AC 2012-4304: INSPIRING INTEREST IN STEM THROUGH SUMMER ROBOTICS CAMP

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Abstract

Summer camps provide an opportunity for children with similar interests to come together for a week, or longer, to gain a unique experience based upon those interests. These camps have been utilized as a means of increase student interest and awareness in science, technology, engineering, and mathematics (STEM). This paper discusses the development, execution, and lessons learned from a robotics summer camp offered to campers from ages 7 to 13. This camp utilized a combination of visual lectures, build activities, and competitions to keep students engaged, teach them about various science and engineering disciplines, and have a fun experience. This paper discusses the background of this camp, the curriculum from the first two years of the camp, feedback from parents and children, lessons learned, and plans to develop a follow-on advanced camp for middle school and science students.

Introduction

For many years, summer camps have provided an outlet for children of varying age levels and backgrounds, but similar interests, to interact with one another. One of the primary goals of a camp is to engage and teach the campers some skills, while maintaining a level of fun and enthusiasm throughout the camp. In order to renew interest in science, technology, engineering, and mathematics (STEM), schools, universities, and other organizations are looking for ways to provide fun opportunities to expose students to STEM topics at an early age so that their interest continues through middle school, high school, and into their college academic careers.

At the author's university, several summer camps have been developed to bring children ages 7 to 13 together to interact with one another on a variety of STEM activities. Each STEM summer camp has its own topic. Over the past two summers, the one week robotics camp has been the most popular camp with highest attendance and media coverage. This paper will focus on the development, execution, and lessons learned from this robotics camp.

Robots provided an ideal platform for introducing a large number of STEM topics in a fun and engaging way. Through a single learning activity, campers are introduced to topics related to mathematics, physics, electrical engineer, computer engineering, computer science, mechanical engineering. These topics can be introduced subtly in engaging ways through a combination of mini-lectures, demonstrations, and build activities.

In this paper, the curriculum of the 2010 and 2011 summer camps are presented. The curriculum is broken into a number of topics: robotics 101, robot motion, robot sensing, robot software, and robot intelligence. For each topic, the sub-topics, build activities, and demonstrations will be described. The camp's two culminating competitive events will also be described; a robot Battle Bot competition (as shown in Figure 1) and a robot talent show. A comparison of the curriculum between the two camps, 2010 and 2011, shall also be discussed as some changes were made based on the feedback and the level of enthusiasm of the campers.

The camp will be assessed given student and parent feedback. Some demographics will be shared regarding the camps attendees. Lessons learned will also be presented based on the experiences of the camp faculty instructors and student counselors. The paper concludes with a discussion of how the curriculum will be expanded to include a second week of advanced topics and build activities for the 2012 camp.

Figure 1: Students preparing for battle bots competition.

Background

Attracting students to Science, Technology, Engineering, and Mathematics (STEM) fields is a challenge that has been addressed at all levels of K-12 education. Outreach programs are designed with the goal of attracting talented and motivated young students into careers focused on STEM.

Embry-Riddle Aeronautical University (ERAU) had an ongoing program of record in operating summer camps to provide outreach to students of varying age groups. The Residential Flight Camp[1] had attracted campers that were interested in space technologies flight, air traffic control, and meteorology. This camp was run by the College of Aviation. ERAU was also actively involved with residential camps and day camps for a variety of sports and extracurricular activities for all age groups.

During the Fall 2009, it was decided that ERAU should develop and support a summer long set of camps focused on STEM topics. The goal of the program was to expose elementary and middle school students to STEM topics. The camp would act as a community service to residents of Daytona Beach, Volusia County, and the state of Florida. There was also hope that exposing ERAU to students in the community could have a benefit in enrollment in STEM related fields.

The first year of the STEM camps was Summer 2010 with a cap of 40 students per week with an age range from 7 to 13 years old. Each week, a new topic would be covered with students and faculty from that area teaching the camp and working as camp counselors. For the summer 2010, topics included mechanical engineering, mathematics, aviation, meteorology, crash scene investigation, astronomy, and robotics. During the first year, the robotics camp was the only to completely sell out, and many potential campers were placed on a waiting list.

During the summer 2011, the camp was offered a second time. The robotics week maintained its high level of attendance. Across the board, enrollment increased during the 2011 camp versus the 2010 camp.

The demographics for the two summer camps are presented in Figure 2, Figure 3, and Figure 4. The first year's distribution of age was fairly uniform with between four to six students for each age. For the second year, the number of students at age seven significantly decreased at the request of the instructors as this age group required greater supervision and was more frequently involved with disciplinary action. Both camps were predominantly attended by male campers, but there was a significant increase in female attendees for the 2011 camp. In 2011, the addresses of the campers were analyzed to determine the location of their residence. The majority of campers are from Volusia County and all but three were from the state of Florida.

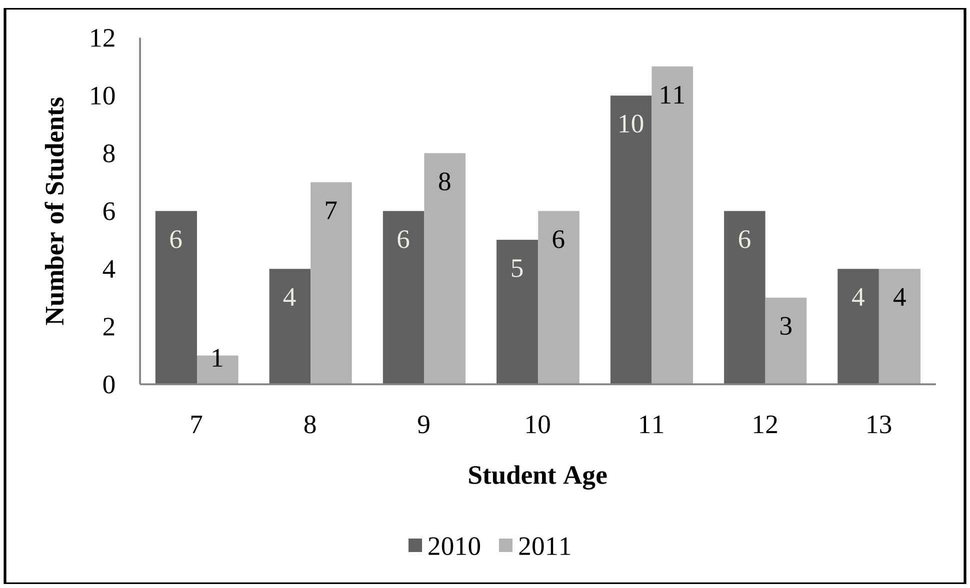

Figure 2: Age demographics for the 2010 (N=41) and 2011 (N=40) summer camps.

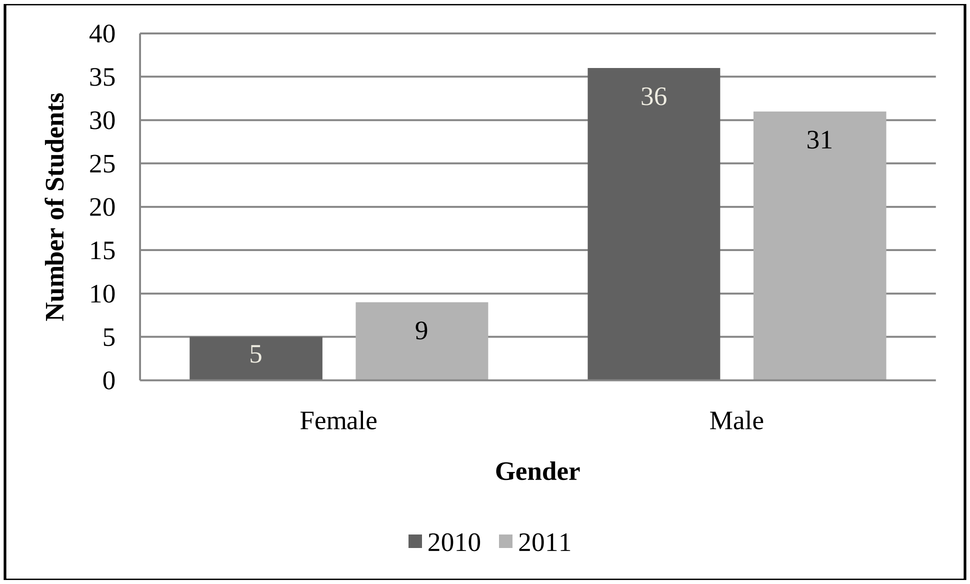

Figure 3: Gender Demographics for the 2010 (N=41) and 2011 (N=40) Summer Camps.

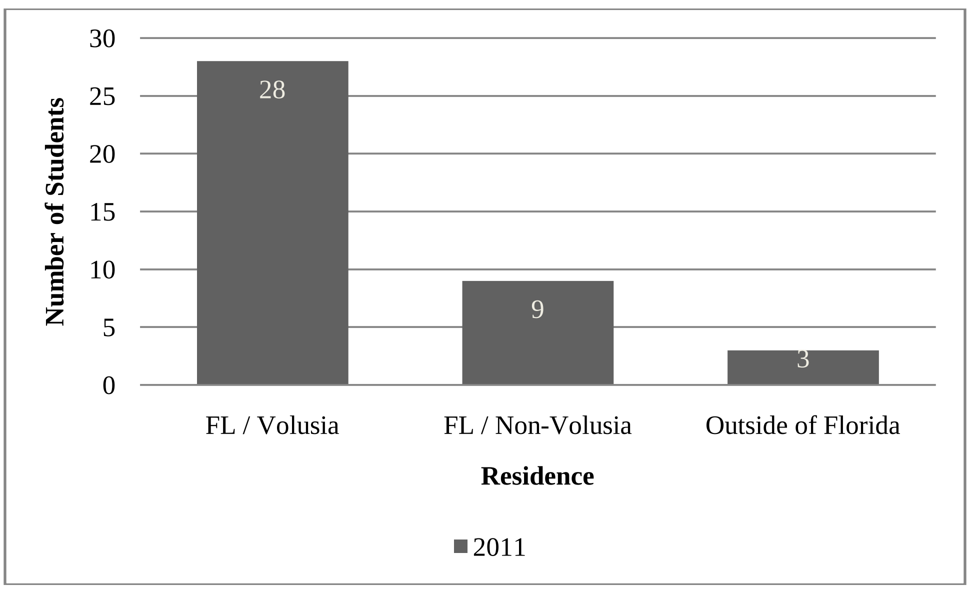

Figure 4: Residency Demographics for the 2010 (N=41) and 2011 (N=40) Summer Camps.

Robotics Camp Summer 2010

Curriculum

The 2010 Robotics Camp was held on a Monday through Friday in July. For each day from Monday through Thursday, the morning session and afternoon session each covered a new robotics and/or computing topic, and included one build activity (or other interactive activity).

Day 1: Monday's goal was to provide a foundation for computing and electronics. In the morning, a computing 101 lecture was given that introduces students to computers, electronics, and how they are used in their every day life. The students then performed an "artificial intelligence" game in which they learned how different elements of a computer system must work together.

The artificial intelligence game involved a group of students trying to stack a set of boxes on top of each other. Students were assigned a role of being the "robot's" brain, left hand, right hand, and eyes. The "brain" student is blindfolded. They must interact with their team of components through simple queries and commands to achieve the goal.

On Monday afternoon, the students learned about electronic circuits and logic. They were then asked to build a set of simple logic circuits using AND gates, OR gates, resistors, and LEDs on a breadboard.

Day 2: The second day's focus was on introducing the students to robots and their sensors. In the morning, a robotics 101 presents the various forms of robotic platforms including industrial, mobile robots, autonomous vehicles, humanoids, animal-like robots, unmanned aircraft, etc. For each robot type, one or more videos were used to demonstrate the platform in use. A lengthy question and answer session followed. The students were then asked to build a simple robot using the Lego Mindstorms NXT kits[2]. For their first build, the built a three wheeled rover capable of aimlessly wandering its environment.

In the afternoon, the robots were introduced to perception. For each of the human senses, a mapping to robotic sensors is provided. For each sensor, a video provides an example of how it is used and if possible its limitations. For the afternoon build activity, created a line following robot capable of using light sensors to identify and follow a path.

Day 3: With a foundation on what robots are and how they perceive the environment, the third day focuses on robot motion and then the basics of robot control where perception and action are tied together. On the morning of the 3rd day, the students were introduced to types of robot locomotion including servos, actuators, robotic arms, and types of drive systems. Each is demonstrated with videos and/or photographs. The advantages and disadvantages of each system was covered. For the morning build activity, students constructed a "kicker" robot that creates a multi-servo arm that swings backward and then forward "kicking" a ball across the room.

In the afternoon, students learned about robot control including finite state automata, reactive control, deliberative control, robotic teams, and robot swarms. This topic is covered at a fairly high level and reply video to demonstrate the concepts. The build project focuses upon the development of the NXT Explorer, which uses reactive controls following a finite state machine. Camp instructors walk each team of students through the program explaining how the system transitions between its states.

Day 4: The fourth morning focuses on students learning to write their own programs. Up to this point, the students have merely downloaded their own programs from NXTPrograms.com[3]. For this final morning, the instructors demonstrate the development of some simple programs using while loops, if/switch blocks, etc. to accomplish some simple goals. The students then write a program for a ball batter robot, which reacts to the detection of the ball and strikes it using an arm attached to a motor.

In the afternoon, the students construct their Battle Bots. The Battle Bot competition is scheduled for the morning of the fifth day. The rules are fairly simple…two robots are placed facing one another, but one foot apart, in the center of a 6 foot diameter arena. The robots are triggered to begin. The robot that leaves the arena first or is physically disabled by the opponent (unable to move under its own power) loses. The students compete under a single elimination tournament. All construction is done by the students with limited software assistance provided by the counselors.

Day 5: The Battle Bot competition is held in the morning after 1 hour of final preparations made by the capers. The competition takes 1 hour. Once completed, the robots are fully disassembled.

The remainder of the afternoon is spent with the students preparing for a talent show. Each team must create a robot that will be judged on creativity and complexity. Judges are provided by the camp coordinators and are impartial. The students have one minute to introduce their robot and three minutes to perform their talent. The talents demonstrated could be something from a team's own imagination, or a challenging robot that they identified from NXTPrograms.com, or other websites.

The talent show is performed in the late afternoon of the fifth day so that parents can attend. This is the campers chance to showcase to their friends, family, and fellow campers what they learned. For instance, a student build a transmission and clutch using Lego Mindstorms as shown in Figure 5.

Error! Reference source not found. presents the schedules for the 2010 summer camp along side the 2011 camp.

Table 1: Summer 2010 and 2011 camp schedules.

	Summer 2010 Robotics Camp		**Summer 2011 Robotics Camp**	
	AM	PM	AM	PM
Monday	Computing 101 Activity: Human AI	Electronics 101 Build: Logic Circuits	Robotics 101 Build: Mini- Rover	Robotic Sensors Build: Line Follower
Tuesday	Robotics 101 Build: Mini- Rover	Robotic Sensors Build: Line Follower	Robotics Motion Build: Ball Kicker Robot	Robot Intelligence and Control Build: Explorer Robot
Wednesday	Robotics Motion Build: Ball	Robot Intelligence and Control	Pool Water Robot Demo	Robot Demonstrations

	Kicker Robot	Build: Explorer Robot	(canceled)	
Thursday	Programming 101 Build: Baseball Batter	Battle Bot Build-off	Programming 101 Build: Baseball Batter	Battle Bot Build-off
Friday	Battle Bot Build-Off (cont.) Battle Bot Competition Talent Show Robot Build-off	Talent Show Robot Build-off (cont.) Talent Show	Battle Bot Build-Off (cont.) Battle Bot Competition Talent Show Robot Build-off	Talent Show Robot Build-off (cont.) Talent Show

Figure 5: Photo showing students working on talent robot.

Lessons Learned

For both instructors, this summer camp was the first time teaching elementary and middle school students let alone developing curricula to keep them engaged for an entire week. As a result, lessons were learned, which will now be shared.

Despite the distribution of age between campers, the initial concern that younger campers and older campers would not get along as a result of their level of maturity was not founded during this first year. Interpersonal issues were often not age driven, but more frequently involved social conflicts such as hurt feelings or the feeling that one student was dominating his or her team. Grouping campers of like age together did seem to work well in avoiding the issue of more experienced/advanced campers from being overbearing.

The youngest campers at age 7 were more frequently involved in disciplinary action as a result of their limited attention span and high energy, and they were much more engaged with visual media such as videos and demonstrations. Older students were more engaged with the build activities, and sometimes became bored and frustrated with the lectures. The female campers were often more focused and cooperative with one another during the build activities.

The digital logic build activity was the least popular of all activities. Despite written and visual instruction, this activity required some significant mentoring from the counselors. It was decided at the conclusion that this activity would not be included in future summer camps.

For the build activities, several lessons were learned. The students were more engaged when web-based instructions and videos were provided rather than written instructions. The older campers were typically more thoughtful of their design versus younger campers that were more interested in "playing around" with the robot kits.

Have a large number of college student helpers (or counselors) was essential to maintaining control and providing the necessary assistance to all student teams. Because of space issues, not all of the students could work in the same classroom. The instructors decided to divide the groups based upon experience with Lego NXT kits. This seemed to work well as the more advanced students required less assistance from the counselors, which allowed us to better utilize the counselors where they were needed. More counselors would have made things even easier, but without any this camp would not have succeeded.

Using competitions provided a great tool to encourage students to apply what they learned and reinforce their earlier build experiences. The battle bots competition forced students to focus both on hardware and software. Many of the campers built upon their previous robots rather than starting from scratch. The talent show allowed for students to showcase both their creativity and the diversity of their experience. Many of the build activities focused upon robots that wander and explore. For the talent show, robots were developed that were more creative, aesthetic, etc.

Robotics Camp Summer 2011

Given the success of the Summer 2010 camp, a second camp was offered during the Summer 2011. Ahead of this camp, there were some curriculum revisions made. This section will briefly describe the new curriculum, feedback from parents/campers after the completion of this camp, and an overview of the new lessons learned from the revised camp.

Curriculum

The curriculum had several changes to address the lessons learned above. First, the first day's introduction to computing and electronics were completely eliminated. The students were already quite familiar with computers and computer technologies. The electronic component topics were too advanced for many of the campers, and the associated build activity was highly demanding on the camp counselors as a lot of assistance was required.

Day 1 for the 2010 camp begun with the Robotics 101 introduction. The remaining lecture and build activities remained consistent through the remainder of the week. Videos were updated to include new examples and examples from current events that would be more familiar to the campers.

By freeing up one full day of content, the students were given the opportunity to add more fun time into the schedule. Wednesday morning was spent at the ERAU swimming pool. Robot demonstrations of underwater robots was scheduled, but could not be performed due to the robot becoming unavailable due to technical issues beyond the coordinator's control. The afternoon was spent with students from the Robotics Association at Embry-Riddle (RAER) demonstrating their robotic systems. These demonstrations included: a legged robot, a quad rotor robotic helicopter, and a robot capable of planning the video game Rock Band. Students were given the opportunity to interact with each of these systems, and compete against the Rock Band robot. During down time, between stations, student teams were encouraged to build a robot given the projects defined on NXTPrograms.com.

The full schedule for summer 2011 is presented along side the 2010 schedule in Table 1.

Lessons Learned

Many of the observations from the first summer camp were reinforced with this second experience. One major issue that had not been considered at the start of the camp was how to engage students that had attended the previous year. While the lecture materials were updated, the students that had previously attended because easily distracted and disruptive. Furthermore, these students did not want to repeat past build activities and wanted to go directly to building their talent or battle bot robots. The instructors worked to accommodate these campers without disrupting the enjoyment of the camp to others. This highlights the need for an advanced summer camp for older campers and those with past summer camp experiences.

Feedback

For the 2011 summer camp, a letter was sent home at the conclusion of all camps soliciting student feedback. These surveys unfortunately did not differentiate which week was being reported upon. Therefore, the authors pulled all surveys that included robotics camp related feedback. From this analysis it was determined that 20 out of 40 surveys were returned that included the robotics camp in its feedback. The results of this survey are presented in Table 2.

Table 2: Survey results from the Summer 2011 Camp.

Survey Question	Number Responded (N=20)		
	Yes	Undecided	No
Did your child(ren) enjoy the camp?	19	1	0
Did you feel the topics were informative enough?	18	2	0
Did your child(ren) feel safe at the camp?	20	0	0
Did your child(ren) think the topics were interesting?	17	3	0
Would you recommend this camp?	20	0	0
Noteworthy Comments: • Looking forward to 2012 camp • My son joined the Lego League team in his school • My son and his friend are trying to design computer codes • Separating younger kids from the older one would be good • Idea of two robotic camp is appealing • Should do something about disruptive students • He is now just interested in robots • More computer applications • She asked for a robot kit for Christmas • My daughter enjoyed the camp and wants to do it next year • So happy to see another robotic camp • My son sees things on the news and makes connections to the ERAU camp • My son truly enjoyed the robotic camp and looks forward to do it again • He wants to work on robotics field someday			

<u>Proposed Summer 2012 Curriculum Revisions</u>

In this section, the revised camp curriculum for summer 2012 is presented. The camp is now divided into a beginner camp, which will be based upon the 2011 summer camp. The second camp discussed is an advanced camp designed for students that have completed the beginner camp. Each is discussed in greater detail.

Beginner Camp

In order to keep high level of interest among all campers, we will be conducting a brief survey on first day of the camp to find out how much exposure each student have had with building and programming Lego Mindstorms robot kits. We will attempt to separate more experienced group in a different location and get them involved in designing their robots for Battle Bots and talent show competitions first before start building them. The experienced groups will create more complicated robot control scenarios with different sensors and motors which requires some thinking and more programming skills. We will also attempt to create groups with members that are closer in age.

As for students with little or no experience with Lego Mindstorms robots or robots in general the existing previous year schedule and activities will be used.

Advanced Camp

During middle school and early high school many students develop attitudes toward particular career paths. Often students are exposed to theoretical concepts for years before receiving the opportunity to see their application to real-world problems. This delay in experiencing and understanding the practical aspects of these fields results in loss of interest in STEM.

Robots are highly complex systems, and provide great examples of applied mathematics, science, and engineering. Robotics projects provide opportunities for multidisciplinary collaborations in computer science, computer engineering, electrical engineering, mechanical engineering, software engineering, and human factors. Furthermore, working with robots is fun, engaging, and inspiring to young engineers.

An advanced summer camp will be developed for deployment during summer 2012. This camp will try to meet two objectives. First, it will provide an opportunity for past campers to return and continue to participate with new projects, challenges, and advanced topics. Second, it will help draw in campers from middle school and early high school interested in robotics, which will hopefully inspire interest in a career in STEM as discussed above.

To minimize cost, NXT robot kits will be used for this advanced camp. However, the Robot C[4] programming environment will be introduced allowing for more advanced software development opportunities for the campers. The Lego Green City Challenge[5] is one particular resource that is currently being investigated. This kit provides an interactive map that the robot can travel through with particular stations that require specific robot capabilities to achieve one or more green energy goals. Having a more structured challenge will assist the instructors in focusing on specific capabilities with a real-world context.

Before each build activity, short lectures will introduce the advanced campers to the tools and subject matter necessary to complete the activity. The topics will be similar to those followed in the beginner camp (i.e. introduction, sensors, motion, control, and programming). However, the campers will be given much greater detail and examples/discussion will be grounded to the specific challenges they will be addressing. Students will be introduced to computer programming early in the camp with the option to do software development in Robot C or the NXT programming environment.

The summer camp will feature demonstrations from Embry-Riddle student robotics teams including Team Blackbird (unmanned aircraft)[6] and the Robotics Association at Embry-Riddle (RAER) [7], which has unmanned ground vehicles, unmanned aircraft, autonomous underwater vehicles, and unmanned surface vehicles. At least one afternoon will feature interactive stations where campers can visit each student team and experience hands-on interaction with the robot or robots that the team has provided.

Conclusion

Overall, the summer camps developed at Embry-Riddle Aeronautical University were a tremendous success. Each camp met or exceeded the maximum designated enrollment totals of 40 students. Student feedback has shown that the camp has had a beneficial impact and inspired students to further consider engineering topics and professions. For summer 2012, the team plans to build upon its success with the introduction of an advanced robotics summer camp to encourage greater participation of an older target audience.

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