

Science Technology Engineering Program (STEP) Summer Camp for K-12 Students

Atin Sinha¹, Wanjun Hu²

Abstract – Albany State University, located in South Georgia conducts a summer camp since 2008 to motivate K-12 students select STEM majors as career goals. The original intent of the camp was to increase the enrollment in computer science programs, but that was expanded to increase other science and engineering programs enrollments also. The camp activities include training in Nxt robots, computer animation and gaming software such as Alice and scratch and various engineering equipment such as Wind tunnel, CNC machine, SolidWorks CAD. The paper describes the projects in brief and students' perception of the week long summer activities.

Keywords: Summer Camp, Nxt Robot, Alice, Scratch, SolidWorks CAD

INTRODUCTION

Academic summer camps in various STEM related disciplines have become popular in recent times partly in response to demands of reinforcing the material covered during the normal school year and partly to provide students exposure to new hands-on project oriented activities which often could not be covered during regular class periods. Albany State University (ASU) located in rural south Georgia holds a number of summer camps, but none offers rigorous project oriented training in any of the STEM disciplines till Science Technology Engineering Program (STEP) was introduced in 2008 with the seed money receive from NSF through a grant from Georgia Institute of Technology. Though the camp started out with a mission to improve the falling enrollment in computer science degree program during the post collapse of the dot com bubble when students avoided everything related to computers, the camp activities were enlarged to include several engineering testing and manufacturing projects in later years.

EARLY EXPERIENCE

When the first camp was held with help and guidance from Georgia Tech, it was more of one tentative step rather than a well planned endeavor. Many of the rules in the playbook handed down by Tech did not have any relevance in socially and economically different South Georgia culture. Hence we had to adapt as we went along which to some extent continues till today. The first order of business in holding a summer camp in any discipline for the first time is to build an organizational structure with clearly delegated responsibility to individuals who will be committed to get the job done which always is a challenge in a small liberal arts university like ASU. Next recruitment of qualified students to fill the camp to capacity was the most daunting task. We advertised through multiple channels: information and application package was posted in the Engineering website, flyers mailed to schools and old fashioned phone calls to the teachers and counselors who participated in other ASU sponsored activities. In order to get a larger share of women enrolled in the camp the local Girls Inc. was contacted though no suitable candidate was found. In spite of all our effort in that first year, there were only 7 students enrolled in the summer camp partially due to the fact that there was an application as well as registration fee charged. Though we planned to hold one camp for high school and one for the middle school, it soon becomes obvious that there would not be enough students to fill both. So, a common camp with both high and middle school students was held with 3 from middle school and 4 from high school. Apart from recruitment next challenge was to arrange the logistics such as food, parking, application package containing various forms including application form, letter of recommendations, financial aid, health insurance, release and waiver form and a sundry others. It was also necessary for the camp director to manage this logistics and keep up to various deadlines including reporting of the event to campus authorities monitoring summer activities and university police department. Apart from academic work, ASU summer camp was also intended to provide the students with a glimpse of college experience and as such an hour of sports activities such as swimming or basketball was arranged every afternoon before adjournment for the day.

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CAMP ACTIVITIES

Nxt Robotics:

These are the next generation programmable robots made by Lego Mindstroms. The primary differences of the Nxt robots with the older Mindstorms version are:

- Fewer parts and hence easy to assemble
- Components are sturdier
- Speech capability with limited vocabulary
- Ultrasonic sensor to sense distance
- Ability to integrate to sensors and other parts from the older robots



Totally these robots have 4 sensor ports and 3 ports for output devices such as motors or lights. ASU Nxt robots use touch, light, sound and ultrasonic sensors. For output devices, we have used only motors for forward/backward motion and lamp only. On the first day of the camp after normal introductory lectures, students were asked to assemble their robots from parts as per the instructions in the manual. Afterwards they were introduced to programming the Nxt which is based on LabVIEW programming language. As with any new equipment, it was a challenge to develop a set of projects that students can complete in a reasonable time with minimum of instructions. Five projects were developed where students can test their knowledge of programming the sensors and output devices as well as specific programming construct such as Loops and Switches.

The Nxt robot programming projects for the camp are derived from the projects from the introductory engineering course, “Principles of Engineering Analysis and Design”[1]. Some sample projects are shown below:

Project 1

The NXT will move forward till it crosses a dark line when it will say “sorry” and start going back till it bumps into an object.

At that point it will say “oops” and move forward again for one second and stop.

Hints: You need to reposition the light sensor downwards so that it can sense the reflected light. Also, calibrate the sensor on the dark line to set the trigger.

Project 2

Program to move your NXT to make a figure of 8. The radius of each of the circle should not be more than 6” to 8”. You have to experiment with the steering control of the move block by using the sliding bar at different setting.

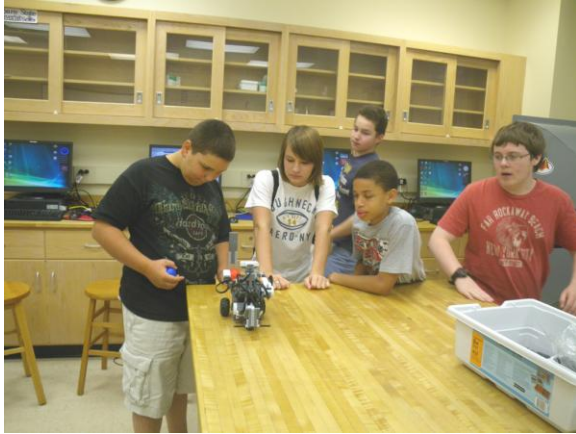
You also need to put a stop control by either setting the time or degree rotation or number of revolutions.

All of the students can complete these projects mentioned above with some help from the instructors. As students work at their own pace another more challenging project is included to accommodate students who finish the earlier projects.

Project 3

The NXT will go forward until it sees an object close enough. At that point to avoid collision, it will stop, say “Sorry” and turn 120°. It will continue moving in its new path till it gets close enough to another object and the process will repeat itself till it crosses a dark line when it will say “Stop” and comes to a stop.

- Hints: 1) You should use ultrasonic sensor to judge how close the NXT gets to an object and set it to trigger at about 10". Use Loop command to repeat the process.
- 2) For stopping use the light sensor and set the trigger at light intensity at about 15.



In that first year, students were extremely impressed with Nxt robots as were evident in their comments in the post camp survey questionnaire as well as letters from their parents describing their children's experience in the camp in glowing terms.

A set of humanoid robots were added in the 2012 camp and they were an instant hit among the students.

Computer Theories through Games:

Computers use a different number system, i.e., binary number system. We were taught to use the decimal number system since kindergarten. However, binary number system is more natural than decimal number system. In all camps, we had one major activity that is identifying binary numbers around us. For instance, in summer 2012, students were asked to use forks and knife, or objects of two different shapes at home to form binary numbers.



Binary numbers in shapes

Students were also exposed to some basic searching and sorting algorithms (or ideas). For instance, students were asked to arrange ten pen/pencils line up by their length intuitively, i.e., placing the longest one at the far left hand side, then the next longest one, then the next longest one and so on. After that, students were present with two questions:

- (1) Do you have any other ideas to do that?
- (2) What if you have ten thousand sticks to line up?



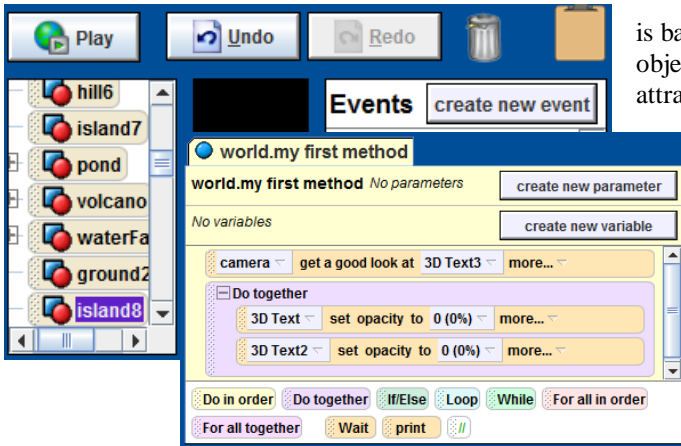
A very long line of pencils for sorting

Then, the ideas (algorithms) of Insertion Sort, Bubble Sort were naturally introduced. The concept of Sequential Search and Binary Search were introduced in a similar method.

During the summer camp, students actively participated in the demonstration of those searching and sorting algorithms. In particular, students were organized outside the building to demonstrate the so-called Network Sort, which was a very good exercise. They were able to understand those basic computer science concepts easily.

Next, students learned basic programming technique in two interactive programming environments, Alice and Scratch.

Alice animation software:



Alice [2] is a 3D programming languages that is based on Computer Graphics. It is event-driven and object-oriented. The design of the software can easily attract students into programming, which makes instructions much easier. When coding, students started with selecting some objects from the existing galleries, and place them inside a so-called “world”. Each object is equipped with some abilities (methods) that a programmer can use to order that object to do certain things. Programming in such an environment, students assume the role of the commander (or director) of a team (resp. film). A commander will issue orders by adding pre-defined events into the coding.

Control structures are introduced naturally when students wanted several objects act in certain ways. Variables and grammars are not a concern at all in Alice, which is a major factor that attracts students’ interest and confidence in computer programming. During all camps, students showed more interests in Alice programming than other computer science activities. In the surveys of 2008, 2011, 2012, students showed positive attitude towards computing programming.

Scratch gaming software:

Scratch [3] is a similar interactive programming environment. Each (2D) object has a place for scripts, a



A student demonstrates his Scratch project

place for loading or creating new costumes, and a place for loading or creating sounds. Scripts are built by control blocks

such as loops, operators, if-then-self, etc. The environment is a very good tool to create a cartoon for telling a story. However, students must get used to variables and logic thinking, which have been the major obstacle for students to write a computer program.

During the camps, students were asked to use either one or two objects (sprites) and include at least three stages for a short story. In general, students were able to use the building blocks for creating a game.

Some students showed strong interests in control structures. The picture on the left hand side shows a student demonstrating his game, which contains six balloons moving at a randomized path at a very fast speed. A point will be scored in this game when a player can click on a balloon.

SUBSEQUENT YEARS

Because of unavailability of instructors during the summer, the camp was not held for two consecutive years. In 2011, the camp was resumed as there was continued interest in the community. This time, the scope of the camp was broadened by including some engineering projects [4] described below:

Manufacturing Project in CNC lathe:

The chosen project was to make a chess piece which is a easily recognizable item.

The CNC lathe is PC Turn 55 built by Emco-Maier. This equipment is controlled by WinCAM software that is well suited for rapid introduction to CNC technology. Students with little or no previous experience can get familiar with all aspects of CAD/CAM assisted NC programming within a very short period though it is more suited for high school students than middle school students because of complexity of the variety of instructions.

WinCAM software is windows based integrated training environment for turning and milling machines. It has 3 modes: CAD, CAM and NC. WinCAM helps create an on-screen graphic workpiece in the CAD mode, and then an NC program can be generated in the CAM mode by means of various icons representing different machining operation. The resulting NC program can be processed in the NC mode to machine the part from the stock or can be transmitted to a full size CNC industrial machine.



Students were supplied coordinates of different chess pieces, such as pawn, bishop, queen etc. to develop a CAD drawing and then program the tool path in the CAM mode. The resulting NC program was transferred to the computer with direct connection to the PC Turn 55 machine where desired chess piece was made from a plastic 1" stock. The machining part was done by the instructor. Though not everyone completes this project, but the actual machining operation always draws everyone present to watch with rapt attention.

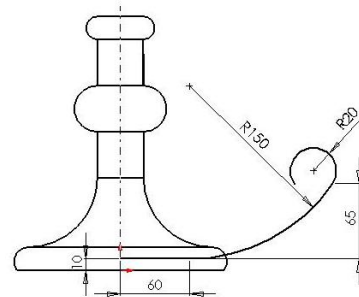
Solid Modeling in SolidWorks CAD software and building Prototype in a 3D Printer

SolidWorks is a computer aided design software package used to produce parts, assemblies and 3-view drawings. It is a Windows based true 3D solid modeling CAD Program. SolidWorks is parametric design software, which is intuitively easy to follow, and one can be productive in developing parts in SolidWorks in a relatively short period of time. The project used in the summer camp is to make a 3D part drawing of a candle stick and build it in a Dimension 3D Printer. Students are given a quick overview of the fundamentals of engineering graphics and introduced to SolidWorks part drawings by first sketching and then solidifying by extruding, revolving or sweeping. The candle stick requires using revolve, sweep and cut-extrude commands. In general students can

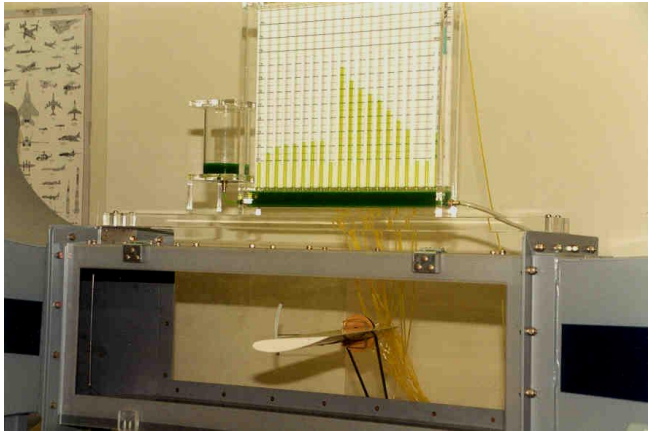


complete this project with some help from the instructor. The saved project in *.stl format is transferred to the catalyst software which sends it to the Dimension 3D Printer to make the prototype part. Though it takes a fairly long time to make the prototype (couple of hours), students are always excited to hold the physical part that they created in their hand.

Normally students spend one entire day to complete the two projects described above.



Flow Visualization in Wind Tunnel



Albany State University's FLOTEK 1440 wind tunnel is a subsonic open circuit tunnel with a test section of 12" x 12" x 36" capable of reaching a maximum wind speed of about 90 mph at the test section. The tunnel speed and model angle of attack can be controlled manually or from a computer connected to the tunnel by LabVIEW software. Students were given a demonstration of airflow over a NACA 2415 airfoil section. Relationship of pressure and velocity as explained by Bernoulli's Equation, creation of lift due to uneven pressure over the upper and lower surface and origin and propagation of stall was explained to them. All of the students always enjoy this demonstration as they can relate it to airplane flight.

DEMOGRAPHICS

ASU being one of the historically black universities; in general about 90% students are African-Americans. Similarly, in the Albany metropolitan area, about two thirds of the population is African-Americans. So, it may logically be expected that in ASU summer camp there will be more African-Americans enrolled than students from any other ethnic background. However, from the very beginning, a conscious effort was made to recruit the most academically gifted students. Also, the first two years of the camp, a registration fee was charged. As a result, in one of the three years, there were very few African-Americans compared to whites. The following table provides the demographic breakdown of the summer camp enrollments.

Table 1. Demographic Breakdown of Summer Camp Enrollment

Year Summer Camp was held	Total number of participants	African-Americans	Whites	Other	Male	Female
2008	7	4	2	1	6	1
2011	6	1	5		5	1
2012	17	13	4		12	5

EVALUATIONS

As has been mentioned earlier, the summer camp in its first year was more of an attempt to establish a constituency of K-12 students who are willing to get hands-on training in STEM subjects when the schools are off. As such, there has not been a systematic effort to collect pre and post student evaluation. However, at the end of the camp students overall comments were:

- (a) It was a great experience
- (b) The workshop was fun
- (c) Hope to be here next year.

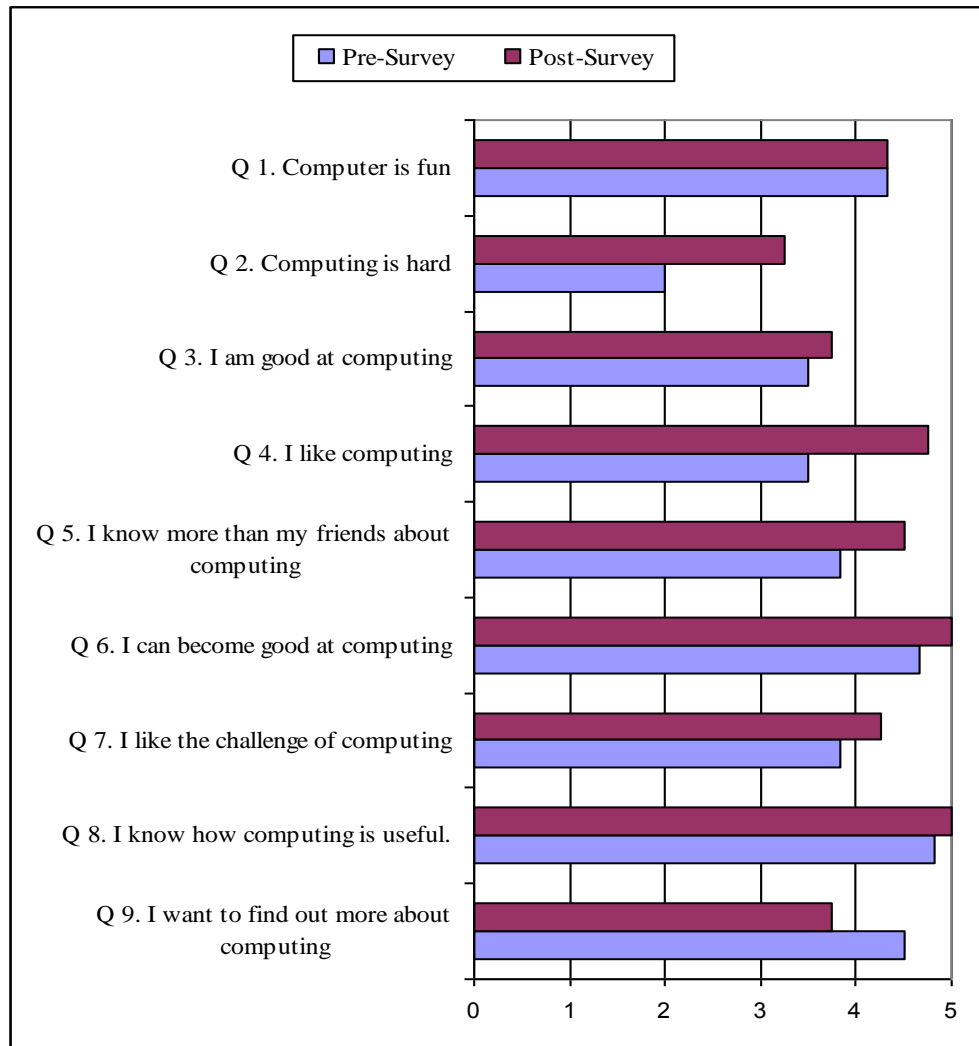
Even more encouraging written testimonials in the form of the following e-mails from parents demonstrated the success of that first camp:

- (a) *"Trey has not quit talking about the classes – he has been on the computer continuously since the finish of the camp. Thank you for offering this camp. It is a great tool to use for increasing the interest of those students who are "engineerically" inclined. Trey truly enjoys your classes and looks forward to learning more about the options available to him in the field of engineering (especially with Robots)."*
- (b) *"I would like to thank you for everything that you all did to make this camp a success! As I watched the kids, I noticed they really were enjoying themselves. They didn't mind sharing what they had done. Please consider more opportunities for learning with the middle school students (to urge them to consider this major and as a possible career path). If possible I would like to see more of this during the school year and possibly culminate with a visit to Georgia Tech campus. Brenten enjoyed himself and learned an amazing amount of information in such a short time."*

In 2011, the second year of STEP summer camp, students were given a more formal pre and post survey questionnaire where they had to select from 1 to 5 in likert scale showing their agreement to questions in increasing order. The questions were concentrated on their experience about computing along with recreational activities that required participation in order to provide a well rounded pre-college experience during the summer. No questions were asked specifically about robotics or other newly introduced engineering projects.

Fig 1. demonstrates the comparison of the mean value of same pre and post survey questions, where 5 means strong agreement and 1 means strong disagreement.

Fig 1. Pre and Post survey comparison for 2011 STEP Summer Camp



Students' answers to every question showed positive effect of the camp other than the second and the last one. The answer to second question can be explained as more students learned on the subject more they realized how complex it is which shows the depth of their understanding. The answer to the last question is probably due to fatigue of over exposure in a fairly short time (about two days).

The 2012 survey questionnaire included questions on robotics and engineering apart from computing. However, the pre and post survey questions were substantially different. Only a handful of questions were same in both the pre and post survey in 2012. Fig 2. display students answers to most relevant questions in the post survey questionnaire which has a bearing on the success of the camp. Fig 3. shows the comparison of the students answers to those questions which were same in the pre and post survey questionnaire.

Fig 2. Student Evaluation of 2012 Post Summer Camp Survey

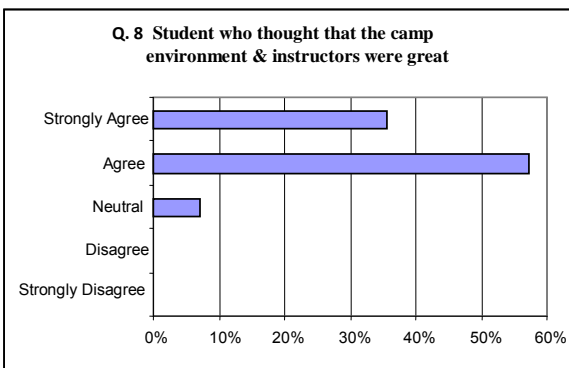
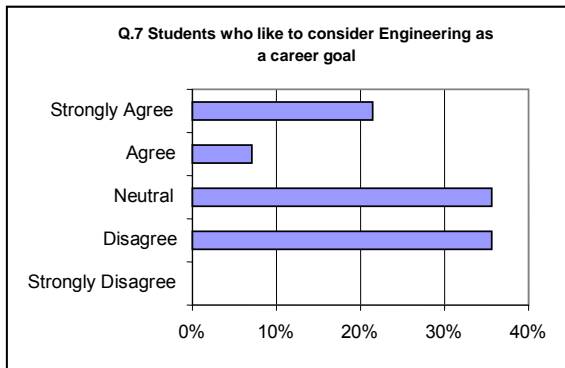
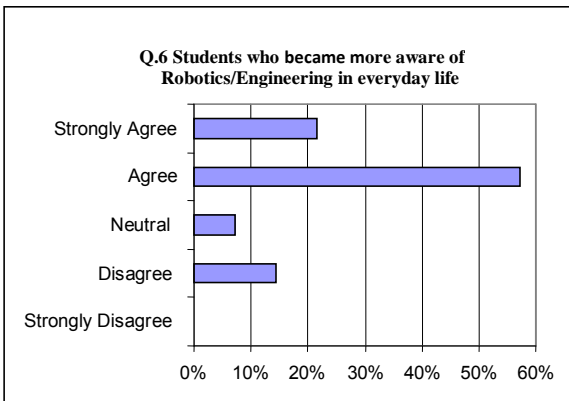
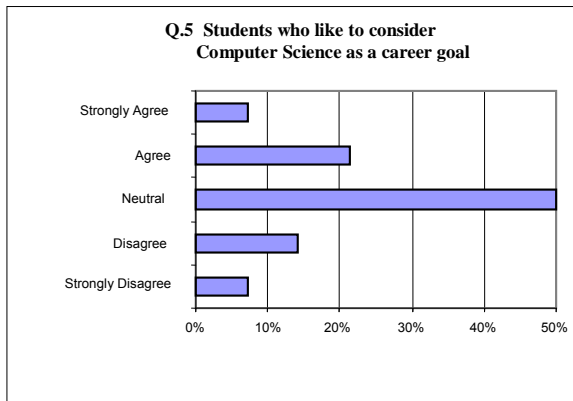
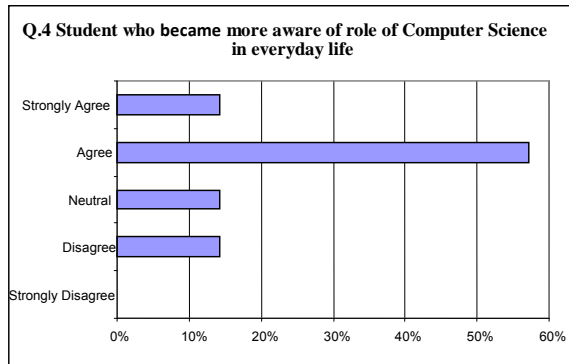
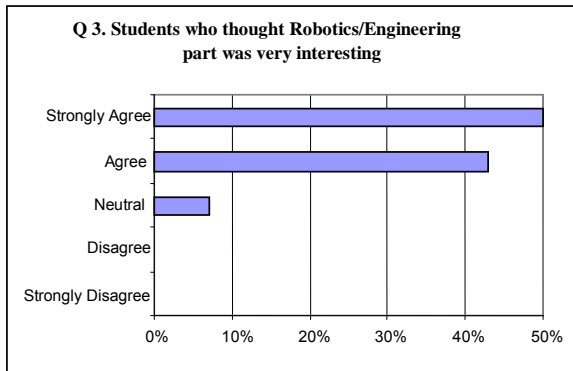
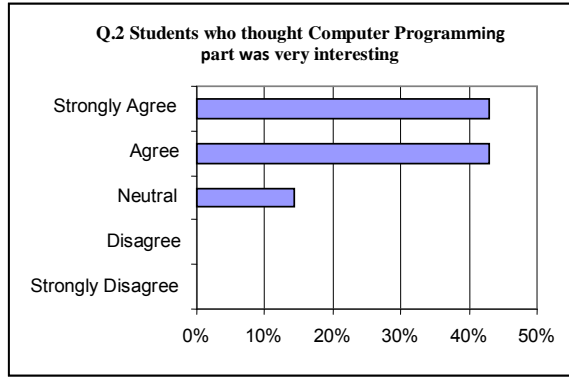
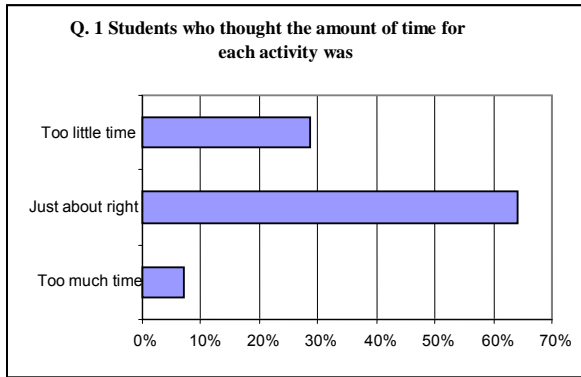
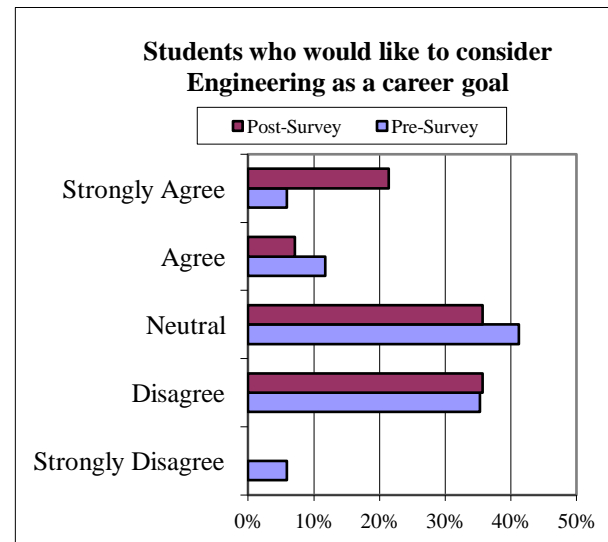
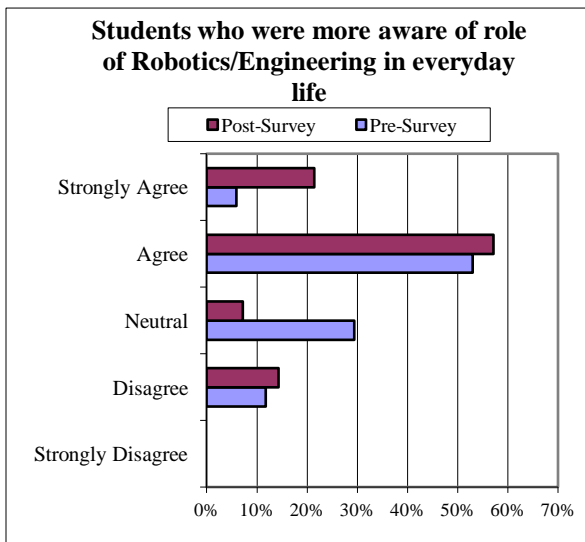
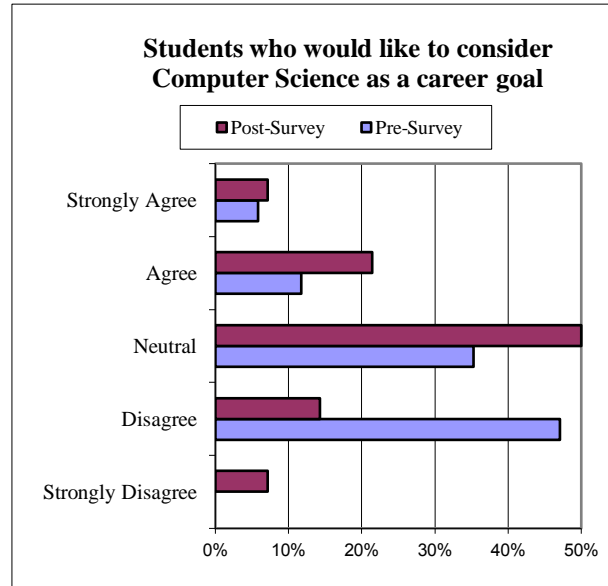
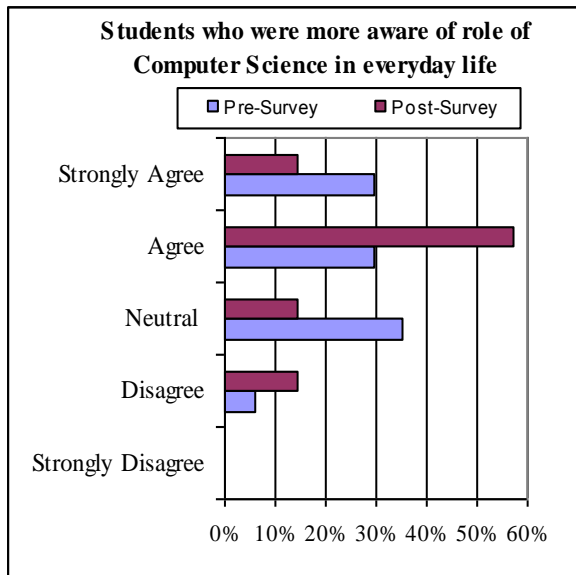


Fig 3. Pre and Post survey comparison for 2012 STEP Summer Camp



Above charts show a clear shifting of students' attitude on both computing and engineering as a result of the camp. Students awareness about role of computer science jumped from 59% pre-camp (judged by the answers given as agreed or strongly agreed) to 71% post-camp. For robotics/engineering the same figures showed 59% pre-camp to 79% post-camp.

Though the comparable figures in answer to choosing either of the disciplines as career goals are much more modest, but it also showed the positive effect of the camp. Both for computer science as well as robotics/engineering, the choice of career goals jumped from 18% (pre-camp) to 29% (post-camp).

FUTURE CHALLENGES

Based on students' evaluation and the parents' comments, the summer camp undoubtedly is a success and should be continued in the coming years. However, recruiting academically qualified students in significant numbers to fill the camp to capacity has always been a challenge. This is evident from the very low enrollment of the first two years when a registration fee was charged. In 2012 the camp could be filled to capacity primarily because it was supported by a grant from Georgia Space Grant Consortium [5], which is funded by NASA's STEM engagement, Office of Education. However, it became evident during the course of the 2012 summer camp that a significant number of students were not interested in Physical Sciences and as such the camp did not have any effect on them. In order to see the full benefit for the students attending the camp we may need to restrict enrollment only to the high achieving students verified by their academic records such as CRCT scores. Also, a stronger recruitment effort has to be launched much earlier than usual. A less than full capacity may have to be accepted if high academic quality in the camp has to be maintained.

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Atin Sinha

Atin Sinha received his Ph.D. from the University of Tennessee Space Institute in Aerospace Engineering in 1984 and worked in Learjet and Honeywell for 6 years before moving to academia. He joined the Albany State University in 1999 as coordinator of the transfer engineering program and teaches freshman and sophomore level courses in engineering. His current research interest is rapid prototyping and reverse engineering. He is also engaged in motivating students in inquiry based learning in engineering problem solving through laboratory experimentation.

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