USING FIRST LEGO LEAGUE TO ENHANCE ENGINEERING EDUCATION AND TO INCREASE THE POOL OF FUTURE ENGINEERING STUDENTS (WORK IN PROGRESS)

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Abstract *¾ FIRST LEGO League (FLL) is an international initiative to encourage students aged 9-14 to pursue careers in technological fields. In its four years of existence, the competition has grown dramatically. During the Fall 2001 semester, several Michigan Technological University students served as mentors for local FLL teams.*

This paper presents details about the national FIRST LEGO League program, and statistics from a survey of FLL coaches in Minnesota are summarized to shed light on the current state of the program. Michigan Tech's FLL mentorship program is described along with the desired outcomes and summarized assessment results. The paper then presents several issues Universities must consider if they would like to begin an FLL mentorship program. Finally, preliminary conclusions are drawn based on the first year of the Michigan Tech program.

Index Terms ¾ outreach, K-12 education, robotics.

THE NEED TO INCREASE THE POOL

According to the National Science Foundation's report on Science and Engineering Indicators 2002, there are several reasons why it is important to increase the pool of students who choose to study engineering in the United States. The report states that the U.S. relies heavily on foreign countries for much of it's technical work force, and although this has been the case for many years, global changes are affecting how many of these workers will be available in the future. As the availability of this foreign resource shrinks, the U.S. will need to rely more and more on a technologically literate pool of American students.[1]

Because of this need, there have been many efforts aimed at encouraging K-12 students to study math and science, in the hopes that they will then pursue careers such as engineering. Some of these efforts are designed to be part of the regular school curriculum, while others are implemented as extracurricular activities. These programs have been funded by both government and industry, and often try to have a component of "fun" in order to attract and keep student interest. Many of these programs are of a competitive nature, modeled after sporting events or games, which have a proven track record of being popular with parents and children. This paper looks into one such program that follows this competitive model; in fact its motto is "Sports for the Mind". This program is called FIRST LEGO League.

WHAT IS FIRST LEGO LEAGUE?

FIRST LEGO League is a program organized by its non-profit parent organization named FIRST. The name FIRST is the acronym of, "For Inspiration and Recognition of Science and Technology." FIRST's mission is: "to excite young people about the fun, accessibility, and importance of science and engineering."

FIRST was started in the early 1990s in response to news that U.S. students were lagging behind their international counterparts in math and science test scores. (The original name of the organization was US FIRST.) For many years, almost all of FIRST's resources were put into FIRST Robotics, a robotics competition where high school students work with practicing engineers.[2]

In order to try to influence students at an earlier age, a new event, called FIRST LEGO League (FLL) was started for kids aged 9-14. It is a partnership between FIRST, the LEGO® Corporation, and other sponsors. In this program, teams of students work together to create a programmable robot to perform on a competitive playing field. Each year a new challenge is presented which is related to the science of a particular environment, such as a volcano or arctic ice field. (The 2002 challenge is entitled "City Sights" and will be officially unveiled in September.)

Although the robot is an important part of the challenge, student-learning opportunities go beyond learning to build and program a robot. Students are encouraged to learn the "science behind the challenge", and to present their findings to a panel of judges at each competition. Since students are working in teams of 7-10 members, they also get the chance to strengthen their team problem solving skills. For example, one part of the challenge asks students to develop a hypothesis to answer a question. The question for the 2002 challenge, Arctic Impact, was: "Is global warming caused by man made factors or is it part of a natural cycle?" Student teams develop an answer to the question based on their research, and then present their findings to judges at the competition. There is no right or wrong answer to the question, students are judged based on the creativity of the presentation and the accuracy of their research. The following list of awards gives some impression of the breadth of the program:

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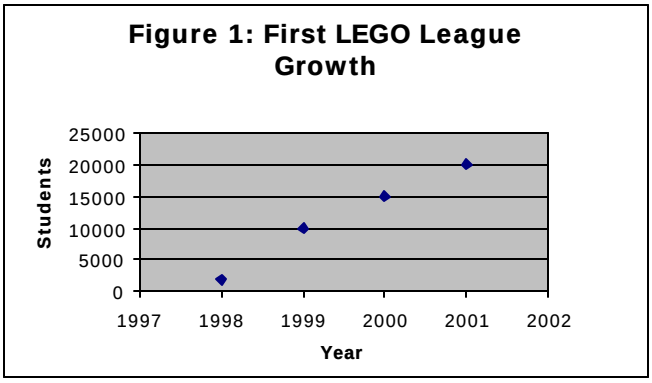
- Hypothesis Presentation
- Technical Interview
- Creativity Award
- Programming Award
- Robust Design Engineering Award
- Team Spirit Award

Each of these awards, as well as others, is given out at each regional and state competition.

DOES FLL "WORK"?

Does FLL make a difference in the numbers of students who choose to study engineering and related fields? Because it has only been in existence for four years, it is hard to measure FLL's effect at this point. The first alumni, who were relatively few in number, are just now applying to college. Examining the number of participants over its short history shows a dramatic increase from 2000 in the inaugural, pilot year, to more than 20,000 four years later. (See figure 1) This alone gives some idea of the demand and potential for this program.[3]



Why has this program grown so much and how can this be exploited to get more students into engineering?

Some evidence comes from a survey given to FLL coaches at the 2001 Minnesota State Tournament. This survey was conducted by the tournament organizer, Mr. Fred Rose, and was designed to gather information to improve the program in Minnesota. The data gives a good general picture of how FLL is perceived by the coaches who put in many hours of work each season. The complete survey results can be found on the Web [4].

Minnesota FIRST LEGO League Coaches Survey

Presented in Table I, is a summary of this survey. The purpose of including it is to give the reader who is unfamiliar with LEGO League some idea of the impact it has on students, and hence, its potential to significantly increase the pool of future engineering students.

The survey was given to 61 coaches who were asked to respond to statements on a 1-10 scale, with 10 being strong agreement, 1 being strong disagreement. In the summary presented here, responses of 7-10 were taken as "agreement", 1-4 as "disagreement", and 5 & 6 as "neutral".

TABLE I
SURVEY SUMMARY OF 61 MINNESOTA LEGO LEAGUE COACHES

Survey Statement	Response Synopsis
The challenge was fun	95% agreement
The level of difficulty was appropriate	79% agreement
My team has a more positive view of science and technology due to FLL	78% agreement
I (coach) have a more positive view of science and technology due to FLL	67% agreement*
My school administration has a more positive view of science and technology due to FLL	50% agreement
Parents has a more positive view of science and technology due to FLL	81% agreement
I will coach again next year	83% agreement
I will recommend FLL to others	98% agreement
My team members are likely repeat FLL next year	95% agreement
Overall, the program was a good value	
Our program was associated with a school	70% agreement

** Most coaches probably already had a very positive view of science and technology before participating in FLL*

These results clearly show that FLL has generated a great deal of dedicated effort from these coaches. Their hard work, along with their positive feelings toward the program demonstrated by this survey; translate into making a positive experience for hundreds of young students. If students have positive experiences with an activity they are likely to come back for more, and in this case, "more" might mean an inclination to pursue studies in science and technology.

FLL AT MICHIGAN TECH

During the Fall 2001 semester, 15 Michigan Technological University (Michigan Tech) students worked with 10 local FLL teams to help them prepare for competition. Prior to this, there were no FLL teams within 100 miles of the university, and only one team within approximately 250 miles. Michigan Tech in unique, in that it is a large engineering school located very remotely to the industrial centers of the Midwest. This leads to the unusual mix of high tech facilities located in a rural area.

Previous attempts to start a LEGO League in the area were thwarted by a lack of funds, as well as a lack of coaches. In 2001, the funding problem was solved by a grant from the Western Upper Peninsula Center for Math and Science Education (WUPCMSE). The center agreed to help fund up to 10 teams as long as there was cost sharing on the part of each team's school district and each team had an adult coach.

The cost to field a new FLL team is around $600.00, with the cost breakdown as follows:

- National FLL Entry Fee - $150
- New LEGO Robotics Kit - $260
- Challenge Kit - $50
- State and Local Tournament Fees - $30 to $50
- Table Materials - $50
- Miscelaneous (treats for team, local travel, etc.) - $50

These do not include long distance travel costs which might be needed to attend a state tournament. After the initial year, a team can re-use their robot kit which lowers the cost somewhat. In 2001, WUPSMSE paid for the LEGO Robotics Kit and the Challenge Kit, while individual schools paid for the rest. Finding coaches turned out to be more difficult than finding funds.

There are two requisites that team coaches must have to be effective. First, there needs to be a willingness and ability to spend time working with students to direct their effort. Second, coaches must have enough technological know-how in order to deal with LEGO RCX components, computers, and other technical details. Finding people with both of these qualities can be very difficult.

Nationally, many teams are part of a school program and have a schoolteacher as their coach, but this often means that the coach needs to be paid which can be problematic. If a teacher is unfamiliar with LEGO RCX, or technology in general, he or she will often decline to coach even though s/he is otherwise highly qualified. Other than teachers, the most likely group of coaching candidates is parents of FLL team members. They possess the willingness and ability to spend time with the teams but often lack (at least in their own minds) the technical ability required, so they often pass on coaching a team.

It is in cases like these, where college students can provide the technical knowledge and LEGO RCX savvy to alleviate these responsibilities from the coach. There are many college students on almost every campus who are very familiar with LEGO RCX and also have time to mentor an FLL team. This is what was done at Michigan Tech.

The Michigan Tech students helped by deciphering the rules to the game and teaching the basics of LEGO RCX programming to coaches and team members. The college students also staged a local competition and helped organize a regional tournament. Most, but not all, of these students had previous experience with FLL in some capacity.

The college students involved were members of Michigan Tech's Robotics Systems Enterprise, which is part of the Michigan Tech Enterprise Program. Their work in FLL was counted as partial credit for the enterprise course. In lieu of getting paid individually for their work, funds were provided through an NSF grant that went directly to the Robotics Systems Enterprise. These funds were then used by the enterprise to for other robotics projects. College students also were reimbursed for traveling to team meetings with a mileage allowance.

The Michigan Tech program was started to accomplish two things, 1. Get more young students interested in engineering, and 2. Give Michigan Tech students an experience to enhance and supplement their engineering education.

Desired Outcomes

Presented below, is a list several desired outcomes for the Michigan Tech students involved in this project. It was desired that would be significant growth in the following areas:

- Commuinication skills
- Programming skills
- Overall technical skills
- Appreciation for community service

In addition, it was desired that the project would strengthen the relationship between the University and the local community, and that the college students would be seen as positive role models who would encourage the young members of their team to pursue studies in science and technology.

First Year Results

As originally conceived, each Michigan Tech student was to be assigned to a team, and would work closely with that team throughout the season. In fact, some students took on a great deal of responsibility for their FLL team, while others merely acted as a "technical consultant" when asked by the team's coach. The level of involvement was dictated by several factors such as; the proximity of the FLL team to campus, the time of the team meetings, and the technical knowledge of the team/coach. Some teams had two college students working together to help them.

There were 15 students who participated in the Michigan Tech LEGO League project. Of these, 4 were very involved in the operation of their team. They interacted with the team and coach on a regular basis and got to know the team members quite well. Eight other students were also assigned to teams either alone or with another person, but were much less a part of that team. Due to time conflicts and other factors, these students attended only some of the team meetings and tried to answer technical questions via e-mail or telephone, when they weren't present.

After the LEGO league season, the Michigan Tech students were asked several questions to crudely measure the effectiveness of the program. Team coaches, and members were also questioned to find what they liked about the program and what should to be changed to improve it. The results of these surveys are summarized in the table below.

TABLE II
SURVEY RESULTS OF 15 MICHIGAN TECH STUDENTS

Survey Question	Response Synopsis
As a result of your participation in this project, do you feel you have improved your skills in the following areas:	
Communication	9 positive 6 negative
Programming	12 positive 3 negative
Overall Technical Knowledge	12 positive 3 negative
Will you participate in this project again next year?	8 positive 5 unsure 2 negative
What is your overall feeling about the FLL/Michigan Tech program?	9 positive 6 neutral 0 negative

When asked to comment on the project, there were a few items that were seen on several of the student's response forms, which are summarized here:

- More training in RCX programming would be helpful.
- Training in working with young students might help.
- College students would definitely prefer to be paid, if only a small amount, for their efforts

Comments from the coaches were distinctly divided into two groups, those who had a student mentor who was very involved with the team, and those who's assigned mentor was less involved. As one might expect, the former group had very positive comments about the program and were excited to participate again. The latter group said that they needed more technical help, and most would participate if they could get this help. No coaches said they would not participate again.

Comments of the actual team members, as reported by their coaches, were very positive. Almost all said they would like to participate again, which corresponds with the Minnesota coaches' survey.

As preparations are made for the 2002 season, plans are being made to improve the mentorship program. Students are being identified who will be able to meet on a regular basis with their assigned team. There will be two hours of training for the college students directed at working with young people and adults in a professional manner. There will also be peer training to assist current and future members in LEGO RCX programming and FLL in general. FLL veterans in the Robotics Systems Enterprise will conduct this training.

Comments to Assist University Mentorship Programs

If a university chooses to support FLL teams by providing student mentors, there are several points that can be taken from the Michigan Tech program.

- Student mentors should have training in working with youngsters and team coaches.
- Students shouldn't, as a rule, be team coaches.
- The more involved the student is with a team, the more postive the experience will be for everyone.
- FLL teams DO NOT have to be associated with a school, although schools are a good place to begin when looking to start new teams.
- If no FLL program exists in your area, it will be better to start several teams to provide a support network and competition opportunities.
- Students mentors will benefit from communicating with each other via an e-mail list or regular meetings.
- New FLL teams might need help finding funding and/or qualified coaches.

FUTURE PLANS AND PRELIMINARY CONCLUSIONS

Since this paper is describing a work in progress, no final conclusions can be drawn. The grade school students who are participating in the Michigan Tech FLL program are being tracked to see if the program is influencing their choices as they progress through high school and college. They will be compared to a control group of students who did not participate in FLL. Care will have to be taken to attempt to filter out influences such as socioeconomic factors and family academic history. These same students might also become part of a larger study with similar goals. The college students involved, will also be followed and given exit interviews before they leave the university. The purpose of the exit interviews will be to assess weather the program outcomes are being attained, and to collect student opinions of the program. These opinions will be used to improve the mentorship experiences of the students who follow.

There are, however, several preliminary conclusions that can be made from the Minnesota coaches' survey and the Michigan Tech FLL mentorship program: 1. There is a great demand for this program demonstrated by its growth over the past four years. 2. Coaches and grade school students like the program and usually return to repeat the experience. 3. Coaches think the program is a good value.

FINAL COMMENTS

By supporting FLL teams through a mentorship program, universities can participate in a national effort to increase the pool of future engineering students. The experience can also be a positive addition to the education of university engineering students. Current and future studies will give a more accurate picture of the effect this program has on young students.

REFERENCES

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