ENCOURAGING SCIENTIFIC IMAGINATION IN ELEMENTARY STUDENTS

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Abstract

Sparking scientific imagination in elementary students is an essential step in developing the engineers of the future. The curiosity to learn how things work while keeping an open mind to create new inventions forms the foundation of engineering. Over the past two summers, Valparaiso University's College of Engineering has introduced approximately 170 primary and secondary school students to the tenets of engineering. We have accomplished this through a national program entitled Camp Invention®, developed by the not-for-profit National Inventors Hall of Fame Foundation. Camp Invention is a weeklong summer enrichment day experience for children entering grades one through six. This program offers institutions an opportunity to reach out to the youth in their community and provide a summer enrichment program that provides a different experience than they normally receive in the classroom.

In 2008, there were seventy-nine different Camp Invention programs across Illinois and Indiana. Valparaiso University, however, was the only engineering college or department in the two states to offer the Camp Invention program. During the two years we have offered this program, we have discovered some of the best ways to integrate Camp Invention into a summertime college or department of engineering environment. Several problems and associated solutions that may be encountered with outreach programs have become apparent as well and are included in the lessons learned to offer insight that might be useful when preparing similar programs.

Though it is difficult to see a direct effect of this program on an institution's enrollment numbers immediately, it is clear that there is a benefit to the students and the institution. By increasing the number of elementary students who maintain an interest in the STEM disciplines, the number of K-12 students likely to consider engineering as a possible career will also increase. Additionally, our faculty and staff have had the opportunity to participate in non-traditional classroom instruction, which has fundamentally changed their approach to undergraduate instruction.

Introduction

Three principles are at the core of higher education: education, scholarship, and service. Engineering colleges can satisfy two of these three core principles by participating in community outreach programs for K-12 students. Colleges can provide an educational experience that is not commonly found in primary or secondary schools.[1,2] Sparking scientific imagination in our youngest students is an essential step in developing the engineers of tomorrow. Engineering is

fundamentally the application of imagination to find the solutions to problems. Creating the desire to see the possibilities of a new and different world is the greatest goal of early science, engineering, and mathematics curricula. In a 2004 ASEE survey, over 89% of K-12 teachers believed a basic understanding of engineering is important for students to understand our world.[3] It is also an excellent opportunity for engineering colleges to market themselves locally and to promote the community's interest in continuing their engineering education at the university level.

While the need for programs like this is clear, university faculty and staff face the pressures of increasing expectations with decreasing resources. Therefore, like most engineering problems, K-12 engineering outreach can quickly become an optimization problem. How do you serve the most students, with the available resources, for maximum short and long term benefit to the students, the engineering college, and society?

In this paper, it is proposed that one potential solution to this optimization problem is Camp Invention®, a week long, summer day camp of experiential learning for elementary school students entering grades one through six.[4-7] The Camp Invention program was developed by Invent Now® Kids, Inc. (INK), a subsidiary of the not-for-profit National Inventors Hall of Fame Foundation. For the last two years, the Camp Invention program has been offered nationally approximately 900 times to more than 60,000 children.[8,9] However, the program is relatively unknown as an outreach tool for engineering colleges. Of the 79 Camp Invention programs in Illinois and Indiana in 2008, our college was the only engineering institution to offer the curriculum.[8] After successfully offering this program for two years, we are now able to report our experiences to other engineering educators.

The rest of the paper is divided into the following sections. We begin with an introduction to the Camp Invention program and curricula. Next, we introduce the various roles individuals from engineering colleges take in the implementation of the program. This is followed by the results of our institution hosting the program for the past two years. Finally, we finish the paper with a section devoted to lessons learned (including mistakes we have made) and our conclusions.

The Camp Invention Program

Camp Invention is a week long summer enrichment day experience with an open enrollment for children entering grades one through six. The day camp experience from 9:00am - 3:30pm allows universities to avoid any housing, dining, or transportation issues. The campers bring their own lunches, but snacks are provided by INK. The size of the camp ranges between 30 and 110 students, depending on the limitations of the host site and student registrations. The number of staff needed to support this program is dependent on the number of campers, but the average ratio of campers to staff is 8:1. If a host site has limited staff or accommodations, the number of campers can be capped at any number with a minimum of 30.

All Camp Invention curricula are written and carefully piloted by educators to align with all state and national education standards and provide customized instruction for each grade level. Each day, campers participate in five continuous thematic modules that place them in settings like a strange planet, a faraway island, or deep under the sea. Campers must then use their imagination

and inventive-thinking skills to solve problems within each environment, such as how to rebuild their rocket ship, how to cross a river of hot lava, or how to gather and contain sea creatures without causing them harm.[10] Through this kind of hands-on fun, children get excited about science and working together as a team. By the end of the week, the campers develop a general understanding of difficult concepts (such as Newton's Three Laws of Motion) from a fun and active learning environment. Several sets of curricula are available to allow campers to come back summer after summer for new adventures.

The Camp Invention Curricula are designed to fall into one of three content areas: science, creative problem solving, and an area that involves math, history, or the arts.[11] To supplement these three modules, each program also includes the "*I Can Invent*™" and "*Recess Remix*™" modules. The "*I Can Invent*" module allows students the opportunity to take apart a small appliance that they bring from home and create a new fantasy invention. "*Recess Remix*" gives the students an opportunity to run off some energy in organized games. All of the activities at Camp Invention are designed to inspire creativity and inventive-thinking while having fun. INK is currently offering three different versions of the Camp Invention programs: *Discover*, *Create*, and *Explore*. A summary of the 2009 Create program is shown in Table 1.

Table 1
Summary of a Camp Invention's Modular Program[6]

Problem Solving on Planet Zak Science fiction has predicted many of today's science facts. This module takes children into the wondrous world of science fiction.	Day 1: Reassemble crashed spacecraft from common objects Day 2: Create spacesuits, helmets, and goggles to handle Zakian weather Day 3: Create devices to retrieve food hard to reach places Day 4: Generate ideas on how to launch the spaceship Day 5: Launch Spaceship
Saving Sludge City Children are introduced to ecology and the concept of conservation when they are challenged to rebuild a cleaner, more eco-friendly city.	Day 1: Clean-up a simulated landfill Day 2: Develop a water filtration device for the swimming area Day 3: Plan Sludge City's future dwelling design Day 4: Build model of new city from recycled materials Day 5: Invent new methods of transportation to prevent air pollution
Imagination Point Children are introduced to Newton's Three Laws of Motion through hands-on activities related to roller coasters and other amusement park rides.	Day 1: Design a rollercoaster based on experimentation Day 2: Experiment to understand the thrill factor of roller coasters. Day 3: Create bumper-car paintings to understand equal and opposite reactions Day 4: Integrate laws of motion to design amusement park rides Day 5: Build models of the rides.
I Can Invent This module uses science, creative problem solving, and hands-on applications to further children's inventiveness and critical-thinking skills.	Day 1: Learn tool safety and take apart broken appliances. Day 2: Learn about gears and magnets and continue taking apart Day 3: Continue taking apart and begin building a multi-step machine. Day 4: Explore product names and enhance multi-step machines Day 5: Wrap up the invention process and apply for a mock patent.
Recess Remix Combines physical activity and creativity. Children practice cooperation, coordination, and creative problem-solving skills during various games.	Children play approximately four games per day. Children are challenged to use nontraditional equipment or incorporate items like water balloons into classic games. All activities are designed to engage the mind and body together while children work as a team. Recess Remix games challenge teams to depend on their own inventiveness and inquisitive thinking.

Since its inception in 1990, the Camp Invention program has grown from two sites in Ohio to a national program offered in 48 states. This has been accomplished by developing a mutually beneficial partnership between INK and the host schools. INK provides the necessary materials and support, while the host site provides the physical location and staff. Responsibilities for this partnership are outlined in the Director's manual and are given below.

INK provides:

- Staff training and compensation including administrative manuals
- Curricula and lesson plans for 5 modules accommodating up to 110 students
- Alignment with national and state education standards
- Administrative and promotional support including flyers, ads, posters, and banners
- Materials for activities in five thematic modules
- Press releases to local media
- Daily snacks for children
- Free T-shirts for children and staff
- Central registration system via a toll-free phone number and website
- Financial incentives to schools with more than 100 children
- General liability insurance covering program activities

The host site provides:

- Physical space (up to five classrooms and a room or outdoor tent to use for a cafeteria)
- Storage room for project materials and completed student projects
- Access to restrooms, phone, water, and outside play area
- Camp Director, Instructors, and Counselors to prepare for and work the camp week
- Distribution of promotional material

This arrangement allows universities an opportunity to offer a quality summer outreach program without investing unavailable time to develop a curriculum, manage registrations, and publicize the event. With these time-consuming elements provided, a university has to provide only the physical space and staff to prepare for the week of camp.

Camp Invention was offered for the first time at Valparaiso University during the summer of 2007. While promotion for this camp was started late in the spring, 59 campers enrolled and started spreading their excitement about their camp experience. In 2008, the camp sold out, with 110 campers by the end of May. With open enrollment and general promotion for camps hosted by universities, there are some general trends in the demographics of the campers that should be noted. This camp attracts more male campers than female campers. At the 2008 Valparaiso University camp, there were 85 boys and 25 girls. This is important to keep in mind when Counselors are selected. There is also a trend in the distribution of ages, since more summer activities are available to students as their age increases. Of the 110 campers, there were 24 entering first grade, 17 entering second grade, 26 entering third grade, 17 entering fourth grade, 15 entering fifth grade, and only 10 entering the sixth grade.

Roles to Play in Camp Invention

Camp Invention has three different roles or positions that can be filled by engineering faculty or staff: Camp Director, Instructor, and Counselor. In this section, the purpose and responsibility of each role will be explained.[11]

Although the position of Camp Director requires the most responsibility to assure that the camp week runs smoothly, INK provides all the support that is needed. An INK Regional Director provides training (via conference call) and is available to answer any questions throughout the process. A Camp Director's manual is also provided, which outlines all the details and includes a checklist and timeline leading up to camp week. The primary responsibilities of the Camp Director are to prepare the host site and hire the staff needed to support the camp. The Camp Director also acts as the liaison between INK and the university.

Preparation of the host site starts with selecting the week that is most convenient for the university to offer the camp. This allows the opportunity to schedule around other summer activities and Instructor commitments. After the details of the camp are communicated to an INK Regional Director, marketing of the camp begins. The Camp Director receives fliers to distribute to the schools to promote the program. INK provides fliers that are boxed for each elementary school and packaged by in classroom bundles making distribution as simple as possible. This minimizes the effort required by the host institution. Two rounds of these fliers are distributed, as well as promotions to camp alumni and newspaper advertisements. In addition to promoting the camp to the public, the Camp Director is responsible for informing all university employees of the host site staff discount for registration of their own children.

Selection of the staff for camp week is the most important decision made by the Camp Director. The quality of the camp week experience for each student will be determined by the attitude of the staff members. If the Instructors and Counselors are excited and enjoy the experience, it will create an environment where the students can open their minds to creativity and imagination. For best results, the Camp Director should choose his or her own staff. Typically, the Instructors are from the hosting institution. However, all camp staff members are independent contractors paid by INK through Camp Invention Program. The most challenging part of selecting the staff is determining how many to select. The number of staff members needed changes based on the number of children registered, which is usually not decided until two weeks before camp week. Even though it can be difficult, it is important to make sure that the eight students to one staff member ratio is not compromised. Otherwise, the quality of this hands-on experience for the campers could be significantly reduced.

For camps with over 50 students, a full-time or part-time Assistant Camp Director is necessary to keep the camp running smoothly. The Assistant Camp Director supports the Camp Director in coordinating all aspects of the program. This position requires someone with great organizational and time-management skills paired with strong interpersonal skills when working with adults and children. The primary duties of the Assistant Camp Director are to assist with site coordination for check-in, child arrival and departure, snacks, base camp, and other activities during the camp day. This is especially helpful for larger camps since there are multiple activities going on at the same time.

The Camp Invention curriculum is delivered to the campers by the Instructors. INK does not list specific requirements for the Instructors other than "[They] are selected for their abilities to excite and motivate children and their enthusiasm for creative learning".[12] Potential individuals to serve as Instructors at our institution were selected by the college dean and the Camp Director. The Camp Director then contacted each potential Instructor to determine if he or she would be willing to serve. Two of our Instructors were engineering faculty, and three hold engineering staff positions (Director of Engineering Information Technology, Freshmen Engineering Coordinator, and College of Engineering Mechanical Technician).

Prior to the start of the program, the Instructors met with the Camp Director to decide dates, room locations, and other camp logistics. The Instructors were responsible for reviewing their individual curriculum program manuals (provided by INK), unpacking program specific supplies (also provided by INK), and preparing their rooms for instruction. These three items required between six and fifteen hours for each of the five Instructors.

During the week of Camp Invention, the Instructors were responsible for delivering their unique program content to the five different groups of campers through five one-hour classes. Each class of campers was introduced to the day's lesson in a short overview (approximately five minutes). The campers then worked on a planning activity that took fifteen to twenty minutes. This time was split between planning their hour's work and retrieving supplies from the recycling room and the materials provided by INK. The remainder of the class time was dedicated to the building and implementation of the camper's projects. After a group of campers left, an Instructor would have five to ten minutes to reset the classroom for the next class of campers. Finally, after the program finished for the day, the Instructors had to prepare their classrooms for the following day. Our five Instructors reported this required between zero and two hours of time each day.

The Counselors were responsible for assisting the campers through the program logistics. Each group of campers was assigned to Counselors who formed a relationship with the students, starting with a welcome phone call including camp reminders. The Counselors were responsible for checking-in the campers upon their arrival and stayed with their group of campers throughout the day. They led the students from one program to the next, assisted the campers in each of the five programs, and monitored them during their lunch and snack breaks. Finally, the Counselors were responsible for checking-out the campers to their parents at the end of the day. The responsibilities of the Counselors varied widely with the age of their campers. Working with six-year old campers required different skills than working with eleven- and twelve-year old campers. All of the Counselors were students selected by the Camp Director as individuals with excellent interpersonal skills and a desire to serve.

Volunteers are also encouraged to participate in the Camp Invention program, but are often overlooked by new programs. Each camp is allowed to reward 2-4 parental volunteers with the opportunity to register their children at a significant discount for their volunteer work. Adult volunteers can promote the camp and keep it running smoothly by supporting first day check-in, activities, snacks, and lunch. Extra help during these times is very valuable. Volunteers can also come in the form of Junior Counselors. These students are too old to participate in the program, but are too young to be a Counselor. When they are Camp Invention alumni, they are often eager to come back to camp even without compensation to have the camp experience again.

Camp Week Results

Quantitatively, there is almost no data available from INK or third parties on the assessment of the Camp Invention program. While there are over 115 national and regional sponsors for Camp Invention,[13] there has been no statistical information published on Camp Invention's results. At the end of the camp week, campers and parents are asked to complete the Parent/Participant survey provided by INK that asks for some basic information about how the camper heard about the camp, their favorite part and least favorite part, what skills were gained from the camp, and if the camper had a good time and would come again. However, no national results from the survey are available.

For the 2007 and 2008 camps hosted at Valparaiso University, over 95% of the campers responded that they enjoyed Camp Invention and would come again. Forty-eight percent of the 2007 campers eligible to attend returned for a second camp in 2008. While we were satisfied with the 95% positive response, we believe the 48% return rate does not provide significant insight into the success of Camp Invention. There are too many other factors (family relocation, vacations, and conflicting sports and camps) to determine if the 48% return rate should be considered good or bad. Therefore, it is our intention to include a more thorough assessment of the Camp Invention lessons during our summer 2009 (and future) programs. However, our program was deemed successful enough that INK requested that Valparaiso University hold two sessions of Camp Invention in the summer of 2009.

Qualitatively, there is a significant amount of positive feedback for the Camp Invention program. First, at the end of every camp week, the students have the opportunity to share their inventions with family and friends at an Inventors Showcase. For many families, this is one of the most enjoyable parts of the camp. The students walk their families through the classrooms and are able to tell stories about all their adventures and show their parents all the inventions they made. This is also a great opportunity for community members to see the university's engineering facilities.

Second, the INK Parent/Participant survey provided space for comments and feedback. Listed below are just a few of the comments for our 2007 and 2008 camps:

- "It's a fun way for kids to find their inner genius."
- "She had such satisfaction and joy when she told me she could use tools and take things apart alone!"
- "… in school they give you things and tell you what to do. At this camp, they give you things and tell you to figure it out."
- "He's very proud of his accomplishments and what he created. It took his love of science to a whole new level!"
- "After the first day of camp he told me it was the best day of his life."
- "He is gifted and other camps sometimes just disappoint - but not this one!"
- "They had no idea how much difficult science they were learning. I highly recommend it to other families…my two will definitely be back next year!"
- "My daughter has loved the program and learned a lot…a good investment."

Lessons Learned

Many best practices were learned after offering a mid-sized (59 students) camp in 2007 and large (110 students) camp in 2008. While smaller camps may be more forgiving of organizational mistakes, the largest camps need to be as organized and efficiently run as possible to keep delays and problems from occurring. Here are a few tips that can keep camps running smoothly but are easy to overlooked.

- Promote the camp as early as possible to provide information to parents before summer vacation and other plans are made. Volunteers are a very helpful resource in this process.
- Attention should be given to the planning of the first day check-in process, especially for larger camps. Several stations should be available where parents can drop off project material donations and take-apart items as well as get vital information on the arrival and departure procedures. In 2008, we underestimated the amount of time this would take and had some parents waiting more than 30 minutes on the first day of camp.
- A careful arrival and departure plan should be developed to help with traffic flow and must be communicated clearly to all staff members and parents. This is compounded by the INK requirement that every child has to be signed in and out every day by their family.
- Several staff members should be available to supervise at base camp during arrival times, snacks, and lunch. It is also helpful for Counselors to have some activities to keep students busy during this time.
- Since the day is action-packed until departure time, it can be helpful to provide the parents with a newsletter during registration that includes all of the activities for the week, instead of a newsletter that is distributed at the end of each day.
- Use the allowed volunteers in staffing Camp Invention. Extra hands make a significant difference during busy times and with the younger groups of campers. We learned this the hard way when we offered a full camp without any volunteers. Several staff members were stretched too thin especially when students with special needs were involved.

The faculty and staff of our College of Engineering learned a number of important lessons which can be applied to our traditional undergraduate students. We noted that the campers were highly motivated by the entertaining story lines that ran throughout the modules. When the activity was tied back to the story line, they were willing to do almost any activity and did not grow discontented or distracted. We believe this is vital, too, for the undergraduate engineering student. When a course is well prepared and planned, the lectures, laboratories, assignments, and projects weave a unifying lesson throughout the semester. This lesson was directly applied to the redesign of three classes in our curriculum in the months following the 2008 program.

We also noted the tremendous interest the campers showed during the "*I Can Invent*" module. In our 2008 program, 110 campers spent approximately five hours each taking apart and rebuilding such household objects as DVD players, ceiling fans, food processors, telephones, phonographs, and radios. They explored the different internal components and how they were connected. Finally, they imagined, documented, and implemented their self-conceived inventions and improvements to their items. This activity has been duplicated in our Embedded Microcontrollers class and expanded in our capstone Senior Design Project sequence.

Conclusion

Through a student focused K-12 outreach program, engineering colleges can affect both their service and education aspirations by providing an educational opportunity not found in a majority of primary or secondary schools. The challenge, however, is to deliver a worthwhile and lasting experience to the students in an environment of constrained resources. To that end, Valparaiso University has worked with Invent Now Kids, Inc. (a subsidiary of the not-for-profit National Inventors Hall of Fame Foundation) to host Camp Invention for over 165 elementary students during the past two years. In parental follow-up survey's, over 95% of the campers enjoyed the weeklong programs, and nearly 50% of the first year campers that were eligible to return did so in 2008. While it is difficult to determine the long term impact upon the children participating in the program, we believe there are still benefits to the students and our institution. These benefits include increasing the number of students with an interest in math and science and encouraging faculty to further practice non-traditional classroom instruction.

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