



How College Students Are Increasing Global Competency while Inspiring the Next Generation of Engineers through UFLL (student poster)

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Christopher F. Thompson has been a student at Salt Lake Community College in Salt Lake City, Utah since the fall of 2009. He is currently studying chemical, civil and environmental engineering. While attending SLCC, he has been involved in extracurricular activities. He is the student president for the American Society of Civil Engineers student chapter at SLCC, and the vice president of Leadership for Phi Theta Kappa. He served as an event manager and the head state referee for the 2012 Utah FIRST LEGO League season. He looks forward to graduating with an A.S. in General Studies in the spring of 2014 followed by an associate's of pre-engineering degree in Chemical/Civil/Environmental Engineering in the fall of 2015. He chooses to study civil/environmental engineering as a way to grow within his already existing career field. For the past six years, he has worked in the civil engineering profession as a designer/draftsman. He works closely with civil, environmental, and structural engineers on a daily basis; so for him, becoming a civil engineer is his next logical career progression. He brings to the table a fresh mind and eagerness to succeed. It is his opinion that experience can overrule education. He has every intention to reach a point where his education will meet his experience, creating a complete and well-rounded professional engineer. Thompson plans to minor in Chemical Engineering. When coupled with his education in civil and environmental engineering, chemical engineering is a field of study that he believes will lead him to achieving his ultimate goal: earning a Ph.D. in nuclear engineering. Thompson believes his education will allow him to know how to design and construct an appropriate nuclear facility, while chemical engineering will help him understand the actual nuclear science process.

How College Students Are Increasing Global Competency while Inspiring the Next Generation of Engineers through FIRST Lego League

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Abstract

This study is to show that college students can play a crucial role in inspiring the next generation of engineers through recreational learning opportunities like FIRST Lego League (FLL). The aspects explored are partnership models between college aged students and the FLL program, the significant educational benefit of these partnerships for both the college and middle school aged participants and the impact FLL has on participant's perceptions of pursuing higher education in the field of engineering.

In the competitive workplace of the world today, it is imperative to have more competent engineering graduates from our Institutions of Higher Ed. The current approach taken for getting young students excited about engineering is not effective enough. Young students are asked "What do you want to be when you grow up?" but often do not know much about their options— not until high school or college are jobs discussed with detail. What if kids could experience firsthand what a career-field might entail, even before middle school? By practicing skills of teamwork, open ended problem solving and critical thinking in a fun and invigorating environment, kids can be inspired to pursue engineering education with passion and become competent international contributors. This study is intended to quantify the effect of a specific extracurricular program on middle school student's views of science and engineering.

FIRST (For the Inspiration and Recognition of Science and Technology) LEGO League (FLL), a global innovation and robotics competition is a way to build this passion. Teams of kids ages 9-14 self-organize with an adult coach and are challenged to provide inventive solutions to real world problems (food contamination, aging, natural disasters) implementing critical research, brainstorming and professionalism skills in a different way than in solely traditional classroom education. This problem solving, combined with the technical challenge of designing and programming LEGO robots is a clever way of developing 21st century skills while having a lot of fun. By increasing the exposure of exciting technology-based activities, whole communities can be energized to provide more STEM (Science, Technology, Engineering and Math)

opportunities and encouragement. The plan of this study is to monitor the success of FLL by tracking and tacking feedback from participants to determine the percent who pursue Engineering education.

Introduction

This paper will outline the manners in which Community College students are teaming up with Middle School age children to increase passion and global competency for science and engineering. An outline of the FIRST LEGO League (FLL) robotics and innovation program will be described, followed by an account of a Qualifying event hosted at a Utah Community College. The skills grown from involvement in LEGO League will then be discussed, finishing off with an analysis of the participation growth pattern shown in FLL and a look towards the future. The main ideas to be covered are the critical life skills of creative thinking, teamwork, communication, international engagement and problem solving.

FIRST LEGO league brings modern issues to the forefront of the minds of Middle school students. They get to the heart of the dilemma through research and investigation of the problems in order to come up with a solution. These students get to see that they can have a say with problems of the day, a notion that empowers them through their entire lives. This is an extracurricular activity that kids are truly excited to take part in. The kids that show up week after week are the ones that really want to be there. There are many reasons for their participation, but a majority of students claim that they enjoy the challenges and the friends that they make during the activity. Kids are excited to work together, being able to display their skills and learn from others—they enjoy the companionship and fun that FLL provides, while college age and adult volunteers get to be part of an invigorating technical atmosphere. Involved college students increase the community benefit of the program by spreading the higher education skills to the youth of the area.

Partnerships between community colleges and Utah FIRST Lego League

Community Colleges play a crucial role in delivering the FIRST Lego League (FLL) program in Utah. Community college students host qualifying events and volunteer to mentor and coach teams. The entire program is operated with volunteers; higher education students are ideally positioned to both contribute and gain from participating in the Utah FLL program in a volunteer role.

The process of mentoring the FLL team has significant benefits to both the team members and the community college mentors/coaches. As the team mentor or coach, college students have the experience of teaching teamwork and communication skills with a real working team. These challenges that college students are facing on their own teams are very similar to what will be faced after entering the workforce. The mentor role allows students to practice teamwork skills, experiment with methods for overcoming obstacles in collaboration and learn to coach a group of individuals into becoming a cohesive and productive team. Community Colleges support FLL qualifying events by both donating space and involving

students to organize qualifying events. These students learn leadership and organizational skills that are essential for future work in a professional organization. As students prepare to host the qualifying event, they work on a diverse statewide team of professionals and volunteers where they have an opportunity to create mentor relationships and gain essential experience. Students have an opportunity to practice leadership, recruitment, public speaking, fundraising, budgeting and stakeholder management skills, all of which will better prepare them to be an innovative contributor to global development efforts.

Outline of LEGO League

A tournament style competition, FIRST LEGO league is primarily composed of three areas of focus; the robot, the project, and core values. These three disciplines represent the varied requirements of engineering industry.

Project

The project presents the teams with a broad contemporary issue to address—past years have included Climate Change, Transportation science, Biomedical Engineering and Food Contamination—the 2012 season’s theme was Senior Solutions; teaming up with a senior partner and develop a solution for a common problem encountered in the elderly community. By researching, prototyping, and analyzing, each team creates a presentation to perform before competition judges. This project is an opportunity to thoroughly investigate how the world is dealing with a current issue, and to create a unique solution to the problem. With this open-ended prompt before presented to teams, some students have come up with solutions so innovative that they end up getting patents—there are no limits to the inventiveness that students practice in the Project portion of FLL. With judge feedback, teams hear how they can take their ideas to the next level. The project is inspiring for teams and judges alike.

Core Values

A less technical aspect, yet no less important part of FLL is Core Values. These guidelines provide the moral structure of the entire competition:

We are a team.

We do the work to find solutions with guidance from our coaches and mentors.

We know our coaches and mentors don’t have all the answers; we learn together.

We honor the spirit of friendly competition.

What we discover is more important than what we win. We share our experiences with others.

We display Gracious Professionalism in everything we do.

We have fun.

(FIRST).

Throughout the entire season, teams actively practice these Core Values each time they meet. As they gain personal meaning of each Value, the team assembles a poster describing their team's unique development of the Core Values. Once at the competition, the Core Values judges present each team with a standard challenge to complete in five minutes; as the team works, the judges make observations on how the team's behavior. Next, the team presents their poster—this gives the judges a chance to compare what they observed about the team with how the team perceives themselves. By continuously practicing Core Values, the teams of kids begin to internalize how to work from a strong foundation of guiding principles. The kids learn ways of overcoming group problems through feedback from Mentors, Coaches and Judges, while developing their own methods by experimentation.

Robot Design

Last, but not least is the LEGO robot game. Using a LEGO kit, programmable brick and programming software, the teams tackle a set of challenges issued yearly by FIRST. The challenges are very open-ended, and engineered so that teams have little chance at a perfect score. Within the established rules, teams can complete tasks in any method they can come up with. The robot uses an array of sensors and motors to autonomously accomplish its tasks. Robot Design effectiveness is evaluated in two different manners; Robot design judging takes place at the very start of the competition, assessing the design process of the robot's physical components, in addition to the structure of programming. This is where teams are questioned why they used certain parts and how they came up with methods of solution. The second manner of evaluation is the design's performance in the Robot Game. Teams have three rounds of two and a half minutes to achieve a high score in Robot Game, changing parts and strategies between the rounds as needed. During the Robot Game is where teams can observe and encourage other teams in action. While teams are competing against each other, they are observing the spirit of friendly competition.

Like a sporting event the atmosphere of a LEGO league competition is exciting. While the kids are displaying their skills and cheering on other teams they have a blast the whole time. They get to practice the valuable skills of research, development, presentation and ethically consistency in a fun and entertaining environment. The excited atmosphere is contagious; kids, parents and volunteers love the competitions and often return to observe or participate year after year. The next section of this paper will describe a qualifying event hosted at Salt Lake Community College in March of 2012.

UTFLL Qualifier on March 2nd 2013

Over a year of preparation went into making the event at the brand new venue of Salt Lake Community College Redwood Campus in Taylorsville Utah possible. The dozens of committed volunteers involved where the reason the event was successful. What follows is a list of the volunteers and their roles:

Volunteer Positions	First Name	Last Name
<u>Event Manager</u>	Jeff	Thomas
Registration/Info/Welcome Table Workers (Photographer)	Becky	Schaap
Registration/Info/Welcome Table Workers (Photographer)	Kristen	Johnson
<u>Facilities Liaison</u>	Trina	Frandsen
<u>Field Manager</u>	Natasha	Brinkley
Team Querer	Erendira	Lopez
Team Querer	Ron	West
Table Setter	Jason	Jones
Practice Table Manager	Devon	Jones
Practice Table Manager	Andy	Jones
Table Setter	Mark	Hall
Table Setter	Aaron	Burton
Score Running	Alice	Hall
Score running	Zach	Maynard
<u>Judge Advisor</u>	Bret	Wardle
<u>Judge Advisor</u>	Jenny	Goodwin
Project Judge	Derek	Jewell
Project Judge	Enrigue	Ruiz
Project Judge	George	Wilson
Project Judge	Rex	Knickerbocker
Core Values Judge	Nellie	Huynh
Core Values Judge	Levi	Manley
Core Values Judge	Tyler	Schmidt
Core Values Judge	Maria	Garcia
Robot Judge	Jenny	Ownby
Robot Judge	Nathan	Rackliffe
Robot Judge	Nick	Traeden (AM)
Robot Judge	Deanne	Hampson
Judge Room Assistants	Cyrus	Safai
Judge Room Assistants	Emma	Ware
<u>Head Referee</u>	Heath	French
Referee	Travis	Walker
Referee	Beau	Freckleton
Referee	Jason	Jones
Referee	Courtney	Doyle
Referee	Ed	Maynard
<u>Technical Manager</u>	Brent	Mellor
Timekeeper/Scorekeeper	Ross	Pope
Timekeeper/Scorekeeper	Adam	Bradshaw
Timekeeper/Scorekeeper	Ryan	Fisher
Timekeeper/Scorekeeper	Jared	Hamblin
Emcee/Game Announcer	Nick	Traeden (PM)
<u>Volunteer Manager</u>	Jamie	Kelsch
<u>SLCC Logistical Support</u>	Nick	Safai
<u>Event Director</u>	Chris	Thompson

These volunteers above performed exceptionally well both during trainings and at the event itself. Being selected from the college community and UTFLL veterans, there were many

skill sets that contributed to making the event a success; fun and educationally stimulating for everyone involved.

To bring this event to the community college took 12 months of planning and coordination from a core group of volunteers and FIRST Personnel that went above and beyond to make this event a reality. Most of these volunteers were listed above, but are listed again with a brief description of their involvement:

- Jeff Thomas: Event manager/Judge Advisor: Trained judges, developed college marketing material, recruited volunteers, coordinated venue setup, and collaborated with state organization.
- Trina Frandsen: Facilities Liason: Coordinated with college services directors for volunteer amenities, participant and spectator concessions, and was a solid resource on college processes and regulations.
- Natasha Brinkley: Field Manager: Critical insight during planning meetings, gathered volunteers as Student President of SLCC's Phi Theta Kappa Chapter, Oversaw Robot Game field during competition.
- Brent Mellor: Technical Manager: Lead the setup of the event's AV and sound equipment, placed overhead cameras for spectator view of the robot game, and organized the scoring software and timekeeping.
- Jamie Kelsch: Volunteer Manager: Negotiated with carpentry shop to build game tables.
- Christopher Thompson: Event Director: Initiated partnership between UTFL and SLCC, worked with both organizations to have all necessary material and space for event, continued to work with organizers even after relocating for a NASA internship.
- Anne Bastien: FLL Operational Partner: Provided extensive knowledge and experience of the LEGO League program, organized teams for the event, gathered volunteers from the statewide organization and was gave essential logistical support during the event.
- Kathy Hajeb: FLL Operational Partner: Organizes state-wide program, provider of media and involvement figures and backer of the SLCC Event
- Dr. Nick Safai: SLCC Professor and Event Logistical Support: Dedicated hours of his time to helping students plan the qualifying event and provided experienced insight to the running of the event and the writing of this paper.

Without this dedicated team, the event at Salt Lake Community College would not have been possible. Because of their hard work and determination, the LEGO League Students had a very positive impression of the FIRST organization, and were inspired to continue their interest in STEM education.

Event on March 2nd 2013

This 2012 Utah FIRST LEGO League season was packed full of surprises that pushed volunteer event-management skills to the limit. Round 1 of qualifiers proceeded smoothly, with 4 teams from each of the state-wide events qualifying for the state championship. The next round was to come a week later on January 12th. The Friday beforehand, a very large snowstorm came through the Salt Lake Valley, covering the ground and roads with drastically varying amounts of snow and shutting down the University of Utah and Salt Lake Community College (SLCC) for the rest of the weekend. Unfortunately, the qualifying event for the Taylorsville City area was to be held at SLCC the next day. Pressed with concerns for safety of the participants, the Event Director Christopher Thompson, an engineering student at SLCC and author on this paper, was forced to make the difficult decision of canceling the event. What this meant was that the four teams that would go to the state championship would be selected by lottery. While there was nothing that could have been done to avert the situation, a primary goal of the State organizers and SLCC's event manager was to keep this unfortunate cancellation from leaving a bad taste in the mouths of the participants, kids and volunteers alike. So while some teams found slots in other nearby events, a plan was put into the works to hold a make-up "LEGO League Celebration" at the soonest time possible to maintain student enthusiasm with the LEGO League program.

After two months of re-planning the venue and recruiting volunteers, the Celebration event could finally take place. The student event management team had coordinated the setup with the school and the FIRST Organization State partners to make sure the venue would be ready and the teams would be there and on Saturday, March 2nd 2013, it did. What follows are pictures of students and volunteers from the event:



Figure 1: March 2nd SLCC LEGO League Celebration Event Robot Game



Figure 2 : Teams, Cyrus Safai and Robot Game Table

This celebration event brought together 12 teams – 6 of these were composed of two larger teams of students from SLC’s McGillis school. All of the teams had worked for the past year on their innovation projects, robot designs and core values, with the McGillis teams standing out especially with their rapid progress and subsequent success.



Figure 3: Core Volunteers

From Left - Dr. Safai, Natasha Brinkley and Trina Fransen



Figure 4 : Core Volunteers and FIRST Partner

From Left - Trina Fransen, Anne Bastien and Jeff Thomas



Figure 5: Teams and Spectators in the Robot Game and Opening Ceremony Room

Figure 6 (Below): SLCC Qualifying Event Volunteers



Overall, the LEGO League Qualifier Event at Salt Lake Community College was extremely successful. The unexpected cancellation served as a valuable lesson for the UTFLC community; currently in discussion are contingency plans for events in the years to come – this is especially appropriate considering the 2013 theme of Nature’s Fury.

Next, we begin to take a more detailed look at the effects that the LEGO league program has on grade school students.

Teamwork

Ideally, people working together pools the talent of all involved—allowing the group to support each other’s weaknesses and achieve more than any of the members could on their own. Unfortunately teams are often fraught with power struggles and miscommunication. This isn’t helped by the way group work is too often introduced to students; “In the worst cases, group work is assigned when a teacher doesn’t feel like teaching. The teacher gives students some questions and instructs them to talk them over in groups” (Quinn 47). In order to give group work the productive reputation that it deserves, participation in a program like FIRST LEGO league gives young students the chance to learn and apply effective team work skills at a young age.

The LEGO league program hinges on teamwork in both planning and execution. Many tasks are involved in both the innovation project and the robot design, allowing teams to experiment and refine which methods best suits their members. Not only do they learn how to work together, these kids learn how to lead and be lead. Often, no single group member has a greater amount of knowledge than the others, which means that leadership becomes a group effort. The critical idea behind this is that each team member has their own area of expertise; if each member’s skills are well applied, the group can adapt and deal with a variety of problems. Yet if members keep quiet about their talents, the knowledge and abilities of the leader is a rather limited pool drawn from. LEGO league directly addresses the issue of shyness by providing students a fun environment with others of common interest; kids learn that their voice is a valuable contribution to the group, also discovering how to let the group know what they have to offer without becoming irritating.



Figure 7: Team at State Championship Event performing a rally

For a group to mesh well together there must be honesty and frankness. When a group is not open, problems are not mentioned until they are too big to deal with. If no one ever said anything about themselves, everyone would be surrounded by nameless, unknown people. In general, if what you have to say

is relevant to the situation at hand, a person shouldn't be afraid to speak up—but effective statements are short and sweet. These insights come from observing teams in FIRST LEGO league. Less effective teams do not communicate—members seem to keep objections to themselves, leaving problems un-addressed. Teams that do well are open with each other and focused on the task that they have at hand. Kids in FLL experience firsthand the various styles of teamwork in a technical environment, giving them many years to develop their own approach before entering into the professional world.

Communication

From a coach's perspective in FIRST LEGO League, a constant balance is made between providing the information that you want to share and what needs to be known. A key aspect of LEGO League is that the kids must do the work themselves in order to make the most from their involvement. However, just because the kids do the work does not mean that they can't be shown effective methods of approaching and accomplishing tasks. The partnership between colleges and LEGO League teams is very useful in this mentoring aspect—the college student can provide general ideas to the kids, but inspiring them to develop the ideas further on their own.

Keeping the mentoring framework in mind, the kids' youthful energy can be optimized by guiding their enthusiasm into constructive discussions. Most anyone will be more productive solving a problem in small steps rather than trying to tackle the whole issue all at once. By asking a group; "What should our next step be?" mental involvement is stimulated, and may produce surprising results. Once ideas start to bounce back and forth, the kids have entered a state of brainstorming. While this is a familiar tactic to most in the professional world, FIRST LEGO League allows this skill to be taught before students have even entered middle school. They learn how to communicate in a group while coming to understand how working relationships affect the productivity of teamwork.



Figure 8: Teams relaxing in pit area before a match.

The friendships that kids make in FLL can be within their team as well as other teams that they meet. All of those kids have common focus and determination, leading not just to the sharing of laughter, but also the exchange of ideas. Having fun and relaxing with friends is important, but the working relationships built during the project give a great deal more focus added to the fun. Whether it was through a friend that a kid got involved in LEGO League, or they make friends during the experience, those connections boost their involvement and enjoyment of the activity (Simpkins,

Delgado, and Price 332-352). While growing up, each of us goes through grade school a little differently than everyone else—causing our experiences to vary. One child may have a great group of friends that does very well in their classes, and thus might have a very positive and excited attitude towards schooling. Conversely, another child’s friends could have struggled through every class and come to hate going to school. Not only do LEGO leaguers have their classmate friends, but also their teammates—a support group of kids who want to exceed expectation. The consequences of these varied experiences grow to be all the more apparent during high school, making their friendships a defining feature of the youth’s attitude and study habits. If good friendships and habits have been built from a young age, by the time a kid goes to

college, they are much more prepared for the experiences ahead and the future challenges of a diverse and dynamic workplace.



Figure 9: A Team discussing their match with a Referee at the State Championship

The kids in LEGO League work closely with a variety of people of all age groups: Coaches, Mentors, Teammates, Judges, Referees – these students become comfortable communicating with people of all ages and

positions. Considering how diverse the modern working world is and will be in the next decade, the skills of comfortable communication that these students are learning will be a huge asset for STEM fields around the world.

Building Passion

The students involved in LEGO League are not only learning more about Science and Engineering, but they are excited about pursuing education and careers in these fields as well. Some students, especially in lower income areas, didn’t have very high expectations about their future before entering into LEGO League. As those students became involved in their projects and designs, many began to realize that they have the potential to have an impact on the innovations of the future.

These students not only experience this feeling to themselves, but also as a team. When one student voices their ideas for the future, soon the entire team is brainstorming ideas of what could be invented or built or researched. Among the other skills that LEGO League brings to Middle School age students, one of lifelong importance is the ability to dream backed up by the passion to make that dream a reality – this past season of involvement has shown that FIRST LEGO League is an effective environment to foster this skill in students.

Participation

As valuable as these aspects of teamwork and communication are to future members of industry, without kids taking part in LEGO League, the benefits would have little effect. The good news is that FLL is experiencing huge rates of growth. Between 1998, when FLL began, and 2001, the kids involved went from 2000 to 20,000 (Oppliger, S4D-12). Over the last 3 years with Utah's FIRST LEGO league, a rapid growth has also been observed. In the inaugural year of 2010, 560 kids participated statewide, growing to 1440 in 2011 and 2190 this year.

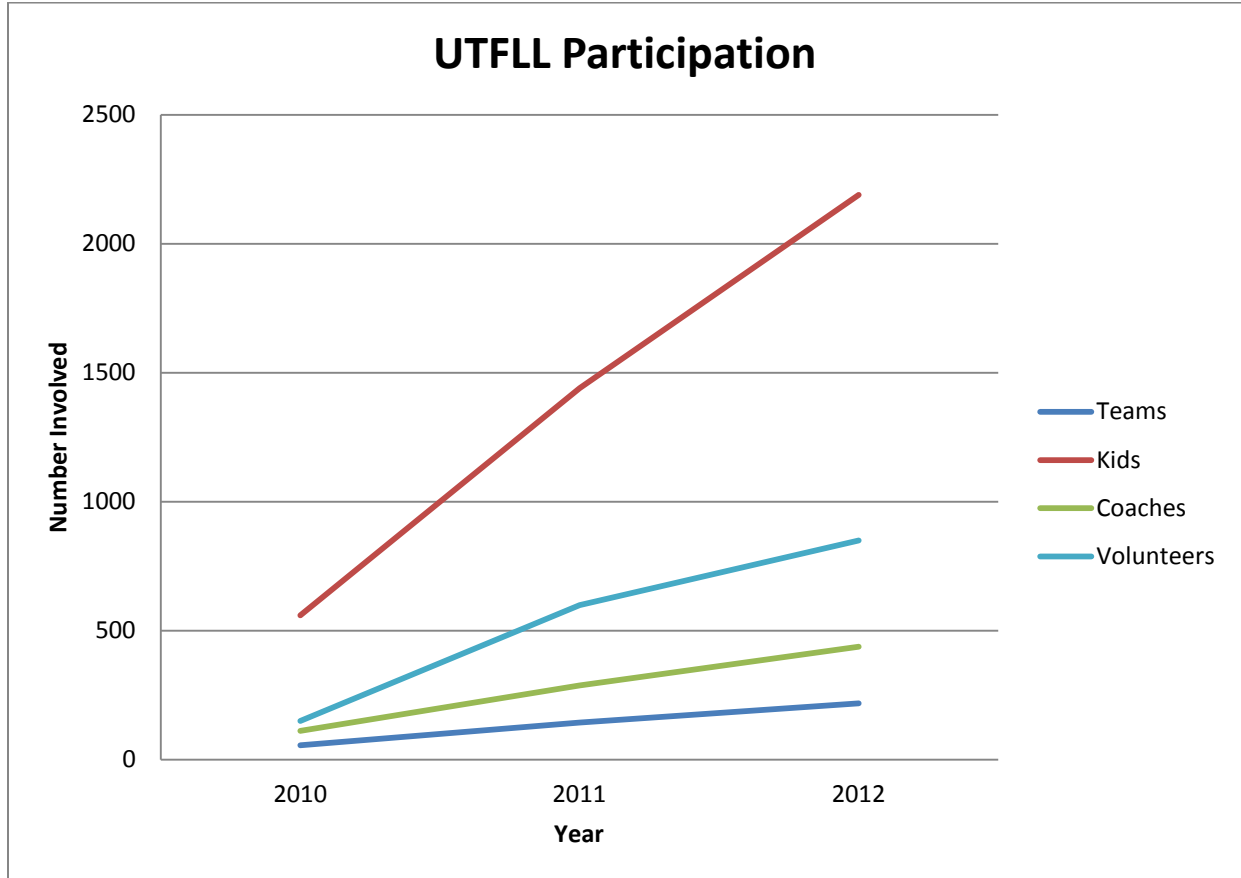


Figure 10: Graph Depicting UTFLLL Participation Growth

Coaches and volunteers have grown accordingly; initial 150 volunteers growing to 850, and 112 coaches reaching 458 this year. This blossoming growth pattern reaches through the entire community, building involvement accordingly. As more people become involved, the possible future involvement increases even further.

Integration into existing after-school programs

While some teams are headed by parents, there is an emerging number that are run through schools as after school programs. Teachers run these programs, sometimes assisted by College-student mentors. Just as with after-school or summer dance or sports programs, the kids are held accountable to be present and be an active member of the team. One benefit to this is the

altered relationships between the students and teachers—creating a coach dynamic that can help the student work more easily with the teacher if they are in the same class. By placing LEGO League teams in elementary and middle schools, kids get the same chance to pursue a technical challenge as they would to play basket ball or football—picking up the same crucial team work skills in addition to the technical and problem solving knowhow that comes from work on their Robots and innovation projects.

Conclusion

FLL is an excellent opportunity for both Middle School and College aged students alike. By creating mutually beneficial partnerships between younger and older students, many skills that are neglected in traditional classrooms are given a fun and exciting environment to develop in. The younger students have the chance to engage in research, brainstorming, computer programming and presentation, all as part of the overlying theme of open-ended problem solving – the college age students gain experience with team work, critical analysis, deliberations, large-scale event planning and reflective-organization shaping discussions. All of these great skills combine with the chance for the younger generation to hear the wisdom and warnings of the older students.

FLL accelerates the growth of communication skills and team work ability within middle school age students. By combining these skills with the technical challenge of the Innovation Project and Robot design, participants in FLL have a significant advantage in Science, Technology, Engineering and Mathematics education. The competition aspect of FLL associates STEM fields with excitement in the minds of the students involved. From observation, there is a large increase of interest in STEM fields between beginning and end of the FLL program. Students gain skills that are widely applicable to the global workplace and shape them into more quality international citizens.

Many communities have seen benefit from FLL, and still more have the potential to. Involvement has been growing rapidly and could see even greater growth if more schools begin to integrate FLL into their afterschool and summer activities.

For the future

By using surveys in the teams of kids and at the events, the continued goal of this study is to trace the effect that FLL has on how Elementary and Middle School age children view the fields of science and Engineering. Even when the tracked students pass beyond the age class of FLL, they can continue onto FIRST Technical Challenge (FTC) and FIRST Robotics Competition (FRC) – thus students could continue to be observed into High School and College, and data collected about their views and plans of STEM education.

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