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Evolution of an Engineering Technology Outreach Program

Abstract

One element of Purdue University’s mission is to play a leadership role in strengthening Indiana’s economy and improving the qualifications of the state’s workforce. One element of the strategy to achieve this is to improve preparatory education through continuing engagement with PK-12 schools, with special emphasis on reading, writing, math, and science. Prior to 2004, the College of Technology in Columbus had little if any engagement with the local PK-12 schools.

In an effort to initiate engagement, professors from the Organizational Leadership and Supervision and Mechanical Engineering Technology departments organized, submitted and received a grant from a local community foundation to bring technology to elementary students using LEGO™ bricks, gears and pneumatic elements. That initial grant for over $6000 resulted in three separate days of workshops in three different schools. In each school workshops were conducted simultaneously for as many as three different classes of fifth and sixth grade students. Nearly all the faculty and most of the staff of the Purdue College of Technology in Columbus were involved in these workshops. Pre and post tests were given to attempt to determine how much learning had occurred. Thank-you notes received by the workshop organizers contained very positive comments from the participants.

After that first success, the author has received 9 more grants from organizations as diverse as community foundations, economic development boards, companies and neighborhood associations totaling nearly $40,000. With all the grants, the funds were used to purchase LEGO™ equipment, LEGO™ software and LEGO™ curriculum plans. In some cases, this equipment has been used to promote the Purdue College of Technology through elementary school science nights, summer camps and career fairs.

This paper will detail the strategy to obtain the grants and the specifics of how they were used. Additionally, the overall outreach strategy has led to the Purdue College of Technology in Columbus hosting a qualifying tournament of the First Lego League for the first time in 2006. The second tournament in 2007 saw a two-fold increase in the number of teams coming to Columbus, Indiana to compete. All of these efforts were aided by the evolution of the outreach programs initiated by the author.

Introduction

Purdue University is a public, state-supported institution that, according to its mission exists to “serve the citizens of Indiana, the United States, and the world through discovery that expands the realm of knowledge, learning through dissemination and preservation of knowledge, and engagement through exchange of knowledge.” Subsequently, one of the corresponding goals to this mission is to “effectively address the needs of society through engagement” and one of the key strategies to attaining this goal is to
In the fall of 2003, the Purdue location in Columbus, Indiana had no engagement activity with PK-12 schools throughout its region and, as a result, was quite unknown in its immediate and surrounding areas. Since most citizens of Indiana were unaware of the higher education opportunities at Purdue University in Columbus, maintaining sufficient enrollments to justify the program was always a struggle. And, while there may exist many ways to increase engagement and enrollment, the effort described herein attempts to take a long-term approach to these goals by increasing engagement at the PK-12 level, although some of the resulting activities have provided positive publicity to provide a short-term effect as well.

Learning from Others

In the fall of 2003, the author attended an ABET-sponsored Technology Education Initiative workshop in Greensburg, Pennsylvania. During a break in the workshop, faculty from a nearby university described an engagement effort called PRIME (Partnership for Regional Innovation in Manufacturing Education) that is an “industry-driven, academic system delivering innovative manufacturing education and career development.” This coalition of six higher education institutions and many manufacturing companies launched this effort to encourage more young people to seek higher education and, in particular, higher education in manufacturing. One of the elements of this effort was a program using LEGO Mindstorm robots and software to develop one-day and weeklong workshops to interest and educate young people about automation in manufacturing. Also included in the workshops was a visit to a local manufacturer to see automation in the real manufacturing world. These workshops attracted great interest. In fact, after the funding ended and the organizers required payment to attend the workshops, the interest did not fade. According to the organizers, it took only a couple days for the workshops to fill to capacity even with the required fee. After some investigation, it was clear that the situation in Pennsylvania was similar to that in Indiana. In southern Indiana, the economy depends largely on manufacturing, and unskilled manufacturing jobs are leaving the state. Advanced manufacturing, requiring highly skilled labor, offers companies an alternative to shipping low-skilled jobs out of the country. The key, though, is for the geographic area to produce the skilled labor necessary for this transformation and it was clear that southern Indiana would be challenged to provide this skilled labor.

Beginnings

Also, in the summer of 2003, the lead administrator at the Purdue University location in Columbus, Indiana allowed the author to spend $500 on anything related to learning, discovery or engagement. This $500 was used to purchase various LEGO sets including a motorized simple machines set, a mechanical engineering set, and several air power sets, and were used to familiarize the author with what was available and what might be possible with LEGOs.

This first purchase plus the experience at the TEI workshop led to a grant proposal to a local center of teaching and learning to conduct a pilot workshop with the air power set. The grant was approved and the additional $500 was spent to purchase as many air power sets ($32) as
possible. These sets were used in two pilot workshops that had a total of 22 participants, and the success of these workshops during the spring of 2004 led to a much larger grant proposal.

Evidence and Statistics

Grant proposals have been targeted to community foundations in the university’s service area. A community foundation in the state of Indiana is defined as a “tax-exempt, nonprofit, autonomous, publicly supported, philanthropic institution composed primarily of permanent funds established by many separate donors for the long-term diverse, charitable benefit of the residents of a defined geographic area.” Historically, the counties in the area surrounding the university regional campus have experienced very low educational achievement. In some counties, the percent of the population with a bachelor’s degree is less than 10% and the percent of the population with a high school diploma is near 60%. These types of statistics, available from the state of Indiana, enforce strongly the need to encourage science, technology, engineering and math (STEM) achievement throughout the educational system. Further evidence used in the grant proposal was provided by a study commissioned by the Indiana Chamber of Commerce and indicated the seriousness of the quality of the Indiana workforce. As stated in the report “In the 21st century, 60 percent of all jobs will require skills that are possessed by only 20 percent of the current workforce. In Indiana, an estimated 960,000 to 1.23 million employed citizens have literacy skills below the minimum standard for successful employment in a knowledge-based economy.”

This grant proposal and all the additional proposals that were funded by community organizations utilized these statistical data to reinforce that young people in elementary and middle school need to learn about possible careers in their area; need to know how their current studies affect their possible career aspirations; need to meet adults who can serve as potential role models; need to know that manufacturing is not a “dirty” and unrewarding career; and need to experience learning in a fun and engaging way. All of these needs are addressed in the grant proposals and in the workshops and camps that have evolved from those proposals. Community foundations in the university’s service area have been interested in funding projects that can positively affect their community as described above. All of the grants obtained have been less than $10,000, which allows the grantees to exclude indirect costs from the proposal, an important provision since this allows all of the foundation’s money to be spent on citizens in their community.

Community Foundation Grant

This first grant from a community foundation was targeted to fourth through sixth grade students and used the Introduction to Air Power set offered by the LEGO Company. This particular set cost $32, allowing the purchase of 210 of the sets with free shipping provided by the LEGO company (www.legoeducation.com). The original proposal included buying 20 each of the Introduction to Air Power set, the Motorized Simple Machines set, and the Robotics Invention System – Mindstorms set and the original plan called for six total workshops with ten students at each workshop. This allowed a broader range of ages for the project. However, the community foundation requested that the focus be placed on elementary school students and that only the Introduction to Air Power set be purchased. This alternate plan certainly maximized their
investment in the community. Also, the participants of the workshops were allowed to keep the LEGO sets at the end of the workshop, ensuring that the equipment would stay in the local community.

The community foundation also required a matching investment by the university. This requirement was satisfied by totaling the faculty and staff time required to conduct the project and multiplying that total by a conservative $50 per hour. This time included 8 workshops lasting 4 hours per workshop, 30 hours of preparation time for two faculty members (2 x 15) and 30 hours of post-workshop time for two faculty member (2 x 15) for a total of 124 hours. At $50 per hour, this effort amounted to $6200, which satisfied the community foundation.

Two additional first-time efforts attempted on these workshops were a pre-test and post-test. The workshop participants were given the pre-test before the workshop and then given the same test after the workshop to investigate whether any learning had occurred. Participants were asked to identify their gender and grade on the tests but nothing more. The results were summarized and graphed in a subsequent paper. Interesting observations from the results included that girls showed the most improvement and that at the 6th grade level in one of the schools the percent correct for both tests for boys and girls were nearly identical, with each showing the same improvement.

An additional aspect of this project was the inclusion of engineers and technologists from the local community to assist in the workshops. Several local companies were contacted and two companies allowed three of their employees to help the students. This was a critical aspect of the project as the students could identify with people from their community and could have viewed them as role models.

The community foundation required a final project report which was delivered to them after the conclusion of the workshops. By all accounts, the project was considered a success. Over 200 fourth through sixth graders were impacted by the investment. The community foundation received positive publicity in the local media and the Purdue University College of Technology in Columbus, Indiana also received terrific exposure in a community that knew little about it previously.

**Neighborhood Association Grant**

Much of the same logic and evidence was included in a grant proposal to a neighborhood association in a nearby large city in the spring of 2005. This neighborhood association seeks to improve the quality of life of their residents and to support schools, churches, and social service programs. A grant proposal was prepared in conjunction with a private school in the neighborhood to offer a 3-hour workshop to the school’s fourth, fifth, and sixth grade students and the neighborhood association funded the grant for $800. This allowed the purchase of 45 LEGO pulley mini-sets. The author and several colleagues traveled to this inner-city private school to conduct two simultaneous 3-hour workshops. Again, a short multiple-choice test was completed by the students before and after the workshop with very positive learning results. These results are summarized in a paper by the author and one of the colleagues.
LEGO Mindstorm - Introduction

The above grants supplied materials to allow the university faculty and staff to interact with elementary students. A different approach was needed to develop a plan to engage the middle school students. A small grant application proposal was completed for the same community foundation as above. This time the amount was for $1450, the grant was approved, and the money was spent to buy four LEGO Mindstorm sets and site licenses of the ROBOLAB software for the university campus and a learning center located in the same community as the foundation. The site license of the ROBOLAB software was really the key purchase with the grant. An elementary school in Greensburg, located in the county supported by the community foundation, had previously invested in LEGO Mindstorm sets, and these sets were used with the software to conduct workshops. In each of two years, four classes of 8th graders were engaged with a LEGO Grand Prix contest. A course was constructed with several obstacles and turns and the students were given the challenge of programming a robot to navigate the course only using the two motors attached to the two wheels of the robot. Students worked in pairs to program their robots. Each of the four classes met for one hour for three straight days to tackle the challenge. Note that these robots are programmable control not remote control. The student teams were required to simply push the run button at the starting line of the course and then watch as the robot moved around the course. There was no remote control involved in controlling the robots.

Again, this was a successful project for the foundation, the university and the middle school. The foundation received positive media publicity and felt their investment was worthwhile. This activity at the school was conducted late in May at the end of the semester when teachers struggle to engage the students. And the university received much-needed exposure in a portion of its service area previously ignored.

LEGO Mindstorm - Summer Camps

This experience with LEGO robotics led the author to offer two robotics summer camps in the summer of 2006. The Purdue University research foundation donated $2000 to allow the purchase of 10 more LEGO Mindstorm sets to be used in outreach projects. In this effort, the author formed a partnership with a fellow faculty member in the Division of Education whose specialty is science education. This partnership broadened the outreach effort to include elementary and middle school science teachers in the service area of the university. The first summer camp in 2006 was conducted with 14 participants, each of whom paid $50 to cover expenses of food, batteries, t-shirts and prizes. The science teachers involved met with the Division of Education faculty member during the morning (9am – noon) to learn about utilizing inquiry in science education. After lunch, the teachers joined the teams of participants to experiment with using inquiry in the classroom. At the end of the four day camp, a competition was held between the teams. Four different challenges were presented to the teams to solve with their robots. To solve these challenges required innovative programming, innovative use of sensors and innovative construction.

The second summer camp in 2006 included 20 students as well as more teachers. The same camp organization was used as the earlier camp with teachers working with the students in the afternoon. This camp was supported by a grant from the state of Indiana Department of
Education and permitted the purchase of 20 more LEGO Mindstorm sets, which became the property of a local organization called the Center for Teaching and Learning. As part of the grant, the 20 Mindstorm sets became a resource that local elementary and middle school teachers could “check out” for two weeks and utilize them in their classrooms. Similarly, the additional sets could be used by university personnel in outreach and engagement projects. In June of 2007, all of the sets were used to conduct another summer camp that included 38 participants. Teachers were also part of that camp, which was organized similarly to the 2006 camps and also was supported by the Indiana Department of Education.

**Scott County Partnership**

In the state of Indiana, the county of Scott is the lowest performing county in the state in terms of educational achievement as defined by percent of population with high school diplomas and bachelors degrees. Representatives of this county have been very aggressive in seeking and receiving grants for economic development. A Technology for Innovation and Entrepreneurship (TIE) center is being built and a partnership group has received grants that have led to an advanced manufacturing training center that is available to any company in the county. The people of the county have recognized their deficiencies and worked hard to begin correcting them. Consequently, there has been considerable interest in Scott County in bringing educational workshops for young people. The author made several presentations to the partnership board, city council, economic development board and local industry representatives.

The result was two separate grants worth a total of $11,600. One of the grants was from the local community foundation and the other was from the economic development board. The funds were used to purchase 48 LEGO Mindstorm sets, and two sets of software site licenses for the two middle schools in the county. Also, included was curriculum software that could be utilized by the teachers of the two schools to implement in the classroom. The author and his Division of Education colleague conducted workshops for the teachers at each of the schools. Also, the author made a promotional presentation at each school in May of 2007 in advance of robotics summer camps conducted during summer 2007.

The interest in the summer camps in Scott County was great enough that two camps were conducted. The first included 16 students and the second had 20 participants. For both camps, several teachers from the two middle schools also assisted in conducting the camps, using the experience to aid them for possible classroom use. Challenges were provided for the participants, who were teamed in pairs, and prizes were awarded. Again, these camps were extremely successful as the grant donors, participants and the university received recognition in the local media.

**First LEGO League**

All of this activity with LEGO robotics in the area led the author and his Department of Education colleague to organize the first Qualifying Tournament of the First LEGO League (FLL) in the southern part of the state of Indiana. As stated on their website, FLL is a “result of an exciting alliance between FIRST and the LEGO Company. Guided by adult mentors and their own imaginations, FLL students solve real-world engineering challenges, develop important life...
skills, and learn to make positive contributions to society."9 FIRST (For Inspiration and Recognition of Science and Technology) states that their mission is “to inspire young people to be science and technology leaders, by engaging them in exciting mentor-based programs that build science, engineering and technology skills, that inspire innovation, and that foster well-rounded life capabilities including self-confidence, communication and leadership.”10 The competitions have a yearly theme and are conducted each fall. The competitions, however, are not solely about programming and building a LEGO robot. Indeed, the competition has four parts — a project presentation, a design review, robot performance and teamwork.

The project presentation is a 5 minute presentation or skit that the team must prepare and perform for judges and focuses on the annual themes. Some of those themes have included alternative energy, Mars exploration, nanotechnology, and underwater exploration. The design review is a 9 minute session with judges where the team describes and demonstrates the construction and programming of their robot. Robot performance comprises the operation of the robot to satisfy the challenges. Finally, teamwork is a subjective evaluation made by judges who observe the team throughout the competition day as well as meet with the team to discuss the process they followed to prepare for the competition. The many facets of the competition help to develop the communication, teamwork, and leadership skills of the participants.

FLL had flourished in the northern part of the state for several years; it had not been attempted in the central and southern part of the state. However, with the seeds planted in various communities due to summer camps and other workshops supported by local community organizations and the university, the interest was sufficient to give FLL a try.

The university hosted the event for the first time in November of 2006. The author made presentations to at least 10 schools in the months leading up to the competition to promote it and encourage participation by the schools. Similarly, the author and his colleague from the Department of Education sought funds and materials donations to properly equip for the competition. They also received support from each faculty member’s institution for the event. In the fall of 2006, 11 teams participated in the competition. Many came from schools with teachers and students who participated in the summer camps. Over 100 children from ages 9 – 14 participated in the competition and most brought their parents and siblings with them to share in the experience. Chief administrators from the university addressed the teams to kickoff the event and banners, pamphlets and other information sources promoting the university were prominent in the competition area. Media coverage was excellent and included several newspapers and a television station from a nearby large city. The television station made available to the university the short video included on the newscast the evening after the competition and the university was able to add a link to the video on their website.

In 2007, the FLL competition really began to build momentum. 21 teams participated in the event, requiring a move to a larger space, an expanded budget, more prizes and more volunteers. This event included over 200 young people and a total number of people estimated at more than 400 gathered at the Columbus Learning Center for the Event. Administrators and deans from the institutions of the author and Department of Education colleague recognized the value of the competition and provided more than twice the financial assistance from the previous year. Donors from the previous year again agreed to support the event. Additional teams came from
the local area and were connected due to the outreach efforts including the summer camps and various grants. However, the largest growth came from areas that recognized that this new tournament held in southern Indiana made their participation possible.

The recognition and outreach of the university due to this event was and is outstanding as it will continue on an annual basis. Administrators and academic leaders of the institutions involved have recognized the benefit of the event and have continued their enthusiastic support financially and materially. And the competition requires and encourages science, technology, engineering and mathematics activities, which will hopefully benefit the engineering technology program in Columbus.

**Conclusions**

Prior to 2004, the Purdue University College of Technology in Columbus, Indiana, had no real presence in the community other than to simply offer degree programs and classes. Even the director of the university admitted that the College of Technology was the “best kept secret” in the area. Clearly, in an environment of shrinking enrollments, this had to change. But also, the university was not fulfilling its mission and goals regarding engagement. The effort began simply, with the author grabbing an idea obtained from a conference presentation. By using various resources to gather employment and education statistics, the author began proposing and receiving grants from small community-based organizations who are interested in helping their communities enjoy a higher quality of life. The outreach effort continued to grow and has eventually led to the university hosting a robotics tournament for children ages 9 – 14 that grew quickly after just one year and has the potential for continued growth.

While this effort is undeniably beneficial for the university and its programs in terms of outreach and recognition, there are no definitive statistics to support this. Clearly, a longitudinal study of the participants involved in the various programs would provide supporting data on whether the children have indeed chosen to study STEM subjects and continued in STEM careers. Another pertinent study would be if some of the participants have enrolled in the university to help increase enrollment. Currently, there is a small effort planned to survey incoming university students if they’ve ever participated in a LEGO workshop or robotics competition. This would provide some concrete data while not requiring many resources to accomplish.

**Bibliography**

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