highly appreciated by the students and educators.
- Students did not get as much exposure to the larger engineering community as was originally planned. Future iterations of the program should be more consistent in building in field trips where students can observe real-world applications of IT and STEM and guest engineers to visit the program to speak with students and perhaps even work on projects with them.
- Parental involvement in the program was limited to attendance at iCODE events such as the BotFest, the Robot Sumo competition, and the Summer Workshop Design Show. The issue of parental involvement should be revisited to determine how it could be enhanced.

"Students working collaboratively to solve problems in a social setting, which is not done frequently in academic coursework."

-an iCODE educator indicating the one of the effective components of the iCODE program

Based on discussions with educators and students, GRG identified specific components that were the most effective over the entire period of the program. These components were:

- Hands-on activities – A common theme throughout the three years of the iCODE program was the high appeal among the students of the hands-on aspect of the various projects. The students enjoyed working on the projects and experiencing success with a project. The projects gave them an opportunity to be creative within the structured program curriculum.
- Structure of the program – The iCODE program each year began with basic modules the students were expected to duplicate and gradually built up to open ended projects, in which the students were then expected to apply their knowledge from the previous modules. The educators were satisfied with this structure of the program, which involved gradual progression. The reflective processes, that the educators were encouraged to involve the students in, enhanced the quality of the iCODE experience. The students were often asked to communicate and document their work, leading to an increase in student engagement.
- A fine balance between autonomy and collaborative work – There was consensus among the educators that online guides allowed the students to be very independent. Students received adequate assistance from the online programming portal to build their projects. During the sessions, the students often built their projects by following instructions from the on-line project guides and by loading codes from the project guides into their projects. The students felt responsible and took ownership for their projects. At the same time, the students had a number of opportunities to

"I liked the fact [that] no matter what we did, it was ours, whether we failed or achieved, it was what we did, there was no handholder or anything, aside from the basic explanation, so it was kind of being your own boss and getting what you wanted to get done."

-an iCODE student talking about the projects

work in small or large groups and with the mentors, leading to community building among students and the mentors.

- Practical experiences – The participation in events such as the BotFest and the Robot Sumo competition, which signified the evolution of students' hands-on projects, were important aspects of the program, according to the educators. The summer session, being more intensive, increased the students' engineering knowledge and skills to a large extent. Working on goal-oriented projects, whether for the competition or through the summer camps, added immensely to the learning experience of the students.

The original iCODE proposal included community building for the students as an important goal. The program developers planned to achieve this goal by offering the students opportunities to interact with professionals in the engineering fields and observing real-world applications of IT and STEM. During the first year, this goal was not achieved. Therefore, GRG recommended at the end of the first program year that iCODE expose students to the larger engineering community through planned field trips to places such as engineering colleges and computer or electronics companies. GRG also suggested that guest speakers from the engineering community also be invited to address the students. Although this program aspect was rolled out during the second and the third year of the program (e.g. some field trips added to the program), it was not consistent throughout all the sites.

Another aspect of the iCODE program that could have been improved throughout the three years was parental involvement. The educators, during the surveys and interviews, answered questions about parental involvement. The parents tended to be only *minimally* involved in the iCODE student activities. Their involvement was limited to their presence at events such as the BotFest, the Robot Sumo competition, and the Summer Workshop Design Show.

MS Summer Camp session (Year 3)

Students engaged in learning of coding and programming, supported effectively by their teachers, and motivated by the nature of the project – text messaging:

A GRG researcher observed a session during the summer camp at the MS site. Three members of Machine Science staff were present as instructors. There were a total of six male and one female high school students (grades 10-12). The project the students worked on was titled "Text messenger."

There were plenty of computers and space for everyone. Each student had a computer to work on and the other required supplies. There were two projectors and screens at the front of the room for the teacher to post directions and for demonstrations. There was also a white board in the front of the room for the teacher to use for additional visual aids. The technology seemed to be working well and according to plan.

Today was the first day on the new project – text message machines. The educator introduced the code, the instructions, wrote up on the white-board, and talked through some of the website content. Then, the students went to work on their own, going through the instructions with the machines. During this time, both the MS staff members went around the room multiple times helping students and doing individualized instruction.

The educator had a very gentle and supportive approach with the students. She seemed to encourage the students to figure out their own problems by doing a combination of asking scaffolding questions and explaining new concepts.

The students were at the computers with their machines, writing the code and trying it out. They mostly used the directions on the Machine Science website, although they also got assistance from the instructors. They were learning about how phones use codes to translate numbers into letters to do text messaging. Later that day, they were going to learn to add a radio frequency component to the machines and try sending texts to each other.

The students were very engaged and focused on learning the code and programming their text messengers.

TC Summer Camp Session (Year 3)

A focused group of mostly girls bringing their creativity and imagination into their engineering projects to make hi-tech accessories:

A GRG researcher observed a TC summer camp session for about an hour. The students consisted of nine young women and three young men, all from the 9th grade. An educator and an undergrad mentor were present to instruct the students. The students worked on their own projects, all approved by the educator earlier in the week. Projects included: lamps with LED lights, night-lights, picture frames with etched Plexiglas and lights, purses and t-shirts – all with lights.

The students had brand new computers, as well as a lot of supplies from which to choose that the educator had collected and saved over the years. There was some structure to the session, but for most part the teacher gave them a lot of flexibility, which the girls really seemed to appreciate.

During this lesson, the educator was mostly observing and helping one-on-one when needed. The educator explained to the GRG researcher that the first day (Monday), she had the students try to make a light-up t-shirt without much instruction, which had turned out to be a struggle. After that day, the girls learned the value of making a design plan and using it to progress step by step through a project. Tuesday, they researched and developed plans for their projects and the educator approved them each individually. Wednesday, they started working on putting the projects together. Thursday (day of the observation) they were all a few steps into their project, revising their design plans as needed.

The GRG researcher observed that the girls were busy doing tasks such as wiring lights, wiring their project items, creating the structure for their projects, testing lights, programming their lights. They seemed to be enjoying the program and the fact that they got to choose their project and make it personal. They also got to take home whatever they made, which seemed to have a positive influence on their progress and enthusiasm for doing and finishing the projects.

Lessons Learned

Lessons learned about project implementation:

- With ongoing support around the material, educators could more effectively assist students with their projects; the educators, especially new ones, found the iCODE content to be quite challenging to master.
- Both students and educators would like to see longer sessions or a greater number of sessions each week so that students could spend more time in the most enjoyable aspect of the program, hands-on project work.
- Prior assessment of project sites with regard to their technical capabilities will help reduce future issues with Internet connectivity, networking capabilities, and computer functioning, all of which hamper the students and educators in their project work.
- Increasing the variety and challenge of the iCODE projects will help enhance student retention from year to year by sustaining the interest level of returning students.

The following themes about project implementation were revealed across the three years through interviews that GRG researchers conducted with the educators and the students:

1. **Increasing assistance to the educators.**
   Although the educators involved in iCODE were generally science/engineering teachers or had some science/engineering background, they often lacked specific engineering design and programming expertise. New educators entering the program each year learned these new concepts through the training and on the job. Sometimes their own lack of adequate experience with engineering and design processes made it hard for them to answer some of the students' questions. They sometimes would find it difficult to come up with ideas to challenge the students further.

   A suggestion by educators to improve this situation would be to allow for sharing of knowledge from educator to educator across sites throughout the year. GRG further adds that, in the future, programs could set up an online tool such as a Facebook page where the educators could voice their concerns, difficulties, or challenges faced and learn about suggestions from other participating educators and/or the program staff.

"I enjoyed having the mentor at the program. She was knowledgeable about the projects, and could help troubleshoot when students were having problems. The students felt comfortable asking her questions, and she was very good at explaining the concepts in the project."

-an iCODE educator talking about the mentors

2. **Increasing iCODE program hours.**
During the first two years of the program, both the educators and the students suggested extending the iCODE program hours – either by increasing the duration of each class or the number of meetings per week. This would give the students more time to work on projects, which was the aspect of the program that the students enjoyed the most. Although this could not be changed from year to year during the current program, it can be a possibility for future programs like iCODE. Based on the popularity of the iCODE projects during the current program, future programs like iCODE could have more contact hours built into the proposal itself.

3. **The important role of mentors.**
A recurring theme was the importance of the role of mentors. The educators relied heavily on the undergraduate mentors for providing the intricacies in engineering and design knowledge. Having an undergraduate or graduate mentor during the iCODE sessions helped the educators better communicate the content material with the students. Educators who did not have such a mentor present during their sessions indicated the need for one. Future programs like iCODE should ensure the presence of a student mentor in the program team.

4. **Introducing advanced projects.**
Another theme that was recurrent in GRG's conversations with both the students as well as the educators was the need to add a variety to the projects and increase the difficulty of similar projects for continuing students. As mentioned earlier, to sustain the interest level of the returning students in the program, iCODE needs to advance the projects that the returning students work on in terms of the content and the difficulty level.

5. **Addressing the technical problems.**
During Years 2 and 3, educators and students faced technical problems at some schools. The successful implementation of the program was hampered by recurring problems with internet, network, or computers. Although this was not an issue with iCODE program per se, future programs need to acknowledge that each school comes with its own set of difficulties surrounding the accessibility and availability of technology and these issues need to be handled before the programs commence.

Profiles of the five students who participated in the program for all three years

All five students who participated in the entire three-year program described themselves as African American and were involved in the Machine Science program. Four out of these five were males. Two of these students started the program when they were in the 9th grade, two of them started in the 10th grade, and one student started during the 7th grade.

At the beginning of the program, all five students:

- had not used computers extensively before the beginning of the program,
- began the iCODE program with minimal engineering and/or electronic circuit building experience,
- did not have any part-time jobs, and
- indicated high educational aspirations.

At the end of the program they:

- continued to have high educational aspirations,
- were very likely to take advanced science classes,
- indicated that they gained a lot of science, engineering, and technology career knowledge,
- were extremely interested in careers in engineering and technology,
- rated highly the hands-on projects component of the program, and
- indicated that they would have liked to see newer design challenges every year.

Examples of changes in the students' qualitative answers over the years

Question: What does an engineer do?

Answer on Year 1 pre-survey	Answer on Year 3 post-survey
I think that it depends on what type of engineer you are.	I think engineers solve problems in science and math.
Engineers work in groups, a lot of hands on, to help make the world easy on humans	Engineers make improvement to satisfy the consumers

Question: What kind of work do you expect to be doing when you are 30 years old?

Answer on Year 1 pre-survey	Answer on Year 3 post-survey
Creating video game software	Computer programming
I don't know	Computer programming, mechanical engineering, or electrical engineering.
I don't know	Electrical or mechanical engineer

SUMMATIVE EVALUATION

The summative evaluation results are based mainly on annual pre- and post-program surveys of students. The results describe students' satisfaction with the program and their perceptions of program quality outcomes of their participation.

Data are provided for all students across the two curricula, unless there were differences by curriculum or by gender. Additionally, unless the results differed by year, for students who participated in more than one year, we used the ratings from their very first pre-program survey (pre) and their very last post-program survey (post).

For nominal data, chi-square tests were used to test curricular and gender differences. For ordinal and continuous data, ANOVAs were used to test group differences. Significant differences between the two curricula or between boys and girls are reported when statistically significant at or above the 95% confidence level.

Before providing the results, we review the number of students included in the various types of analyses in this section. The iCODE program served 294 students during the three years. Table 9 provides the breakdown in terms of number of students in the program for a single or multiple years.

Table 9
Student Participation in the NSF ITEST iCODE Program 2006-2009

Participation		**Number of students**
Participated for one year*	2006-2007	40
	2007-2008	88
	2008-2009	131
Participated for two years	2006-2008	12
	2007-2009	21
	2006-07 and 2008-09	2
Participated for all three years	2006-2009	5

* Attended at least some part of the program

iCODE was appealing enough to school-year participants that many of them elected to continue with the program into the summer and participate in the summer camp. Indeed, the majority of summer camp attendees were continuing iCODE students (See Table 10).

Table 10
Summer Camp Attendance by School Year Participation

Participated in iCODE during school year	**Tech Creation**		**Machine Science**	
	2008	2009	2008	2009
Yes	17	29	10	6
No	7	4	3	1
Total	24	33	13	7

Student Satisfaction with the iCODE Program

Indicators of student satisfaction with the program included whether it met students' expectations, how likely students were to recommend the program to others, and students' perceptions of program quality.

Student Expectations

iCODE met students' expectations and, in Year 2, the program even exceeded their expectations. See Table 11.

Table 11
Level at Which iCODE Met Student Expectations

	Mean	Did not meet expectations	Sort of met expectations	Met expectations	Exceeded expectations	Far exceeded expectations
Year 1	3.00	2%	32%	32%	32%	2%
Year 2	3.57	3%	14%	32%	25%	26%
Year 3	3.13	11%	23%	21%	32%	13%

Student Likelihood of Recommending iCODE to Others

Students were quite likely to recommend the program to others. Their endorsements indicate particularly high satisfaction in Year 2, as indicated in Table 12. Not pictured here is the finding that, in Year 2, this indicator of satisfaction was significantly more positive for Tech Creation students than it was for Machine Science students ($p<.05$).

Table 12
Likelihood of Recommending iCODE to Others

	Very unlikely	Unlikely	Possibly	Likely	Very likely
Year 1	2%	14%	18%	32%	34%
Year 2	0%	2%	6%	31%	62%
Year 3	6%	1%	27%	27%	39%

Student Perceptions of the Quality of iCODE Components

The program was very appealing to participating students. Across the three years of the program, students rated each of the key iCODE components – hands-on projects, on-line resources, in-person visits of engineering and technology experts, Internet-based interactions with industry mentors, and collaboration with the mentors – as *very good* or *excellent*, the top two ratings on a five-point scale from *poor* to *excellent*. See Table 13.

The hands-on projects were the most appealing program component. Each year, hands-on projects received the highest mean rating. Although not practically significant, and therefore not displayed here, we did observe that participants were most satisfied with the program in its second of three years. For all program components except one, the trend was for Year 2 mean ratings to be highest, followed by Year 1, and then Year 3. The exception was collaboration with mentors, where the mean rating was highest in the program's first year.

Table 13
Student Ratings of Quality of iCODE Components

		Mean	**Poor**	**Fair**	**Good**	**Very good**	**Excellent**
Hands-on projects	Year 1	4.40	0%	2%	14%	25%	59%
	Year 2	4.50	0%	2%	9%	28%	62%
	Year 3	4.30	3%	1%	7%	37%	52%
On-line resources	Year 1	3.70	4%	11%	13%	49%	22%
	Year 2	4.13	0%	6%	17%	35%	42%
	Year 3	3.52	7%	6%	31%	30%	26%
In-person visits of engineering and technology experts	Year 1	3.89	9%	7%	11%	33%	40%
	Year 2	3.89	9%	6%	14%	27%	44%
	Year 3	3.56	6%	14%	20%	30%	30%
Internet-based interactions with industry mentors	Year 1	3.72	7%	7%	25%	27%	34%
	Year 2	3.91	6%	3%	22%	32%	37%
	Year 3	3.39	10%	12%	17%	39%	22%
Collaboration with the mentors	Year 1	4.19	0%	0%	23%	34%	43%
	Year 2	4.13	5%	2%	19%	29%	46%
	Year 3	3.78	4%	13%	14%	31%	38%

Gender Differences in Satisfaction

While girls and boys viewed the program similarly during its first two years, in the final year of the program, boys were significantly more satisfied than were girls. As shown in Table 14, in Year 3, boys were significantly more likely than girls to have had their expectations met and to say they would recommend the program to others.

Table 14
Gender Differences in Satisfaction with iCODE

	Girls (N=19)	**Boys (N=51)**
Extent to which expectations were met***	2.11	3.50
Likelihood of recommending the program***	3.16	4.20

*** p<.001

Also in the final year of the program, boys were significantly more positive about all five of the main program components than were girls. On average, girls found the program components *good* and boys rated them as *very good*. See Table 15.

Table 15
Gender Differences in Year 3 Ratings of iCODE Components

	Girls (N=19)	**Boys (N=49-51)**
Hands-on projects**	3.84	4.51
On-line resources*	3.11	3.78
In-person visits of engineering and technology experts**	2.90	3.90
Internet-based interactions with industry mentors*	3.00	3.67
Collaboration with the mentors***	2.90	4.20

* p<.05, ** p<.01, *** p<.001

Curricular Differences in Satisfaction

For the most part, the two curricula were equally appealing. One exception was in Year 3, when the Machine Science students viewed their on-line resources more positively than did the Tech Creation students; the third cohort of Machine Science students' mean rating for on-line resources was 4.10 (*very good*), compared to 3.28 (*good*) for Tech Creation (p<.05).

Overview of Student Outcomes

Before examining individual outcome areas, we present an overview of students' ratings of the range of iCODE benefits across the three years of the program. See Table 16. Students felt they benefited most from the program in three areas: gaining understanding of computer programming, gaining understanding of electronic devices, and having opportunities to work together with other students. Each year, these three impact areas were the top-rated among students. The second cohort of iCODE students appeared to derive the most from the program. In all eight outcome areas of interest, cohort two's mean ratings were the highest.

Table 16
Student Ratings of iCODE Benefits

		Mean
Increased students' understanding of computer programming	Year 1	3.49
	Year 2	3.66
	Year 3	3.41
Increased students' understanding of electronic devices	Year 1	3.56
	Year 2	3.63
	Year 3	3.37
Provided students with opportunities to work together with other students	Year 1	3.28
	Year 2	3.64
	Year 3	3.25
Prepared students to do better in school	Year 1	2.51
	Year 2	2.95
	Year 3	2.77
Exposed students to information about careers in science and technology	Year 1	3.18
	Year 2	3.38
	Year 3	3.08
Improved students' attitudes about careers in science and technology	Year 1	3.16
	Year 2	3.34
	Year 3	3.01
Increased students' problem solving abilities	Year 1	2.89
	Year 2	3.24
	Year 3	3.03
Connected students with professionals in the fields of engineering and technology	Year 1	3.07
	Year 2	3.25
	Year 3	3.14

Students' perceptions of iCODE's impact were generally the same for the two curricula. However, in Year 2, Tech Creation students rated the program higher in increasing their understanding of computer programming and electronic devices than did Machine Science participants, although on average both groups reported the program helped *a great deal* in these areas. In contrast, in Year 3, the Machine Science students were more positive about the program's ability to improve their attitudes about science and technology careers than were the Tech Creation students, although the average response at both sites was that the program helped *some* in this area. These differences are depicted in Table 17.

Table 17
Curriculum Differences in Ratings of iCODE Benefits

	Tech Creation	**Machine Science**
Year 2	**(N=33)**	**(N=28)**
Increased students' understanding of computer programming*	3.79	3.50
Increased students' understanding of electronic devices*	3.79	3.46
Year 3	**(N=43)**	**(N=21)**
Improved students' attitudes about careers in science and technology *	2.78	3.38

* p<.05

During the first two years that the program was in operation, girls and boys attributed similar outcomes to the program. However, in the last year, there were three ways in which boys felt they benefited more from the program than did girls, as can be seen in Table 18. Boys felt the program was *somewhat* helpful in preparing them to do better in school and improving their attitudes about careers in science and technology, while girls found the program only *a little* helpful in these areas. The third area in which boys were more positive than were girls was regarding opportunities to work with others students.

Table 18
Gender Differences in Ratings of iCODE Benefits

	Girls (N=19)	**Boys (N=50-51)**
Prepared students to do better in school *	2.32	2.92
Provided students with opportunities to work together with other students **	2.68	3.45
Improved students' attitudes about careers in science and technology **	2.37	3.24

* p<.05, ** p<.01

Now, we turn to examining these outcome areas individually and in more depth.

Student Engineering and Programming Skill Acquisition

iCODE introduced student participants to computer programming and increased their perceived understanding of computer programming and electronic devices. The vast majority of program participants (80%) had never written a computer program prior to iCODE. However, four in ten students had completed an engineering project before iCODE and four in ten had built electronic circuits beforehand. Table 19 shows these data. Machine Science participants were significantly more experienced with engineering projects and computer programs than were Tech Creation participants.

Table 19
Relevant Experience Prior to iCODE, by Program

	Tech Creation (N=154-157)	Machine Science (N=104-107)	Total (N=261-262)
Completed an engineering project before iCODE***	27%	52%	37%
Built electronic circuits before iCODE	41%	41%	41%
Wrote a computer program before iCODE*	15%	27%	20%

* p<.05, *** p<.001

At the end of the program, nearly all students reported at least *a little* increase in their understanding of computer programming and electronic devices and, in each of these areas, 59% of students felt their understanding had increased *a great deal*. See Table 20.

Table 20
Perceived Extent to which iCODE Increased Students' IT Understanding

Increased Understanding of:	Not at all	A little	Some	A great deal
Computer Programming	2%	6%	32%	59%
Electronic Devices	1%	9%	31%	59%

N = 145

Students' previous experience did not affect their perceptions of what they learned from iCODE. Students who had previous experience building electronic circuits were just as likely to report gains in their understanding of electronic devices at the end of the program as those who had no prior experience. The same was true with respect to writing a computer program.

However, it is interesting to note that students who were in the program for one year or less (n = 49-50) gave higher mean ratings for the changes in their engineering and programming than did students who were enrolled for more than one year (n = 21), as shown in Table 21.

Table 21
Differences in Ratings of Veteran and Novice Students

The extent to which the iCODE program increased your understanding of …	Mean ratings of novice students (in the program for only 1 year) **	Mean ratings of veteran students (in the program for more than 1 year)
Computer programming *	3.46	3.29
Electronic devices *	3.43	3.24

* p<.05
** Mean ratings based on a scale from *1* to *4* where higher numbers indicate higher competence.

This finding suggests that the veteran students did not feel they were getting as much from the program as the new students. This supports the necessity for programs like iCODE to provide opportunities for advanced learning and challenges for returning students, particularly with the learning of computer programming and electronic devices.

During Years 2 and 3, the student competencies regarding the various engineering and programming skills were also measured through online quizzes. The students were allowed multiple attempts at each of the three quizzes throughout the academic year. The rationale behind this was to give students an opportunity to improve the skills they lacked, thereby also improving their scores on the quizzes. The quizzes, with a total score of 10 points each, included both multiple choice and open-ended questions. The quizzes were scored by either the educators or the mentors at each site. With each successive quiz, the engineering and programming skills required to complete the quiz progressed in sophistication.

Higher scores on each of the three quizzes indicated the presence of the following competencies:

Quiz 1 Competencies: Student learns to build simple circuits

- Student can identify basic components in simple circuits – wire, LED, buzzer, resistor, switch, and battery.
- Student understands tool use and safety measures.

Quiz 2 Competencies: Student learns to build programmable circuits and write basic programs

- Student can identify components in programmable circuits – microcontroller, circuit board or breadboard, and speaker.
- Student is able to connect input and output devices to the microcontroller.
- Student is able to log into his/her iCODE account, write a new program or bring up an existing one, and download it into the microcontroller.

- Student is aware that the computer program is downloaded into the controller.
- Student can, with assistance, write a basic program that turns on an output device, e.g., LED, speaker, or LCD.
- Student can, with assistance, write a basic program that uses a sensor, e.g., temperature or light sensor.
- Student can change specific elements within a program, e.g., variable values, to achieve different results.

Quiz 3 Competencies: Student applies level two circuit-building and programming skills to complete guided projects

- Student is able to specify which sort of device would be appropriate for a given task and write code that would accomplish the task, e.g., getting a motor to change direction when light level falls beneath a given amount.
- Student understands basic execution model of microcontroller evaluating instructions in sequence.
- Student knows looping constructs and is able to write a program that loops a series of instructions a certain number of times or indefinitely.
- Student has had some experience with if-then (conditional) constructs and can explain a program that his presented to him/her.
- Student has been introduced to sub-procedures and can describe execution flow if presented with a program.
- Student has familiarity with basic programming concepts: main function, secondary functions with arguments (motor, beep, etc.), inputs and outputs, delays, loops, and conditionals.

Table 22 indicates the number of students making multiple attempts for each quiz and the mean scores broken down by the curriculum for Years 2 and 3. The mean scores dropped only slightly as the difficulty level of the quiz increased.

The overall performance of the students in quizzes seemed to have dropped from Year 2 to Year 3:

- Overall the mean scores reduced from Year 2 to Year 3.
- The number of students making multiple attempts also dropped.
- A total of nine students in Year 2 obtained a perfect score of 10 across the three quizzes. This number was reduced to four in Year 3.
- The TC students did not make any attempts at the third quiz in Year 3.

Table 22
Quiz Data for Years 2 and 3 for Tech Creation and Machine Science

Tech Creation Quiz level		Attempts	# students with multiple attempts	Mean score of students making single attempt	Mean score of students making multiple attempts
1	Year 2	39 Students made 58 attempts	11 (28%)	7.25	7.68
	Year 3	44 Students made 55 attempts	5 (11%)	8.00	7.80
2	Year 2	19 Students made 29 attempts	6 (33%)	6.83	5.67
	Year 3	32 students made 32 attempts	0	5.50	--
3	Year 2	27 Students made 31 attempts	1 (3%)	3.52	7.00
	Year 3	No attempts made	--	--	--
Machine Science Quiz level		**Attempts**	**# students with multiple attempts**	**Mean score of students making single attempt**	**Mean score of students making multiple attempts**
1	Year 2	36 Students made 74 attempts	9 (25%)	9.07	6.33
	Year 3	4 students made 5 attempts	1 (25%)	8.50	7.30
2	Year 2	14 Students made 18 attempts	1 (5%)	7.38	7.65
	Year 3	4 students made 4 attempts	0	6.00	--
3	Year 2	9 Students made 14 attempts	3 (33%)	7.50	6.40
	Year 3	10 students made 10 attempts	0	7.00	--

We also measured summer students' engineering and programming skills by having them indicate their proficiency with performing ten specific skills related to their summer camp projects. The measure required students to respond on a five-point Likert scale: 1=*I cannot do this*, 2=*I can do this but only with assistance*, 3=*I can do this well enough for my own personal use*, 4=*I can do this pretty well, and could show a friend how to do it if I had time to review*, and 5=*I can do this very well and could show a friend how to do it*.

Statistical tests confirmed that the set of skills reliably assessed the overall outcome of interest (e.g., engineering and programming skills), so we used students' average response to the items as a "score." The scores are shown in Table 23. On average, each iCODE cohort left their summer camp feeling that they could perform their set of engineering and programming skills pretty well and, with enough time to review, they could lead friends in performing the skills.

Table 23
Students' Perceived Skill Level Post Summer Camp

Scale: 1-5	**Tech Creation**			**Machine Science**		
	2007 (N=11)	2008 (N=34)	2009 (N=35)	2007 (N=11)	2008 (N=13)	2009 (N=7)
Mean score	3.74	4.25	3.64	3.56	3.79	4.07
Minimum score	2.30	2.64	1.18	2.22	2.30	3.00
Maximum score	4.70	5.00	5.00	4.80	4.80	5.00

One summer camp cohort in which there was a higher percentage of students new to iCODE (more than a third of participants) was the Tech Creation 2008 cohort. In this cohort, there was a statistically significant difference between the perceived skill scores of new and continuing students, with continuing students outperforming new students, displayed in Table 24.

Table 24
Tech Creation 2008 Summer Cohort: Perceived Skill by School Year Participation

	Participated in iCODE during school year	
	Yes	No
Perceived skill score*	4.56	3.88

NOTE: Maximum skill score was 5.
* $p<.05$

The specific items used to measure engineering and programming skills are identified in Table 25 (on the following page), along with their reliability statistics (i.e., Cronbach's alpha).

Table 25
Skills Gained by the Students through Summer Camps

UML Year 1 (α=.90)	**UML Years 2 and 3 (α=.91)**
Setting up the Cricket, and IR interface	**Scratch:** Making sprites move
Wiring output devices, switches, and sensors	**Scratch:** Changing a sprite's costume
Writing, downloading, and running procedures	**Scratch:** Getting sprites to reach to react to each other with touching
Determining sensor values – loop send [sensor]	**Scratch:** Changing backgrounds
Writing *if* and *if-else* statements with loops	**Scratch:** Communicating with the broadcast command
Using equipment such as servo motors, LEDs, relay switches & special output devices/ voice controllers, thermistors/ other special sensors	**Scratch:** Using the Scratch Board
Collecting data	**Cricket:** Logging into the iCODE site, then downloading and running programs
Writing *and/or*: *if* statements with two conditions	**Cricket:** Wiring sensors and motors
Multi-tasking using the when statement	**Cricket:** Using the LED number display
Advanced skills such as using global variables, using timers and counters, conducting math operations/ equations, dealing with random variable, and IR communication	**Cricket:** Writing *if* and *if-else* statements with loops **Cricket:** Writing *and/or*: *if* statements with two conditions
MS Year 1 (α=.85)	**MS Years 2 and 3 (α=.83)**
Building a structure with PVC pipe	Build a circuit by following a schematic diagram
Building a basic water rocket	Measure voltage in a circuit using a multimeter
Using physics principles to improve rocket height and accuracy	Write C code to control LEDs and button switches in a circuit
Modifying a rocket to protect a payload	Program the GPS receiver to display satellite data on the LCD
Calculating a rocket's altitude using geometric methods	Use a GPS device to find a location based on its latitude and longitude
Adding electronic sensors to the rocket	Write C code to retrieve and play MP3 files on a USB flash drive
Retrieving data from the sensor circuit board	Use buttons to customize the interface for your MP3 player
Graphing the sensor data on the computer	Design an interactive video game using Scratch
Adding a video camera to the rocket	Use data from the accelerometer to make things happen in Scratch
Evaluating rocket performance to make design modifications	Upload a Scratch project to the Scratch web site

What was the most interesting thing you did or learned as a part of the iCODE Program?

... the amount of things you can do with programming.

... learning the C program was very interesting to me.

... that I had the ability to make a robot.

... to further program a robot to make it meet my goals.

... go to and compete in the very cool Sumo-bot competition!

... competing with other people in the Sumo-bot competition was interesting because it's cool to see others put their knowledge to use.

... how a lot of every day items work and the components in them and what they do.

... the fact that kids younger than I am are interested in machine science.

Finally, when asked to indicate the most interesting thing they learned or did during the iCODE program on their post surveys, over the years the most frequently mentioned student responses were:

- Learning about computer programming,
- Using computer programs to create their own projects, and
- Competing in the Robot Sumo competition against other students' creations.

Robot Sumo Competition

Every year iCODE students gathered at the Museum of Science Boston for the annual iCODE Robot Sumo Event. The competition included middle and high school students who participated in the yearlong after school program.

Various schools in Boston, Lowell, and Lawrence (working on the TC and MS projects) entered robots into the competition. Students worked as individuals and in teams to create the robots. The program provided materials to design, program, and modify robots for the competition.

The competition consisted of multiple robot duels in a round-robin style. iCODE had full reign of the lower level of the museum and students could be seen working on their robots between heats with laptops and other engineering tools. The event closed with the awarding of trophies and awards.

Student Workforce Skill Acquisition

We assessed students' teamwork attitudes before and after their iCODE participation. As evident in Table 26, both before and after participation in iCODE, students enjoyed team-oriented activities and felt that teamwork was an important life skill. Their positive baseline attitudes did not improve any further after the program.

Table 26
Mean Teamwork Attitudes Before and After iCODE

Scale: 1-5	Pre	Post
I enjoy participating in team-oriented activities.	4.36	4.21
Everyone should be taught to be a good team player.	4.52	4.41
I prefer to work on teams where members perform their tasks independently rather than together.	4.10	3.14
Teamwork is one of the most important skills in life.	4.26	4.24
I prefer working alone than as part of team.	2.82	2.94

N = 99-100

At the same time, iCODE provided students with opportunities to work together, increased their perceived problem solving abilities, and connected them with professionals in the fields of engineering and technology – all important factors in encouraging workforce readiness. Table 27 provides these findings.

Table 27
Perceived Extent to which iCODE Increased Students' Workforce Skills

	Not at all	A little	Some	A great deal
Provided students with opportunities to work together with other students	5%	12%	29%	55%
Increased students' problem solving abilities	9%	17%	34%	40%
Connected students with professionals in the fields of engineering and technology	8%	18%	27%	48%

N = 143-145

Connecting Students with STEM Professionals

The one community-building aspect of the program that all the students and educators rated extremely highly was, as mentioned earlier, the mentors' involvement. The contributions of the mentors to the program included, but were not limited to:

- Supplementing the educators' knowledge of content areas: the mentors sometimes had more programming expertise than did the educators. This was more common among the new educators each year than among the veteran teachers.

- Challenging the students to go a step further: the mentors could gauge the potential of the students and challenge them with questions, problems, and issues that helped the students go beyond their acquired expertise. Educators were sometimes not as experienced in this realm.

- Troubleshooting when students had technical problems: the students were comfortable asking the mentors questions and, with their background knowledge, the mentors could explain well the concepts in the project. They were available to the students to work on all aspects of their projects.

- Helping with materials: on some occasions, the mentors brought equipment over from the University of Massachusetts and on other occasions they helped create teaching materials such as worksheets for the students.

As mentioned previously, the iCODE program, according to the original proposal, aimed at providing students with opportunities to connect with the larger engineering community in the outside world. This aspect of the program was rolled out to some extent during the second and third years of the program. The educators recognized the importance of this aspect of the program because it not only informed students about various careers in engineering but would also give them a chance to see the relevance of engineering to workplaces and everyday life.

Also, as mentioned earlier, the educators noticed the positive effects of these experiences and suggested inclusion of more such experiences throughout the academic year. Suggestions for inclusion in future programs were field trips to a university laboratory or an engineering company, inviting guest speakers from engineering communities, and increasing the number of competitive events such as the Robot Sumo or Bot Fest. Some of these suggestions were implemented at some of the program sites.

Student Attitudes about Science, Math, and Information Technology

We assessed students' attitudes in three areas – science, math, and information technology –the start of their iCODE participation and at the end of the program. Each of these attitudinal outcomes was measured by having students indicate their agreement with a set of statements related to each area. The statements required students to respond on a five-point Likert scale, from *strongly disagree* to *strongly agree*. Statistical analyses revealed no significant differences in the students' pre and post attitudes. See Tables 28-30.

The lack of attitudinal change may be explained by the fact that these students had strong positive STEM attitudes even before they began the program, reflected in their pre-program survey ratings. Indeed, students who had been nominated by teachers for the iCODE program were students who were not challenged enough by their school curricula and who were expected to benefit from the program. This undoubtedly led to selection of a group of students already interested in STEM. To the extent that our attitudinal measures may have been unable to distinguish between positive pre-iCODE attitudes and *even more positive* post-iCODE attitudes, the effects of iCODE in this area may have been undetectable.

Table 28
Students' Pre and Post Mean Science Attitude Ratings

	Pre	**Post**
I like science.	4.36	4.37
I enjoy learning science.	4.30	4.29
Science is boring.	2.05	2.05
Science is important to everyone's life.	4.09	4.10
I would like a job that involved using science.	3.80	3.80

N = 131-135

Table 29
Students' Pre and Post Mean Math Attitude Ratings

	Pre	**Post**
I like math.	4.14	4.12
I enjoy learning math.	4.10	4.00
Math is boring.	2.24	2.47
Math is important to everyone's life.	4.38	4.33
I would like a job that involved using math.	3.60	3.63

N = 131-135

Table 30
Students' Pre and Post Mean IT Attitude Ratings

	Pre	**Post**
IT skills are important to everyone's life.	3.96	3.98
I would like a job that involved using IT skills.	3.72	3.69

N = 134-135

Student Enjoyment and Challenge in STEM Subjects

iCODE did not appear to influence students' attitudes about their STEM subjects in school. Students enjoyment of science, math, and technology, and the level at which they felt challenged by these subjects, remained stable from pre- to post-program survey each year. Nevertheless, these data tell us something about students' STEM experiences in school.

First, students enjoy STEM subjects more than they are challenged by them; on average, they enjoy STEM subjects *a lot* yet are only challenged by them *a little*. Second, no one STEM subject stands out as more or less enjoyable or challenging than the others; students experience a similar level of enjoyment and challenge in science, math, and technology. See Table 31.

Table 31
Students' Enjoyment and Challenge in STEM Subjects

			Pre	**Post**
STEM Enjoyment	Science enjoyment	Year 1	3.35	3.36
		Year 2	3.65	3.52
		Year 3	3.44	3.45
	Math enjoyment	Year 1	3.38	3.19
		Year 2	3.46	3.41
		Year 3	3.43	3.26
	Technology enjoyment	Year 1	3.42	3.32
		Year 2	3.69	3.64
		Year 3	3.61	3.50
STEM Challenge	Science challenge	Year 1	2.12	2.52
		Year 2	2.45	2.49
		Year 3	2.57	2.41
	Math challenge	Year 1	2.21	2.55
		Year 2	2.42	2.44
		Year 3	2.56	2.44
	Technology challenge	Year 1	2.06	2.13
		Year 2	2.44	2.65
		Year 3	2.58	2.37

Education Expectations

On pre- and post-program surveys, students indicated the highest level of education they expected to obtain. About four in ten students overall entered and exited iCODE with an expectation of obtaining a professional degree, Ph.D., or M.D. About three in ten entered and exited anticipating a Master's level of education. Table 32 presents these results.

Table 32
Students' Pre and Post Education Aspirations

	Pre	**Post**
Graduate from high school	2%	1%
Some vocational or technical education	1%	1%
2 year college degree	6%	8%
4 year college degree	25%	14%
Masters degree	28%	36%
Professional degree e.g. law business	14%	11%
Ph.D. or M.D.	25%	29%

N = 274

Student Likelihood of Persisting in Science and Math in School

The mean ratings for how likely students were to persist in science and math before and after participating in the iCODE program are presented in Table 33. Results indicate that students were likely to persist in science and math before and after participating in the program.

Table 33
iCODE Students' Likelihood to Persist in Science and Math

	Pre	**Post**
Likelihood of taking advanced science in high school	3.98	4.06
Likelihood of taking science in college	4.08	4.14
Likelihood of taking advanced math in high school	4.01	3.82
Likelihood of taking math in college	4.86	4.11

N = 131-133

Student STEM Career Awareness

Students' knowledge about STEM careers and their STEM careers aspirations were measured before and after their participation in the program. The knowledge items required students to rate how much they knew about STEM careers using a four-point Likert scale ranging from *nothing* to *a lot*. The aspirations items required students to rate how interested they were in STEM careers on a five-point Likert scale ranging from *not at all interested* to *extremely interested*. Each pool of items was then averaged as a score. Reliability analyses indicated the scores were reliable.

Students began their participation in iCODE believing that they had *some* knowledge of STEM careers and they were *very interested* in having a career in a STEM field. For the most part, their perceived knowledge and their interest did not increase after iCODE. See Table 34. However, in Year 2, students' average STEM Career Knowledge score increased significantly from pre- to post-program ($p<01$). Their average STEM Career Interest score did not change significantly. That is, students were just as interested in a STEM career after iCODE as they were before the program, but they *knew more* about STEM careers after their experience.

Table 34
Students' Pre and Post STEM Career Knowledge and Interest

		Pre	**Post**
STEM Career Knowledge Score	Year 1	3.15	3.07
	Year 2**	2.96	3.24
	Year 3	3.06	3.12
STEM Career Interest Score	Year 1	3.80	3.59
	Year 2	4.00	4.09
	Year 3	3.91	3.79

N = 127-131
** $p<.01$

Gender and Curricular Differences in STEM Career Awareness

In Year 1, for the STEM Career Knowledge score, there was a significant interaction between curriculum and gender ($p<.01$). The adjusted post-test scores of girls and boys from the Tech Creation program were roughly equivalent, whereas the Machine Science girls had higher adjusted post-test scores than did the Machine Science boys. And, in Year 3, for the STEM Career Knowledge score, there was a main effect of gender, with boys scoring higher than girls on the post-test, when controlling for pre-test differences ($p<.01$). See Table 35.

Table 35
Group Differences in STEM Career Knowledge Score

Year 1 Group Differences		
Curriculum	Gender	Mean
Machine Science	Female	3.331(a)
	Male	2.814(a)
Tech Creation	Female	3.018(a)
	Male	3.292(a)
Year 3 Group Differences		
Curriculum	Gender	Mean
No difference	Female	2.369(b)
	Male	3.278(b)

a Pre STEM Career Knowledge score appeared in the model as a covariate and was evaluated at the following value: 3.15.
b Pre STEM Career Knowledge score appeared in the model as a covariate and was evaluated at the following value: 3.06.

While the STEM Career Knowledge and STEM Career Interest scores described above did not detect an effect of the program, Table 36 shows that the majority of participants (more than three-quarters) reported that the iCODE program:

- exposed them to information about careers in science and technology either *some* or *a great deal* and
- improved their attitudes about careers in science and technology either *some* or *a great deal*.

Table 36
Perceived Extent to which iCODE Increased STEM Career Preparation

	Not at all	**A little**	**Some**	**A great deal**
Exposed students to information about careers in science and technology	6%	16%	30%	48%
Improved students' attitudes about careers in science and technology	8%	17%	36%	40%

N = 144-145

It is interesting to note that significant positive correlations were found among ratings given by the students over the period of the three years on the following iCODE program aspects, as shown in Table 37:

- online resources aspect of the iCODE program,
- in-person visits aspect of the iCODE program,
- how successful the program was in connecting students with professionals in the engineering field,
- how successful the program was in exposing to info about engineering/technology careers, and
- how successful the program was in improving attitude about engineering/technology careers

These positive correlations indicated that the students who rated the *online resources* and *in-person visits* aspects of iCODE highly were also more satisfied with the *career* aspects of the program.

Table 37
Correlations Between Students' Ratings on Aspects of the iCODE Program

	Improved attitude to STEM careers	**Connected with professionals in the field**	**Exposure to STEM careers**	**Hands on projects**	**Online resources**	**In person visits by experts**
Improved attitude to STEM careers	_	_	_	_	_	_
Connected with professionals in the field	.558**	_	_	_	_	_
Exposure to STEM careers	.591**	.537**	_	_	_	_
Hands on projects	.435**	.487**	.423**	_	_	_
Online resources	.355**	.409**	.302**	.414**	_	_
In person visits experts	.473**	.523**	.324**	.434**	.463**	_

Student Familiarity with an Engineer and What Engineers Do

As an additional indicator of iCODE effectiveness in exposing students to STEM careers, we asked them before and after the program whether they knew an engineer. These results are given in Table 38. About four in ten students entered and left iCODE knowing an engineer and about two in ten entered and exited the program without knowing an engineer. For the remainder of students, familiarity with an engineer changed from iCODE beginning to end. About one-quarter of students came to know an engineer during the time they were in iCODE.

A small percentage of students who said before the program that they knew an engineer reported afterward that they did not. We can only speculate that perhaps these students believed initially that they knew what it meant to be an engineer and realized while in the program that they had been mistaken.

Table 38
Student Familiarity with an Engineer Pre and Post iCODE

		N=129
% whose familiarity with an engineer did not change	Knew an engineer pre and post	43%
	Did not know an engineer pre or post	23%
% whose familiarity with an engineer changed	Did not know an engineer before iCODE; knew an engineer after iCODE	26%
	Knew an engineer before iCODE; did not know an engineer after iCODE	7%

On the pre- and post-program surveys each year, students were asked "What do engineers do?" There were 101 cases in which students answered at both pre and post. These responses were coded for accuracy and completion/sophistication. As Table 39 illustrates, there was variation in how students fared on this question. Of the 101, about half gave more appropriate or more complete responses after the program than they did before it. Of these, eight students' responses changed from "*I don't know"* at pre to giving a simple explanation including one or two of elements of what an engineer does: design, build, program computers, fix things, work with technology. Others started with responses such as "*make stuff*" and ended with "*design things and solve problems to make human life easier*." The other half of students gave fairly similar responses pre and post or gave a scantier response at post. Most of them wrote at least one element of what an engineer does.

Interestingly, those students who participated multiple years and completed more than one set of pre-post responses did not necessarily give more sophisticated definitions on the subsequent post surveys. By the second or third time around, they may have been bored with the question. What is apparent from the responses is that students' understanding of the role of engineers was quite focused on what they learned in iCODE (e.g., work with computers, create things, work on machines) rather than a broader understanding of the field that would encompass the various elements of the design/build process.

Table 39
"What Does an Engineer Do?"

Response on post survey was…	Less adequate than at pre	Same as at pre	Marginally better than pre	Substantially better than pre
	10% (N=10)	40% (N=41)	15% (N=15)	35% (N=35)

N=101

Educator and Mentor Perceptions of iCODE

According to the educators and mentors, some of the highlights of the program – indicative of its success over the span of three years – were:

In the words of educators, skills and experiences gained by students through iCODE:

- *basic engineering design process*
- *troubleshooting code*
- *getting excited about engineering*
- *small group work*
- *independent learning*
- *real world problem solving*

- The use of hands-on curriculum with an online programming component as a unique approach to introduce engineering and design skills to students.
- The high appeal of the program for the participating students.
- The students' enjoyment of and responsibility for their own projects.
- Increases in students' knowledge about programming and understanding of electronic devices.
- Opportunities for students to practice work-force skills like creativity, teamwork, and problem solving.

On the other hand, the educators and mentors pointed to aspects of the program that could be improved upon in future programs building on the iCODE model.

- Increase the exposure of the students to the larger IT engineering community in such a way that they feel a part of it.
- Retain the interest level of the returning students by introducing a greater variety of projects so that these students can experience new challenges.
- Encourage students to find answers to some questions about the projects, or about careers in engineering, by doing online research.
- Continue to offer the veteran students a mentoring position or the opportunity to do an independent study.
- Provide opportunities for educators to collaborate online with each other during the academic year to discuss challenges, issues, and successes.

- Make additional efforts in the future years to engage the parents of the participating students in the program.

CONCLUSIONS

Overall, the iCODE program successfully met all the requirements of ITEST project goals.

By serving middle- and high-school students, particularly those from disadvantaged urban and rural communities, with year-round IT enrichment experiences and opportunities through hands-on, inquiry-based activities, the iCODE program met all the requirements of the ITEST projects goals, the NSF platform through which it was funded.

The implementation of the iCODE program was closely aligned with the original plan.

Starting with five sites in Year 1, the iCODE after-school program involved up to 14 sites across the three years, and served close to 300 students. Successful one- and two-week summer camps ran in two locations each summer. Training sessions, which allowed the educators to experience the hands-on aspects of the program themselves, were held every year.

The program had a high retention rate from the after school program to summer program every year. Most of the participating educators and five of the students remained in the program across all the three years.

Each year, the program was highly successful at attracting and retaining students from diverse racial backgrounds. Across the three years, the percentages of Whites, African American, Asian, and Hispanic students were fairly equivalent. The program was less successful in attracting girls into the program; overall there were three boys for every girl across the three years.

The effects of iCODE for students specifically on the changes in their attitudes about STEM subjects may have been undetectable.

Statistical analyses revealed very few significant differences in students' pre and post surveys for questions related to their attitudes toward STEM subjects. The lack of change may be explained by the fact that these students were very positive about STEM even before they began the program. Indeed, students who had been nominated by teachers for the iCODE program were students who were not challenged enough by their school curricula and who were expected to benefit from the program. This undoubtedly led to selection of a group of students already interested in STEM. To the extent that the evaluation measures may have been unable to distinguish between positive pre-iCODE attitudes toward STEM subjects and *even more positive* post-iCODE attitudes, the effects of iCODE in may have been undetectable.

Students reported substantial gains in engineering process and workforce skills.

The specific projects created both during the school year and at the summer camps increased student understanding of computer programming and electronic devices. Through individual and team-based projects, the program also offered students multiple opportunities to exercise and practice their workforce skills such as teamwork, problem solving, and creativity.

Students learned about STEM-related careers

During the second year, iCODE was successful at enhancing students' knowledge about careers in science, engineering, and technology, as measured by pre to post surveys. In addition, during both the second and the third year, the students perceived a significant increase in their knowledge about preparations required for a career in Information Technology.

Students' positive attitudes toward STEM were maintained through the program.

The positive attitudes of the students toward STEM were maintained every year. It is not uncommon for students' STEM attitudes to actually become less positive after participation in an introductory STEM program, so the maintenance of positive attitudes was encouraging.

The iCODE program was very appealing to students and educators.

iCODE students greatly enjoyed gaining hands-on experience with their computer-based projects and enjoyed working directly with the technology. The online guides, hands-on projects, and the collaboration among students and mentors were the most appealing aspects of the program. Summer camps and events such as Robot Sumo competition were also exceedingly popular. In the final year of the program, boys appeared to have a somewhat more positive experience than girls. The educators enjoyed learning engineering concepts themselves and watching students' excitement build as they completed their projects.

The mentors played significant roles in the iCODE program.

The participation/involvement of the undergraduate mentor was a highly successful component of the program. The undergraduate mentors played various roles, from teaching the actual iCODE content to the students to troubleshooting with hands-on projects. They were capable of challenging students depending on their capabilities and providing programming expertise to the educators. During the third year, high school and middle school veteran students functioning as mentors for newer students was well-received.

The most successful year of the program in terms of student gains was year 2.

The second year of the program was the year in which students showed significant gains in their knowledge about STEM careers. Also, during the same year – although the number of females in the program was lower than that of males – the program appeared to have contributed to an increase in positive attitudes of those females toward STEM and IT subjects and careers. Student performance on the programming quizzes was better during the second year than during the third year. Finally, students were most satisfied with the program in its second of three years; the second year of the program exceeded student expectations. For these reasons, GRG concludes that the second year was the highpoint of the program.

Parental involvement in the iCODE program was low.

The parents of the students in the iCODE program were only minimally involved in the program. Their involvement was limited to their presence at the various annual events in which the students participated. However, low parental involvement is endemic to out-of-school-time programs such as iCODE.

RECOMMENDATIONS

Continue the mentor role.

Based on the data around the successful role of the mentors in the iCODE project, GRG recommends that program developers continue to incorporate mentors into future programs. Increasing the accessibility of the mentors by making their services available through the student or educator online modules is a consideration. Undergraduate college students, graduate students, and experienced high school students can both help the educators and serve as role models for the less experienced students.

Enhance the experiences of the returning students.

Educators and returning students alike indicated that the returning students were looking for newer, more challenging projects as they made their way into the second or third year in the program. As a lesson for the future program, making newer learning challenges available to returning students in the program would help to sustain their interest and motivation in the program.

Step up measures to encourage girls and young women into the program.

GRG recommends that UML and Machine Science continue to increase their efforts to recruit and retain female students. Through strategies such as making the projects female-friendly and using female mentors/role models in promoting the program, future program developers can work toward encouraging girls and young women to participate in their programs.

Enhance the educator training.

Although the educators themselves gained knowledge about a number of engineering and programming concepts through the training they received for conducting the iCODE program, they suggested that, during training, the iCODE experts go beyond what the students will learn so that the educators will be better equipped to answer students' questions and address any programming difficulties.

One of the lessons learned through the current program was that new educators, unlike the veteran educators, need scaffolding throughout the year. Therefore, GRG recommends that, in the future, resources such as an online educational module or a Facebook page be made available once the program has begun, for continued assistance to them.

Build on the community building component of the program.

The collaborative aspect of the iCODE program was well defined when it concerned teamwork among the students themselves or between the students and the mentors. It was less defined when concerned with reaching out beyond the program. GRG recommends that future program work on extending the community-building aspect to include more "outside-the-school-walls" experiences for the students, such as guest lectures and field trips.

Increase parental involvement in the program.

From the start of the iCODE program, parental involvement has been very limited. At the end of the first and second years of the program, GRG had suggested including take-home activities that require parental feedback, like technology questionnaires and interactive games. GRG recommends that program developers take steps to encourage greater parental involvement in future program endeavors.

Tackle technical issues arising at the sites.

During Years 2 and 3, educators indicated that the recurring technical and computer software and Internet-related problems posed continuing challenges to program implementation. Although these issues may not be directly related to the iCODE technology but to the infrastructure at the sites, these problems need to be addressed and fixed in order for the program to run smoothly. GRG recommends that, in future, collaborators of programs such as iCODE work with the school authorities and/or the educators to help avoid technical difficulties such as issues with the Internet, network, or computers. An expert could be assigned at the beginning of the program with the task of setting up the computer and internet systems. Avoidance of such problems would ensure smooth progress on the computer and internet-based student projects.

In summary, the iCODE program can serve as a model for other ITEST initiatives that feature programmatic efforts to make hands-on, inquiry-based engineering and programming experiences available to underrepresented groups in the middle and high schools. Future programs can apply lessons learned about the challenges of recruiting girls, the extent of training needed to satisfy educators, and the goal of connecting students with STEM professionals. The outstanding aspects of the program were its hands-on projects, its exciting competitions, and the involvement of mentors.

APPENDICES

Appendix A: Student Pre-Survey

About You

1. Your Name: ____

2. Are you:

❑ Male ❑ Female

3. How old are you? __________

4. What grade are you in?

❑ 5th ❑ 9th
❑ 6th ❑ 10th
❑ 7th ❑ 11th
❑ 8th ❑ 12th

5. What is your race/ethnicity? *(Check all that apply.)*

❑ American Indian or Alaska Native
❑ Asian
❑ Black or African American
❑ Native Hawaiian or Other Pacific Islander
❑ Spanish/Hispanic or Latino
❑ White
❑ Other; please specify
____

About Your Family

6. What is your mother's job? ______________ ❑ Doesn't apply
What is your father's job? ______________ ❑ Doesn't apply

7. How far in school did your parents go? *(Check one box for each parent.)* Mother Father

❒ Completed grade school......
❒ Some high school..........................
❒ Graduated from high school..........
❒ Had some education after high school
❒ Graduated from a 2 year college...
❒ Graduated from a 4 year college.............
❒ Masters degree..........
❒ Professional degree (e.g., law, business)..
❒ Ph.D. or M.D.....
❒ I don't know.......
❒ Doesn’t apply.........

<u>Your Opinions about Science, Math, and Engineering</u>

8. How strongly do you agree or disagree with each of the following statements about science? *(Check one box for each.)*

I like science.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

I enjoy learning science.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

Science is boring.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

Science is important to everyone’s life.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

I would like a job that involved using science.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

9. How strongly do you agree or disagree with each of the following statements about math? *(Check one box for each.)*

I like math.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

I enjoy learning math.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

Math is boring.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

Math is important to everyone’s life.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

I would like a job that involved using math.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

10. Do you know any engineers? ❒ Yes ❒ No ❒ Not sure

11. What do you think engineers do?

____

____

12. List two different places where engineers might work.

1) ____
2) ____

13. How strongly do you agree or disagree with each of the following statements about computer programming skills? *(Check one box for each.)*

Computer programming skills are important to everyone's life.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

I would like a job that involved using computer programming skills.
❒ Agree a lot ❒ Agree a little ❒ Not sure ❒ Disagree a little ❒ Disagree a lot

<u>Your Thoughts about Careers</u>

14. How far do you think you will actually go in school?

❒ Graduate from high school
❒ Some vocational or technical education
❒ 2 year college degree
❒ 4 year college degree
❒ Masters degree
❒ Professional degree (e.g., law, business)
❒ Ph.D. or M.D.

15. How likely are you to do the following? *(Check one box for each.)*

	Very Likely	**Likely**	**Possibly**	**Unlikely**	**Very Unlikely**
Take elective or advanced science classes in high school (if they are offered)	❒	❒	❒	❒	❒
Take science classes in college	❒	❒	❒	❒	❒
Take elective or advanced math classes in high school (if they are offered)	❒	❒	❒	❒	❒
Take math classes in college	❒	❒	❒	❒	❒
Take elective or advanced computer/technology classes in high school (if they are offered)	❒	❒	❒	❒	❒
Take computer science classes in college	❒	❒	❒	❒	❒
Take engineering classes in college	❒	❒	❒	❒	❒

16. What kind of work do you expect to be doing when you are 30 years old?

____

____

17. How much do you know about different careers in each of the following fields? *(Check one box for each.)*

	A lot	Some	A little	Nothing
Science	❐	❐	❐	❐
Math	❐	❐	❐	❐
Engineering	❐	❐	❐	❐
Computer science	❐	❐	❐	❐

18. How interested are you in having a career in each of the following fields? *(Check one box for each.)*

	Extremely interested	Very interested	Somewhat interested	A little interested	Not at all interested
Science	❐	❐	❐	❐	❐
Math	❐	❐	❐	❐	❐
Engineering	❐	❐	❐	❐	❐
Computer science	❐	❐	❐	❐	❐

Your School Experiences

19. In general, how much do you enjoy each of the following classes in school?
(Check one box for each.)

	Doesn't apply	A lot	Some	A little	Not at all
Science	❐	❐	❐	❐	❐
Math	❐	❐	❐	❐	❐
Technology	❐	❐	❐	❐	❐

20. In general, how challenging do you find each of the following classes in school?
(Check one box for each.)

	Doesn't apply	A lot	Some	A little	Not at all
Science	❐	❐	❐	❐	❐
Math	❐	❐	❐	❐	❐
Technology	❐	❐	❐	❐	❐

21. What grades do you usually get in school? *(Check only one box.)*

❐ Mostly A's
❐ Mostly B's
❐ Mostly C's
❐ Mostly D's
❐ Mostly F's
❐ A's and B's
❐ B's and C's
❐ C's and D's
❐ D's and F's

22. What grades do you usually get in <u>science</u>? *(Check only one box.)*

❒ Mostly A's
❒ Mostly B's
❒ Mostly C's
❒ Mostly D's
❒ Mostly F's
❒ A's and B's
❒ B's and C's
❒ C's and D's
❒ D's and F's

23. What grades do you usually get in <u>math</u>? *(Check only one box.)*

❒ Mostly A's
❒ Mostly B's
❒ Mostly C's
❒ Mostly D's
❒ Mostly F's
❒ A's and B's
❒ B's and C's
❒ C's and D's
❒ D's and F's

24. In the last 12 months have you …..? *(Check one box for each.)*

Participated in

Science fair ❒ Yes ❒ No
Science club ❒ Yes ❒ No
Math club ❒ Yes ❒ No
Computer club ❒ Yes ❒ No
Engineering club ❒ Yes ❒ No
Science enrichment program ❒ Yes ❒ No
After-school academic club ❒ Yes ❒ No
Which one(s)? ___________________
Any other club/program/activity ❒ Yes ❒ No
Describe: ________________________

Worked in a scientific research setting ❒ Yes ❒ No
Describe: ________________________

Tutored another student in a school subject ❒ Yes ❒ No
Which subject(s)? _________________

<u>Your Experience with Computers</u>

25. Do you have a computer at home that you can use on a regular basis? ❒ Yes ❒ No

26. Typically, how many days *per week* do you use a computer?
❒ 0 days ❒ 1 day ❒ 2 days ❒ 3 days ❒ 4 days ❒ 5 days ❒ 6 days ❒ 7 days

27. Which of the following computer resources have you used? ***(Check all that apply.)***

❐ Word processing software
❐ Spreadsheet software (e.g., Excel)
❐ Slide software (e.g., PowerPoint)
❐ Painting/drawing software
❐ Instant messaging
❐ Other uses; please explain:
❐ Email
❐ Internet/Web
❐ Computer games
❐ Photo editing software

28. Have you used computers for your school work? ❐ Yes ❐ No

If yes, in what ways?

29. Have you ever done any of the following activities? *(Check one box for each.)*

Completed an engineering project ❐ Yes ❐ No
***If yes*, please describe:**

Built electronic circuits ❐ Yes ❐ No
***If yes*, please describe:**

Wrote a computer program ❐ Yes ❐ No
***If yes*, please describe:**

The iCODE Program

30. Why are you attending the iCODE program? *(Check all that apply.)*
❐ I want to learn more about science and/or engineering.
❐ I want to be challenged in science and/or engineering.
❐ I want to meet other students like me.
❐ I think it will help me do better at school.
❐ I want to make new friends.
❐ I think it will help me get into a better college.
❐ My parents/teachers/guidance counselor want me to.
❐ My friends are going.
❐ Other (please explain):

31. What do you expect to gain from attending this program?

____

____

Appendix B: Student Post-Survey

Your Experiences in the iCODE Program

1. Please rate each of the following components of the iCODE program: *(Check one box for each row.)*

	Excellent	Very good	Good	Fair	Poor
Hands-on projects	❒	❒	❒	❒	❒
On-line resources	❒	❒	❒	❒	❒
In-person visits of engineering and technology experts	❒	❒	❒	❒	❒
Internet-based interactions with industry mentors	❒	❒	❒	❒	❒
Collaboration with the mentors	❒	❒	❒	❒	❒

2. How much has the program helped you in each of the following ways? *(Check one box for each row.)*

	A great deal	Some	A little	Not at all
Increased your understanding of computer programming	❒	❒	❒	❒
Increased your understanding of electronic devices	❒	❒	❒	❒
Prepared you to do better in school	❒	❒	❒	❒
Provided you with opportunities to work together with other students	❒	❒	❒	❒
Exposed you to information about careers in science and technology	❒	❒	❒	❒
Improved your attitude about careers in science and technology	❒	❒	❒	❒
Increased your problem solving abilities	❒	❒	❒	❒
Connected you with professionals in the fields of engineering and technology	❒	❒	❒	❒

3. How likely are you to recommend this program to a friend, sibling, or other student? *(Check one)*

❒ Very likely ❒ Likely ❒ Possibly ❒ Unlikely
❒ Very unlikely

4. Did iCODE turn out to be what you expected it to be? *(Check one.)*

❒ It did not meet my expectations at all.
❒ It sort of met my expectations.
❒ It met my expectations.

❐ It exceeded my expectations.
❐ It far exceeded my expectations.
Please comment on your response:

5. What was the most interesting thing you did or learned as a part of the iCODE Program?

____

____

<u>Your Opinions about Science, Math, and Engineering</u>

6. How strongly do you agree or disagree with each of the following statements about science? *(Check one box for each row.)*

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
I like science.	❐	❐	❐	❐	❐
I enjoy learning science.	❐	❐	❐	❐	❐
Science is boring.	❐	❐	❐	❐	❐
Science is important to everyone's life.	❐	❐	❐	❐	❐
I would like a job that involved using science.	❐	❐	❐	❐	❐

7. How strongly do you agree or disagree with each of the following statements about math? *(Check one box for each row.)*

	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
I like math.	❐	❐	❐	❐	❐
I enjoy learning math.	❐	❐	❐	❐	❐
Math is boring.	❐	❐	❐	❐	❐
Math is important to everyone's life.	❐	❐	❐	❐	❐
I would like a job that involved using math.	❐	❐	❐	❐	❐

8. Do you know any engineers? ❐ Yes ❐ No

9. What do you think engineers do?

____

____

10. List two different places where an engineer might work.

1) ________________________ 2) ________________________

11. How strongly do you agree or disagree with each of the following statements about IT (information technology) skills? *(Check one box for each row.)*

	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
IT skills are important to everyone's life.	❒	❒	❒	❒	❒
I would like a job that involved using IT skills.	❒	❒	❒	❒	❒

<u>Your Thoughts about Careers</u>

12. How far do you think you will actually go in school? *(Check <u>one</u>.)*

❒ Graduate from high school
❒ Some vocational or technical education
❒ 2 year college degree
❒ 4 year college degree
❒ Masters degree
❒ Professional degree (e.g., law, business)
❒ Ph.D. or M.D.

13. How likely are you to do the following? *(Check one box for each row.)*

	Very Likely	Likely	Possibly	Unlikely	Very Unlikely
Take elective or advanced science classes in high school (if they are offered)	❒	❒	❒	❒	❒
Take science classes in college	❒	❒	❒	❒	❒
Take elective or advanced math classes in high school (if they are offered)	❒	❒	❒	❒	❒
Take math classes in college	❒	❒	❒	❒	❒

14. What kind of work do you expect to be doing when you are 30 years old?

____

____

15. How much do you know about different careers in each of the following fields? *(Check one box for each row.)*

	A lot	Some	A little	Nothing
Science	❒	❒	❒	❒

Math	❒	❒	❒	❒
Engineering	❒	❒	❒	❒
Technology	❒	❒	❒	❒

16. How much do you know about the necessary preparations for an IT (Information Technology) career? *(Check one.)*

A lot	Some	A little	Nothing
❒	❒	❒	❒

17. How interested are you in having a career in each of the following fields? *(Check one box for each row.)*

	Extremely interested	Very interested	Somewhat interested	A little interested	Not at all interested
Science	❒	❒	❒	❒	❒
Math	❒	❒	❒	❒	❒
Engineering	❒	❒	❒	❒	❒
Technology	❒	❒	❒	❒	❒

Your School Experiences

18. In general, how much do you enjoy each of the following classes in school? *(Check one box for each row.)*

	Doesn't apply	A lot	Some	A little	Not at all
Science	❒	❒	❒	❒	❒
Math	❒	❒	❒	❒	❒
Technology	❒	❒	❒	❒	❒

19. In general, how challenging do you find each of the following classes in school? *(Check one box for each row.)*

	Doesn't apply	A lot	Some	A little	Not at all
Science	❒	❒	❒	❒	❒
Math	❒	❒	❒	❒	❒
Technology	❒	❒	❒	❒	❒

20. The following statements are about teamwork. Circle the number that best describes what you think about each statement. *(Circle one for each row.)*

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

I enjoy participating in team-oriented activities.	1	2	3	4	5
Everyone should be taught to be a good team player.	1	2	3	4	5
I prefer to work on teams where members perform their tasks independently rather than together.	1	2	3	4	5
Teamwork is one of the most important skills in life.	1	2	3	4	5
I prefer working alone than as part of team.	1	2	3	4	5

21. What grades do you usually get in school? *(Check only one box.)*

❒ Mostly A's
❒ A's and B's
❒ Mostly B's
❒ B's and C's
❒ Mostly C's
❒ C's and D's
❒ Mostly D's
❒ D's and F's
❒ Mostly F's

22. What grades do you usually get in <u>science</u>? *(Check only one box.)*

❒ Mostly A's
❒ A's and B's
❒ Mostly B's
❒ B's and C's
❒ Mostly C's
❒ C's and D's
❒ Mostly D's
❒ D's and F's
❒ Mostly F's

23. What grades do you usually get in <u>math</u>? *(Check only one box.)*

❒ Mostly A's
❒ A's and B's
❒ Mostly B's
❒ B's and C's
❒ Mostly C's
❒ C's and D's
❒ Mostly D's
❒ D's and F's
❒ Mostly F's

24. In the last 12 months have you ? *(Check one box for each row.)*

Participated in
Science fair ❒ Yes ❒ No

Science club ❐ Yes ❐ No
Math club ❐ Yes ❐ No
Computer club ❐ Yes ❐ No
Engineering club ❐ Yes ❐ No
Science enrichment program ❐ Yes ❐ No
After-school academic club ❐ Yes ❐ No W*hich one(s)?* _______
Any other club/ program / activity ❐ Yes ❐ No *Describe*: ________
Worked in a scientific research setting ❐ Yes ❐ No *Describe:* ________
Tutored another student in a school subject ❐ Yes ❐ No *Which subject(s)?*

Appendix C: Summer Camp Reflection Questions

The following reflection questions will be provided to iCODE summer camp educators to administer to participating students. Educators will administer the questions to students at appropriate intervals during the summer camp (i.e., timed to correspond to the summer camp activities and content). The questions will be provided on post-it notes that students will place in designated areas in their summer camp notebooks, where there will be adequate room for their written responses and accompanying diagrams and drawings.

General question to be used during the initial days of the summer camp

What did you learn in today's session? Describe two new engineering related concepts that you learned today.

Questions to be administered after students identify their project and before they begin building

Today's goal is to identify something to build that could solve a specific problem. Please answer the following questions. You may use drawings if you find them helpful.

What is your idea? What are you going to try to build, and what will it do?

At this point, how do you expect to build your project? What steps will you take? What resources will you use? How will you work with others?

Which concepts from today's mini-lecture will you use in designing and building your project? What will you do to incorporate these concepts into your project?

What seems difficult about this project? What are you not sure how to do?

How did you come up with your idea?

What do you like most about your idea?

Questions to be administered after students first try out the project they built

You've just completed building your project and tried it out for the first time. Please answer the following questions. You may use drawings if you find them helpful.

First, how did you build your project? What steps did you take? What resources did you use? How did you work with others?

What worked well during the building process?

What didn't work out so well during the building process?

How well did your idea/project work when you tried it out?

Describe two ways you can modify your design to improve it. Why do you think these modifications will help?

What did you need to learn to do in order to build your project? What tools did you need to learn how to use?

Questions to be administered at the end of the project/camp

Your time working on this project is done. Please answer the following questions. You may use drawings if you find them helpful.

After first building your idea/project, what are some things you did to try to make it work better?

In the end, how well do you think your idea/project worked?

Imagine another student wanted to do this project. How would you explain how your project works?

If you had more time, what more would you want to do with this idea/project?

What did you learn about yourself by working on this project? What did you learn about working with others?

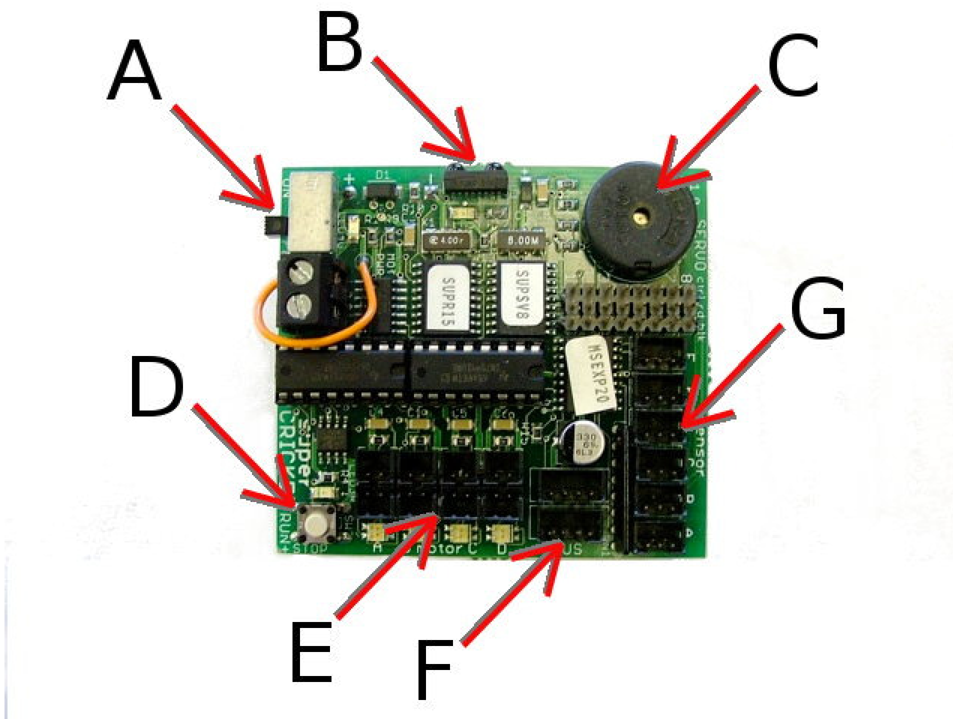
Appendix D: Rubric to Score Summer Journal

Phase of the project	Science / Engineering process skill	Questions on the portfolio	Scoring
Identification of the project	Identifying problem / generating ideas	How well does the student describe her idea?	Ratings from 0 to 5 based on how well the student articulates the various aspects of her idea (what is the idea, how did she come up with it, what is the best thing about it, what is difficult about it, etc.)
Project building	Gaining knowledge	Does the student indicate gain in knowledge?	Score Yes (1) / No (2) based on whether the student can explain new science / engineering concepts learnt.
	Researching / investigating	How well does the student explain the process of testing the product?	Ratings from 0 to 5 based on how well the student articulates what about the project worked well and what failed.
	Redesigning	How well does the student explain the required modifications to the project?	Ratings from 0 to 5 based on how well the student explains the required changes to the project and the expected results from those changes.
End of the project	Modeling and producing	How well does the student explain the overall success at the project?	Ratings 0 to 5 based on how well the student explains what did and did not work in the project.
	Communicating and Documenting	Does the student demonstrate the capacity to document his investigation and experiment?	Ratings from 0 to 5 based on how well does the student explain the entire process of the project to another student?
	Using teamwork approach and program resources	Does the student refer to working with others in a team as part of the project building process?	Ratings from 0 to 5 based on how well the student demonstrates an understanding of teamwork and adequate and optimal use of program resources

[2] Terminology based on "Ventures in Robotics": 4-H Science, Engineering and Technology curriculum, The University of California Division of Agriculture and Natural Resources Cooperative Extension.

Appendix E: Example of an Online Quiz

1. Identify the parts of this SuperCricket by matching the letter pointing at the part to that part's proper name.



D Choose...

F Choose...

E Choose...

A Choose...

B Choose...

2. Let's say you write a program on the computer and download it to the Cricket. After you do that, you immediately turn the computer off. What happens when you try to run the program?

Choose one answer.

❒ The program partially works, but the Cricket gets confused without a computer nearby.

❒ Nothing, the program can't run without the computer.

❒ The program runs fine, the Cricket doesn't need the computer once it's downloaded.

3. What will the Cricket do when the following Logo code is downloaded and run on it?

```
to main
a, on for 10
end
```

Choose one answer.

❒ Run Motor A for .1 seconds

❒ Run Motor A for 1 second

❒ Run Motor A for 10 seconds

❒ Run Motor A for half a second

❒ Run Motor A backwards

4.What will the Cricket do when the following Logo code is downloaded and run on it?

```
to main
 a, on
 wait 50
 a, off
end
```

Choose one answer.

❒ Run Motor A for 5 second

❒ Run Motor A for 50 seconds

❒ Run Motor A backwards

❒ Run Motor A for .5 seconds

❒ Run Motor A for half a second

5. What will the Cricket do when the following Logo code is downloaded and run on it?

```
to main
 beep
 wait 3
 beep
end
```

Choose one answer.

❒ Beep twice

❒ Beep twice, but you'll only hear one it happens so fast

❒ Beep forever

❒ Beep every .3 seconds

6. What will the Cricket do when the following Logo code is downloaded and run on it?

```
to main
 loop [
 wait 2
 beep
 ]
end
```

Choose one answer.

❒ Beep when it's done looping

❒ Beep twice

❒ Keep beeping forever

❒ Beep, wait .2 seconds, then end

7. What will the Cricket do when the following Logo code is downloaded and run on it?

```
to main
 repeat 2 [
 beep
 wait 3
 ]
end
```

Choose one answer.

❒ Beep two times every three seconds

❒ Beep three times

❒ Beep twice

❒ Beep forever

8. About how long will it take this program to run?

```
to main
 a, onfor 10
 note 70 3
 wait 10
 a, off
end
```

Choose one answer.

❒ 2.3 seconds

❒ 2.0 seconds

❒ 1.3 seconds

❒ 8.0 seconds

❒ 1 second

9. Fill in the blanks to make the program beep after a light sensor in port A goes above 200.

to main
______ [______]
beep
end

10. There is a sensor attached to sensor port A. We want a program to run the motors until the value of the sensor drops below 75. At that point, the program should turn the motors off for one second and then start again.

How can you modify the following program to do this?

You can copy and and paste the code into the answer area, then make your changes.

```
to main
 loop [
 ab, on
 waituntil [sensora > 25]
 ab, off
 wait 10
 ]
end
```

Answer:

Appendix F: Summer Camp Survey for TC Students

Did you participate in the iCODE program during the school year 2007-2008?
❒YES ❒NO

Please rate the iCODE summer camp on each of the following components: *(Check one box for each row.)*

	Excellent	**Very good**	**Good**	**Fair**	**Poor**
Hands-on projects	❒	❒	❒	❒	❒
On-line resources	❒	❒	❒	❒	❒
In-person visits of engineering and technology experts	❒	❒	❒	❒	❒
Internet-based interactions with industry mentors	❒	❒	❒	❒	❒
Opportunity to work with the mentors	❒	❒	❒	❒	❒
Field trip to a manufacturing or high-tech firm	❒	❒	❒	❒	❒
Opportunity to work in teams with other students at the camp	❒	❒	❒	❒	❒

In one or two sentences, how would you describe what the Summer Camp was about to a friend?

____

____

Please write one to two sentences to describe the project that you worked on during the summer camp.

____

____

What was your favorite thing about working on your project?

____

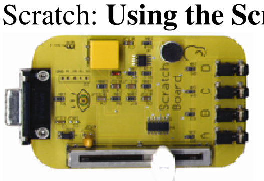
____

What was the most interesting thing you did or learned as a part of the summer camp?

____

____

During the summer camp you had the chance to develop these different skills using a cricket. Please share how skilled you think you are in each of the following areas.

	I can do this very well and could show a friend how to do it	**I can do this pretty well, and could show a friend how to do it if I had time to review**	**I can do this well enough for my own personal use**	**I can do this but only with assistance**	**I cannot do this**
Scratch: **Making sprites move**	❒	❒	❒	❒	❒
Scratch: **Changing a sprite's costume**	❒	❒	❒	❒	❒
Scratch: **Getting sprites to reach to react to each other with** 	❒	❒	❒	❒	❒
Scratch: **Changing backgrounds**	❒	❒	❒	❒	❒
Scratch: **Communicating with the**  **command**	❒	❒	❒	❒	❒
Scratch: **Using the Scratch Board** 	❒	❒	❒	❒	❒
Cricket: Logging into the iCODE site, then downloading and running programs	❒	❒	❒	❒	❒
Cricket: Wiring sensors and motors	❒	❒	❒	❒	❒
Cricket: Using the LED number display	❒	❒	❒	❒	❒
Cricket: Writing *if* and *if-else* statements with loops	❒	❒	❒	❒	❒
Cricket: Writing *and/or*: *if* statements with two conditions					

How likely are you to…	**Very likely**	**Likely**	**Possibly**	**Unlikely**	**Very unlikely**
Recommend the summer camp to a friend, sibling, or other student?	❒	❒	❒	❒	❒
Participate in the camp next summer?	❒	❒	❒	❒	❒
Participate in the iCODE program during the school year 2007-2008?	❒	❒	❒	❒	❒

Do you have any suggestions for the summer camp next year?

____

____

Appendix G: Summer Camp Survey for MS Students

Did you participate in the iCODE program during the school year 2006-2007?

❒YES ❒NO

Please rate the iCODE summer camp on each of the following components: *(Check one box for each row.)*

	Excellent	Very good	Good	Fair	Poor
Hands-on projects	❒	❒	❒	❒	❒
On-line resources	❒	❒	❒	❒	❒
In-person visits of engineering and technology experts	❒	❒	❒	❒	❒
Opportunity to work with the mentors	❒	❒	❒	❒	❒
Field trip to a university research facility	❒	❒	❒	❒	❒
Opportunity to work in teams with other students at the camp	❒	❒	❒	❒	❒

In one or two sentences, how would you describe what the Summer Camp was about to a friend?

Please write one to two sentences to describe the project that you worked on during the summer camp.

What was your favorite thing about working on your project?

What was the most interesting thing you did or learned as a part of the summer camp?

During the summer camp you had the chance to develop many skills. Please share how skilled you think you are in each of the following areas.

	I can do this very well and could show a friend how to do it	I can do this pretty well, and could show a friend how to do it if I had time to review	I can do this well enough for my own personal use	I can do this but only with assistance	I cannot do this
Build a circuit by following a schematic diagram	❒	❒	❒	❒	❒
Measure voltage in a circuit using a multimeter	❒	❒	❒	❒	❒
Write C code to control LEDs and button switches in a circuit	❒	❒	❒	❒	❒
Program the GPS receiver to display satellite data on the LCD	❒	❒	❒	❒	❒
Use a GPS device to find a location based on its latitude and longitude	❒	❒	❒	❒	❒
Write C code to retrieve and play MP3 files on a USB flash drive	❒	❒	❒	❒	❒
Use buttons to customize the interface for your MP3 player	❒	❒	❒	❒	❒
Design an interactive video game using Scratch	❒	❒	❒	❒	❒
Use data from the accelerometer to make things happen in Scratch	❒	❒	❒	❒	❒
Upload a Scratch project to the Scratch web site	❒	❒	❒	❒	❒

How likely are you to…	Very likely	Likely	Possibly	Unlikely	Very unlikely
Recommend the summer camp to a friend, sibling, or other student?	❒	❒	❒	❒	❒
Participate in the camp next summer?	❒	❒	❒	❒	❒
Participate in the iCODE program during the school year 2007-2008?	❒	❒	❒	❒	❒

Do you have any suggestions for the summer camp next year?

____

____

____

Appendix H: Educator Survey

Implementation of the Program

Please base your answers to these questions on the iCODE sessions you conducted during the 2006-2007 school year (i.e., not including the iCODE summer camp).

1. How many iCODE sessions did you conduct in the 2006-2007 school year? __________

2. On average, how long was each session? __________

3. Please provide the following information about student participation:

students who started the program at the beginning __________
students who joined the program after it started __________
students who dropped out before the end of the program __________

4. In a typical iCODE session, to what extent did each of the following happen? Please consider the class as a whole.

	To a great extent				Not at all
Students built their project by following instructions from the on-line project guides	5	4	3	2	1
Students loaded code from the project guides into their projects	5	4	3	2	1
Students extended the physical or electrical designs of their projects in ways that were not laid out by the project guides	5	4	3	2	1
Students extended code for their project in ways that were not explicitly provided in the project guides.	5	4	3	2	1
Students debugged the physical or electrical design of their already-built projects (trying to get them to work properly)	5	4	3	2	1
Students debugged the code for their existing project	5	4	3	2	1
Students used quantitative and measurement skills	5	4	3	2	1
Students engaged in a reflective process (e.g., discussed past work/accomplishments, documented their own work, shared ideas with peers)	5	4	3	2	1
Students engaged in exploratory/research work (e.g., looking at others' designs, in the classroom or on-line)	5	4	3	2	1
There was discussion about the relevance of the session (the activities, student work, etc.) to real-world activities	5	4	3	2	1
Students worked side by side with undergraduate mentors	5	4	3	2	1
There was community building among students	5	4	3	2	1
There was community building between students and engineers, inventors, and/or other adults	5	4	3	2	1

5. How did you use the iCODE curriculum and materials?

❑ I used curriculum and materials exactly as I received them.

❑ I made some changes and modifications to the curriculum and materials. Please explain:

6. Thinking about your iCODE experience thus far, to what extent have you felt …

	To a great extent				Not at all
Prepared to lead the program?	5	4	3	2	1
Confident leading discussions with students about the design activities?	5	4	3	2	1
Knowledgeable about the design process?	5	4	3	2	1
Comfortable using the iCODE tools?	5	4	3	2	1

7. Please describe any specific challenges you faced during the implementation of the program:

8. Is there any kind of assistance or support you would have liked from the iCODE project team, but didn't receive?

❑ Yes; please explain:

❑ No

The Role of Undergraduate Mentors

9. Did you have any undergraduate student mentors help you implement the program?

❑ Yes; how many? __________

❑ No

10. How many iCODE sessions did your undergraduate student mentors attend?

11. Describe briefly how your mentors were involved in the program:

12. Overall, how helpful were the mentors?

❑ Extremely helpful

❑ Very helpful

❑ Somewhat helpful

❑ A little helpful

❑ Not at all helpful

Benefits to Students

13. Overall, how interested were students in the programs?

- ❑ Extremely interested
- ❑ Very interested
- ❑ Somewhat interested
- ❑ A little interested
- ❑ Not at all interested

14. How successful would you say the program was in accomplishing the following objectives for students?

	Extremely successful	Very successful	Somewhat successful	A little successful	Not at all successful
Increasing their understanding of engineering	5	4	3	2	1
Increasing their understanding of electronic devices	5	4	3	2	1
Increasing their academic achievement	5	4	3	2	1
Providing them with opportunities to work together with other students	5	4	3	2	1
Increasing their knowledge about careers in science and technology and engineering	5	4	3	2	1
Improving their attitudes about careers in science and technology and engineering	5	4	3	2	1
Increasing their problem solving abilities	5	4	3	2	1
Assisting them to translate the program materials into hands-on-projects	5	4	3	2	1
Helping them feel connected to the larger IT community through program involvement	5	4	3	2	1

15. In your opinion, what aspects of the iCODE program have been most effective in accomplishing the program's objectives for students, and why?

Involvement of Parents

16. How involved in your program were parents of iCODE students?

❑ Extremely involved
❑ Very involved
❑ Somewhat involved
❑ A little involved
❑ Not at all involved

17. In which of the following events did parents participate?

❑ Feedback on take-home activities
❑ Year end evening program at the after school program site
❑ Career events
❑ BotFest event
❑ Robot Sumo event
❑ Summer workshop Design Show

Your Feedback about iCODE

18. How satisfied have you been with your experiences in the iCODE program?

❑ Extremely satisfied
❑ Very satisfied
❑ Somewhat satisfied
❑ A little satisfied
❑ Not at all satisfied

19. How satisfied have you been with the following iCODE materials?

	Extremely satisfied	**Very satisfied**	**Somewhat satisfied**	**A little satisfied**	**Not at all satisfied**	**Not applicable**
Design challenges (instructions, interactive exercises, programming tasks, explanatory notes, video clips)	5	4	3	2	1	N.A.
Instruction manuals	5	4	3	2	1	N.A.
The on-line programming portal	5	4	3	2	1	N.A.
Collaboration tools	5	4	3	2	1	N.A.
Project portfolios	5	4	3	2	1	N.A.

20. What have you enjoyed most about being involved in the iCODE project?

21. Please take a moment to write your suggestions for improving the iCODE project:

<u>About You</u>

22. Are you a teacher by profession? ❑ Yes ❑ No

If yes, what grade(s) do you currently teach? *(Check all that apply.)*

❑ 6th grade ❑ 7th grade
❑ 8th grade ❑ 9th grade
❑ 10th grade ❑ 11th grade
❑ 12th grade ❑ Other; please specify:

23. Do you teach science and/or math? ❑Yes ❑ No

24. If yes, how many years have you been teaching science and/or math? _____________

25. How many years have you been teaching in total? __________

26. Are you:
❑ Male
❑ Female

27. What is the highest degree you have received? *(Check only one.)*
❒ None
❒ Elementary school diploma
❒ High school diploma or the equivalent (GED)
❒ Associate degree
❒ Bachelor's degree
❒ Master's degree
❒ Professional degree (MD, DDS, DVM, LLB, JD, DD)
❒ Doctorate degree (Ph.D. or Ed.D.)

28. What is your race/ethnicity?
❒ American Indian or Alaska Native
❒ Asian
❒ Black or African American
❒ Native Hawaiian or Other Pacific Islander
❒ Spanish/Hispanic or Latino
❒ White
❒ Other; please specify
____

THANK YOU!

Appendix I: Observation Protocol

Observation Date: _____________ Time Start: ______End: ________

Site: __________________________ Leader: ________________

Part One: Descriptive information about the Session

1. Name of project students working on: __________________________

2. Students: ______ Number of males __________ Number of females

Grades of the students: ❑ 5th ❑ 9th
❑ 6th ❑ 10th
❑ 7th ❑ 11th
❑ 8th ❑ 12th

3. Was there an undergraduate mentor present? ❒ Yes ❒ No

4. How did the leader introduce/begin the session?

5. Indicate how session time was spent.

Activity Description Time Allotted to Activity

________________________________ ______________ minutes

________________________________ ______________ minutes

________________________________ ______________ minutes

6. Indicate which components of the on-line system the students used and describe their use of each component:

On-line System Components	Used	Describe use
Design challenges	❒	
Collaboration tools	❒	
Project portfolios	❒	
Instruction manuals	❒	
Programming interface	❒	

7. A. Did the physical environment constrain the implementation of the activities in any way?

❒ Yes ❒ No

If yes, please explain:

____

____

7. B. Did any specific parts /aspects of the environment work well to promote the success of the activity?

❒ Yes ❒ No

If yes, please explain:

____

____

Part Two: Approach to the Session

8. Considering only the amount of time spent on the activities (excluding housekeeping activities, etc.), approximately what percent of this time was spent on each of the following?

Listening to the leader lecture or instructions	__________%
Watching the leader demonstration	__________%
Facilitated group conversations	__________%
Hands-on activity with physical materials	__________%
Writing code	__________%
Making plans or drawings or other design activity	__________%
Documenting past work	__________%
Off-task activity (cell phone use, conversation off topic etc)	__________%
	100%

9. Considering only the amount of time spent on the activities (excluding housekeeping activities, etc.), approximately what percent of this time was spent in each of the following arrangements?

Whole class	__________%
Pairs/small group	__________%
Individuals	__________%
	100%

10. What was the educator's role in the lesson? ***(Check all that apply.)***

❒ Demonstrated a new concept/lab activity
❒ Lectured
❒ Gave procedural instructions
❒ Introduced new material
❒ Reviewed previous material
❒ Supervised group activities
❒ Posed questions that had predefined, "fill-in-the-blank" answers
❒ Posed questions that encouraged students to generalize their knowledge to new situations
❒ Posed questions that created open-ended discussion
❒ Encouraged students to raise questions for discussion

11. What was the mentor's role in the lesson? ***(Check all that apply.)***

❒ Demonstrated a new concept/lab activity

❒ Lectured
❒ Gave procedural instructions
❒ Introduced new material
❒ Reviewed previous material
❒ Supervised group activities
❒ Posed questions that had predefined, “fill-in-the-blank” answers
❒ Posed questions that encouraged students to generalize their knowledge to new situations
❒ Posed questions that created open-ended discussion
❒ Encouraged students to raise questions for discussion

Part Three: Indicators of Design and Implementation of Session

12. Please rate the following indicators of the design of the session:

	Not at all				To a great extent
Hands on activities					
Students were building their project by following instructions from the on-line project guides	1	2	3	4	5
Students were loading code from the project guides into their projects	1	2	3	4	5
Students were extending the physical or electrical designs of their projects in ways that were not laid out by the project guides	1	2	3	4	5
Students were extending code for their project in a way that was not explicitly provided in the project guides.	1	2	3	4	5
Students were debugging the physical or electrical design of their already-built projects (trying to get them to work properly)	1	2	3	4	5
Students were debugging the code for their existing project	1	2	3	4	5
Engineering design processes and communication					
The session allowed students to use quantitative and measurement skills.	1	2	3	4	5
Students engaged in a reflective process, including but not limited to, discussions of past work/accomplishments, documenting their own work, sharing ideas with peers	1	2	3	4	5
Students were engaged in exploratory/ research work: looking at others' designs, in the classroom or on-line	1	2	3	4	5
Community Building					
There was discussion about the relevance of the session	1	2	3	4	5

(the activities, student work, etc.) to real-world activities.					
The session encouraged students to work side by side with undergraduate mentors.	1	2	3	4	5
The session encouraged community building among students.	1	2	3	4	5
The session encouraged community building between students and engineers, inventors, and other adults.	1	2	3	4	5

Comment on your ratings:

13. Please rate the following indicators of implementation:

	Not at all				To a great extent
The leader appeared prepared to lead the activity.	1	2	3	4	5
The leader appeared confident in her ability to lead the activity.	1	2	3	4	5
The pace of the activity was appropriate for the developmental levels/needs of the youth.	1	2	3	4	5
The leader appeared confident in her ability to lead discussion/give feedback about the activity.	1	2	3	4	5
The leader appeared fluent in the design process.	1	2	3	4	5
The leader knew how to use the tools	1	2	3	4	5
The leader appeared to understand safety considerations.	1	2	3	4	5
The leader encouraged students to share their ideas.	1	2	3	4	5

Comment on your ratings:

____

____

Comment on any implementation challenges observed during the session:

____

____

Part Four: Student Engagement

Overall, how engaged were the students in the session?

❒ Not at all engaged
❒ Only a little engaged
❒ Somewhat engaged
❒ Very engaged
❒ Extremely engaged
❒ Too varied to rate; please comment

____
____

Examples of behaviors, remarks, etc. that were used to indicate engagement:

Part Five: Narrative Summary

Tag line: Write a phrase or brief sentence that captures the story of this observation

____

Narrative
In a few short paragraphs, describe what happened during this session, including enough rich detail that readers have a sense of having been there. Include:

- Where this session/activities fit in the overall program
- The focus of the session/activities
- The materials used
- A synopsis of the structure/pace of the session/activities
- Roles of the leader and students, including self- and leader-directed learning, posing questions, etc.
- Roles of any other adults in the room
- The physical environment, including the size and feel of the room, the availability or appropriateness of furniture, materials, etc.

Appendix J: Student Focus Group Protocol

A Research Associate from GRG will conduct half-hour, semi-structured focus groups with the students participating in the iCODE project. Two such focus groups will be conducted, one at a Boston site and the other at a Lowell site. If conditions allow, the discussions will be tape-recorded. Name tags will be used to identify participants.

The main objective of the focus groups is to gather information from the students on the following topics:

- Student experiences with iCODE
- Student engagement with the materials
- Student feedback about the iCODE activities

The moderator of the group will use this protocol to introduce herself/himself to the group, and to elicit information on the above mentioned themes.

I. Welcome/Background information

- **<u>GRG Introduction:</u>** *My name is _______. I am with Goodman Research Group, an education research group in Cambridge, Massachusetts. We are the evaluators of the iCODE program.*

- **<u>Participant Introduction:</u>** *Could we go around the room/table and have everyone say their name? I'd also like you to put on a nametag so that I can use your names during our discussion.*

- **<u>Statement of Purpose:</u>** *The purpose of the discussion today is for us to hear about your experiences participating in the iCODE project. We'll summarize what we hear and share it with the iCODE team, and what you say will be used to help improve the program. I want you to know that what you say in this discussion is confidential; we will not use your individual names in our report.*

- **<u>Request to Tape-record:</u>** *I'd like to tape this discussion so that I can listen to what you say and remember it without taking lots of notes. I'm the only one who would listen to the tape. Does anyone object to taping?*

- **<u>Ground Rules:</u>** *Okay, a few ground rules before we get started. First, in some ways your experiences might be the same, but in other ways they might be different. I want to hear everyone's perspective, so please speak up if your experience is different than someone else's. Also, I want to hear from* *everyone, so if some people are talking a lot and other people aren't talking much, I might ask you if you have something to say.*

- **<u>Questions:</u>** *Do you have any questions before we begin?* ***Let's get started!***

Date and time of focus group:
Name of interviewee:

Researcher comments (if any):

II. Student experiences with iCODE

- Tell me a little bit about your experiences with the program.
- What do you like best about the program? Why?
- What do you like least about the program? Why?
- Is the program what you thought it would be like, or is it different from what you thought it would be?
- Was there anything about the program that you found to be really hard? (Probe for implementation challenges)
- Do you all plan to continue the program next year? If no, why not?

III. Student engagement with the materials:

- Are the materials used in the program easy or hard to use? (Probes for relevance and ease of use of the materials). Also ask the students to particularly comment on the online-collaboration tools
- Did you use the student project booklets? If yes, how and when did you use them?
- Do you have any suggestions for improving the material?

IV. Student feedback about the iCODE activities

- Which activities, conducted during the program, have been most interesting to you?

- Which Design Challenge was your favorite? Why?

- How do you think you would use the knowledge gained through these activities in future?

- What are some of the new ideas / concepts / technologies you learnt during the program?

V. Concluding remarks

- Before we end, do you have any suggestions for improving the program?

- That covers all my questions. Is there anything else you would like to tell me about your experiences and opinions that we haven't already talked about?

Thanks so much for taking the time to talk with me. Your feedback is very valuable to iCODE. Good luck with the project!

Appendix K: Educator Interview Protocol

A Research Associate from GRG will conduct semi-structured interviews with the educators involved in the iCODE project. Two interviews will be conducted one at a Boston site and the other at a Lowell site. If conditions allow, the interview will be tape-recorded.

The main objective of the interviews is to gather information from the educator on his / her perceptions about the particular session.

The interviewer can use this protocol to introduce herself/himself to the educator. The questions listed in the following sections can be used as prompts.

I. Welcome/Background information

- **<u>GRG Introduction:</u>** *My name is _______. I am with Goodman Research Group, an education research group in Cambridge, Massachusetts. We are the evaluators of the iCODE program.*

- **<u>Statement of Purpose:</u>** *The purpose of the interview today is for us to hear about today's session with the students. I want you to know that what you say in this interview is confidential; we will not use your individual name in our report. The information you provide will be used to help improve the program*

- **<u>Request to Tape-record:</u>** *I'd like to tape this interview so that I can listen to what you say and remember it without taking lots of notes. I'm the only one who would listen to the tape. Do you object to taping?*

- **<u>Questions:</u>** *Do you have any questions before we begin?*

Let's get started!

Date and time of interview:
Name of interviewee:

Researcher comments (if any):

II. Today's Session

How did you feel about the session today?

What do you think worked particularly well?

Was there anything that was particularly challenging, or that didn't work out as you had planned?

Did you accomplish what you wanted to today?

How did you use the different on-line system components of the program (design challenges, collaboration tools, project portfolios, instruction manuals, programming interface) today?

II. Today's Session in Comparison to other Sessions

How did this session (or activity) compare to other sessions (or activities) you've done as part of this project? Was it more or less successful, or about average?

How did it compare to other sessions in terms of students' engagement? Were they more or less engaged today, or about the same?

III. Preparation for Today's Session

Can you tell me a little bit about how you prepared for today's session (or activity)?

In retrospect, how well did the training prepare you for this session (or activity)?

Did you modify today's activity, or use it "as is"?

IV. Concluding remarks

- That covers all my questions. Is there anything else you would like to tell me about your session today that we haven't already talked about?

Thanks so much for taking the time to talk with me. Your feedback is very valuable to iCODE. Good luck with the project!