AC 2008-750: DIVERSIFYING PARTICIPATION IN FIRST LEGO LEAGUE

Marion Usselman, Georgia Institute of Technology

Dr. Marion C. Usselman is a Senior Research Scientist at the Center for Education Integrating Science, Mathematics and Computing (CEISMC) at the Georgia Institute of Technology. Marion received her Ph.D. in biophysics from Johns Hopkins University and has taught in the Biology Department at the University of North Carolina, Charlotte. She focuses on equity issues in education and K-12 educational reform. She has co-directed the Georgia FLL program since 2001.

Jeff Davis, Georgia Institute of Technology

Dr. Jeffrey Davis, an associate professor of computer engineering at Georgia Tech, received his B.E.E., M.S.E.E., and Ph.D. from Georgia Tech in 1993, 1997, and 1999, respectively. In January 2001, he was awarded the National Science Foundation CAREER Award for excellence as a young educator and researcher. He has published over 40 journal, conference, and workshop papers. In 2001 Dr. Davis also initiated the first FIRST LEGO League competition in Georgia, and has served as the Georgia FLL tournament director since then.

Jeff Rosen, Georgia Institute of Technology

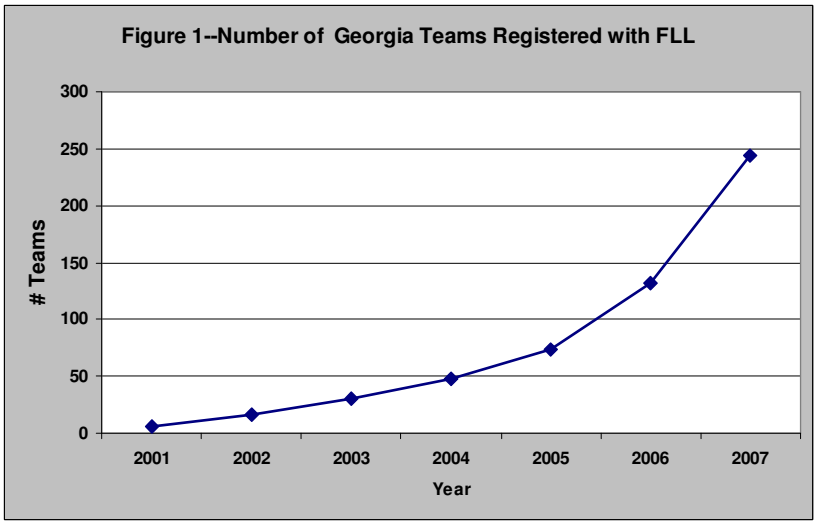
Jeff Rosen is a Program Director in Georgia Tech's Center for Education Integrating Science, Math and Computing (CEISMC), leading up K-12 student activities in technology. Before arriving at Georgia Tech, Jeff was a veteran high school mathematics and technology teacher at Wheeler High School in Cobb County, Georgia, and organized the school's extensive robotics program.

Diversifying Participation in FIRST Lego League

Introduction

The FIRST LEGO League (FLL) competition is frequently promoted as an effective method of introducing middle school children to engineering problem solving and of increasing the pipeline of students into engineering and other STEM disciplines[1,2,3,4,5,6]. The FLL program challenges students ages 9-14 to tackle a problem with a socially relevant theme and is designed to increase the students' awareness of current affairs and possible engineering solutions. Each student team is required to build a robot that can perform 8-10 tasks that relate to the overarching theme, and to research the theme and develop a product or strategy to address the social issue. The tournament consists of the robot competition, presentation of the research projects, and an analysis of the technical and creative merits of the robot design. Historically, FLL has addressed issues such as alternative power sources and use of resources (2007), an exploration into the possibilities of nanotechnology (2006), the ocean resources and how we interact with them (2005) and making the world more accessible to the disabled (2004).

The 2007 international FLL competition, coordinated by FIRST LEGO League International, is projected to include 10,600 teams and 106,000 children from 31 countries[7]. This is an increase of 18% over the previous year's participation rate. The FLL growth in Georgia has been even more dramatic, with the number of Georgia teams registering with FLL increasing from 48 in 2004 to 244 in 2007, for an average increase of 75% per year for each of the last 5 years (Figure 1). Clearly FLL is a highly successful program that provides a compelling experience to middle school students, and appeals to the parent, teacher, university and corporate volunteers necessary to coordinate the program.

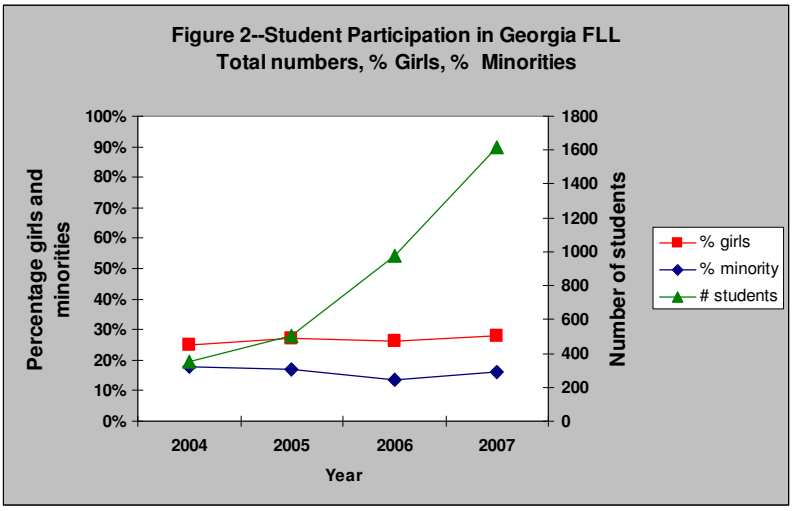


As more and more resources in the form of both time and money are dedicated to any student enrichment program, it is important to monitor exactly who is participating and under what circumstances. This information can help us to proactively create an infrastructure that promotes successful participation by students historically under-represented in the field. It is currently impossible to find data about the demographics of students participating in the national FLL program, as the national organization does not collect these types of statistics from the individual teams or state organizers. During the last two years the Georgia state-wide FLL program, which

is coordinated by the Georgia Institute of Technology, has collected data to determine the circumstances under which students engage in FLL and has tracked the participation and success of minority students (here defined as African Americans and Hispanics) and girls. This data will enable us to initiate state-wide educational initiatives to try to increase the number of minority and female students participating in FLL, and it will also help us to create an infrastructure that best promotes the success of a wide variety of FLL teams. This study does not address the effectiveness of the FLL program itself, an interesting question that is beyond the scope of this study.

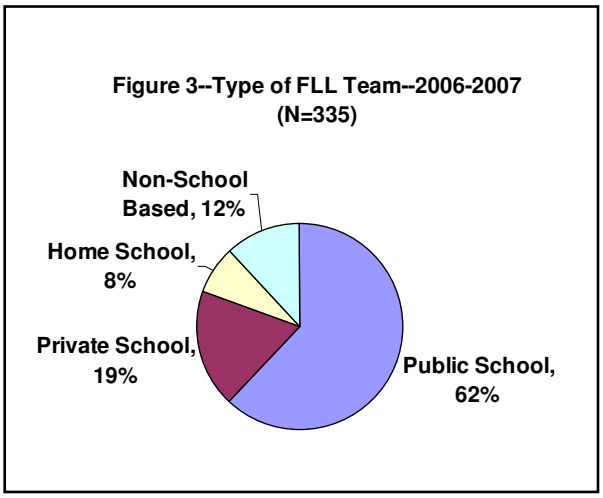
FIRST LEGO League—Who Participates, and Where?

Since our first FLL competition, held in 2001 with six teams, the number of students participating in the Georgia FLL tournament sequence has increased dramatically without any concerted promotional effort to over 1,600 students in 2007 (Figure 2). In 2005, to facilitate better tracking of students, we implemented an online registration procedure, and in 2006 began collecting detailed student demographic data and information about the circumstances that surrounded each team. Students participate in FLL through a number of different routes. Any person can create and register a FLL team through the FIRST LEGO League website. The only constraints are that the students are age 14 or less (though there is no official checking mechanism to enforce this), that there are 10 or fewer students per team, and that team coaches submit a designated waiver form for each child if they participate in an official tournament. As part of our data collection process, we now require that teams registering for the Georgia state tournament report whether they are affiliated with a school, and if so, which type (public, private, or home), whether the program is offered as part of the school-day curriculum or as an extracurricular club, and the nature of their participant selection process. We also require that participating teams submit student rosters that include demographic information on each student. This online data collection process now enables us to analyze the participation and success rates of different demographic groups, as well as different types of FLL teams.

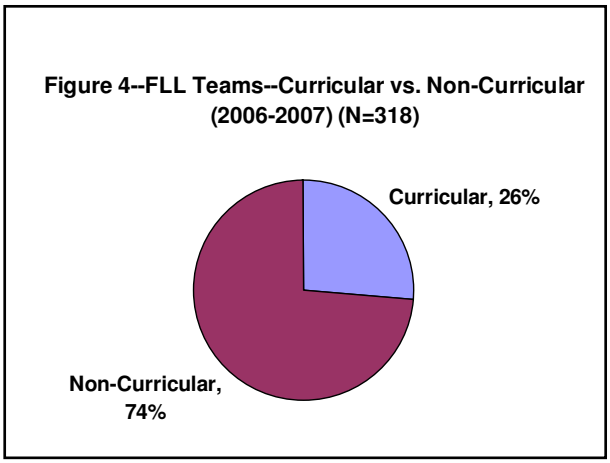


Since 2004, as the total number of students participating in the Georgia FLL program dramatically increased, the number of girls and underrepresented minorities participating also increased. However the percentage of girls has remained essentially constant at approximately 25-27%, and the percentage of African American and Hispanic students has stayed in the 14-18% range (Figure 2). A small dip in the 2006 minority student participation rate can be explained by an increase that year in teams affiliated with schools from one particular majority white suburban public school system, which was the result of an initiative encouraged by an

alliance between that school system and industry partners. In 2007, the minority percentage rebounded as a large urban school system, enrolling primarily minority students, initiated teams at schools that are essentially 100% African American. These perturbations notwithstanding, over time it has become clear that without concerted effort the percentage of the FLL participants who are traditionally under-represented in the field will not increase.

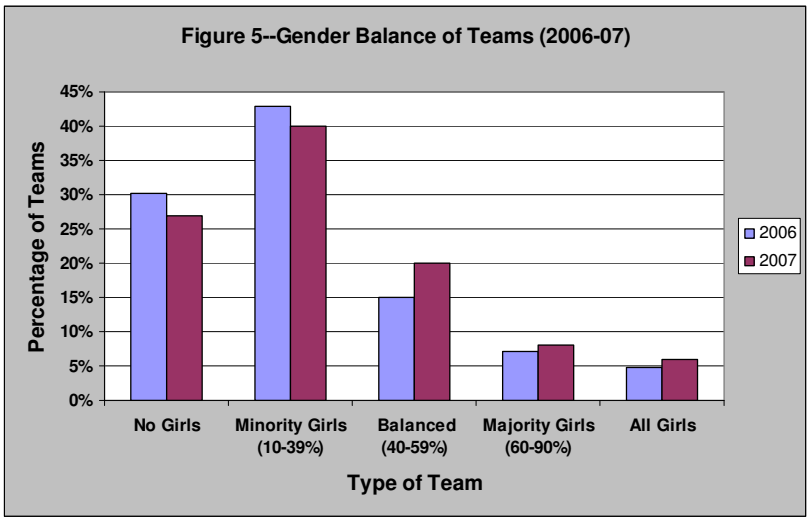


To design intervention strategies that encourage participation by girls and minorities, it helps to know where they are in the program. There tend to be four different categories of teams—those associated with public schools, those associated with private schools, those that are made up of groups of home school students, and those that are not part of a school setting and are instead formed and coached either by the parents of neighborhood friends, or by youth organizations such as the YWCA or the Girl Scouts. Figure 3 shows that in the Georgia FLL program, the large majority of teams are affiliated with formal school settings, with 62% participating through public schools and 19% through private schools. These teams, and teams associated with youth organizations, generally have more limitations on them, in terms of available time to build and level of adult support, than do teams associated with home school groups and those that consist of groups of neighborhood friends. Home school teams often use FLL as the center of their curriculum, and can spend enormous amounts of time on their robots and research projects. Neighborhood teams, working out of a team member's house, can also generally put in more work in the evenings and weekends than teams that rely on the use of school facilities. Public and private schools also have less control over who participates on the team than do home school and neighborhood teams, as the latter groups can much more easily exclude children than can the school-based teams. These issues of the differing constraints inherent to different types of teams will be further addressed in relation to team success and the building of the Georgia FLL infrastructure.

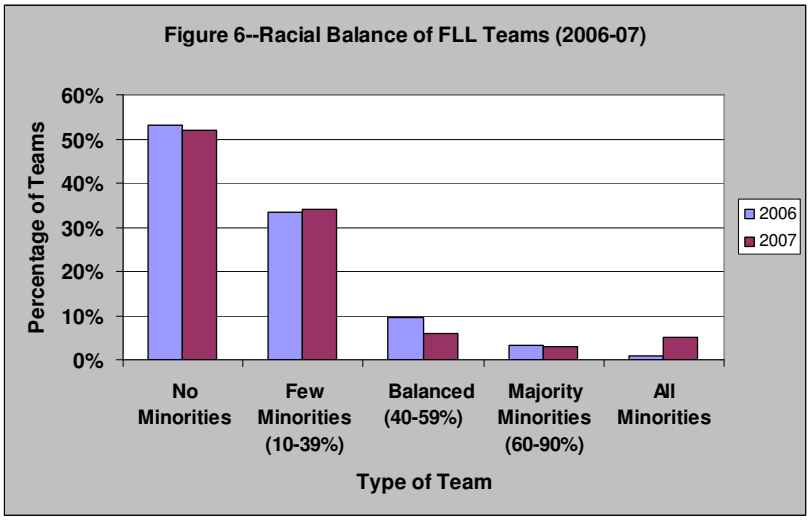


FLL challenges and competitions can be undertaken either as an independent activity, unconnected to a course curriculum, or they can be integrated into a class during the normal school day. Overall, approximately one quarter of the Georgia FLL teams construct their robots and create their research projects as part of a class (Figure 4). A few of these are associated with home school groups, but most function within a public school setting, usually as part of a Gifted and Talented "Connections" class, or as a technology-based "Exploratory" course. Some teams are a hybrid, with the LEGO Robotics

introduced in class as part of the technology or physical science curriculum, but with the actual competition robots created as part of an extracurricular club. These distinctions become important if the goal is to diversify the participation in the FLL program.



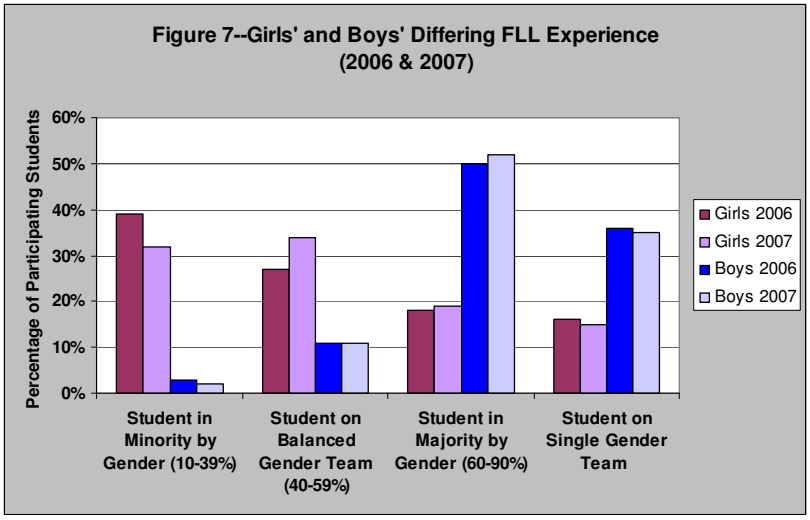
Since our FLL program has an explicit goal of increasing the representation of girls and under-represented minorities on the Georgia FLL teams, we have analyzed the composition of teams, classifying them by gender and by minority participation. For the latter analysis, students are grouped either as "Minority", here defined as African American and Hispanic, or "Majority", here defined as Caucasian, Asian American, or "Other". Teams are classified by the percentage of their members that are girls, and the percentage that are minorities. Figure 5 illustrates the gender distribution of the teams in 2006 and 2007. In 2006, 73% of teams had fewer than 40% girls, with 30% having no girls at all. In 2007, the percentage with fewer than 40% girls dropped to 67%, with 27% of teams consisting of all boys. Teams that were balanced by gender (with 40-59% girls) increased from 15% to 20%. The number of all-girl teams increased from 6 to 12, which represented a slight increase in the rate of those teams, from 4.7% to 6%.



In regards to minority participation (Figure 6), more than 50% of the teams in both years had no minority members at all, and an additional 30% had few minority members. The major difference seen between 2006 and 2007 was an increase in the number of teams that were exclusively minority (from 1% to 5%), and a decrease in the number that were balanced. The increased number of all minority teams is a result of the infusion of teams from African American middle schools mentioned earlier.

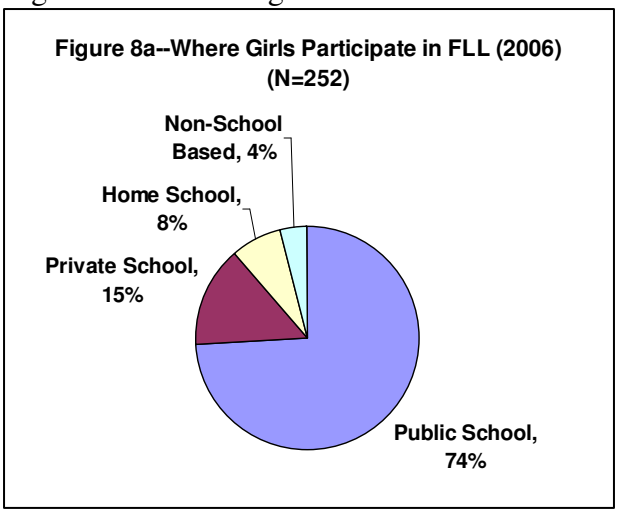
How Girls and Boys Experience FLL

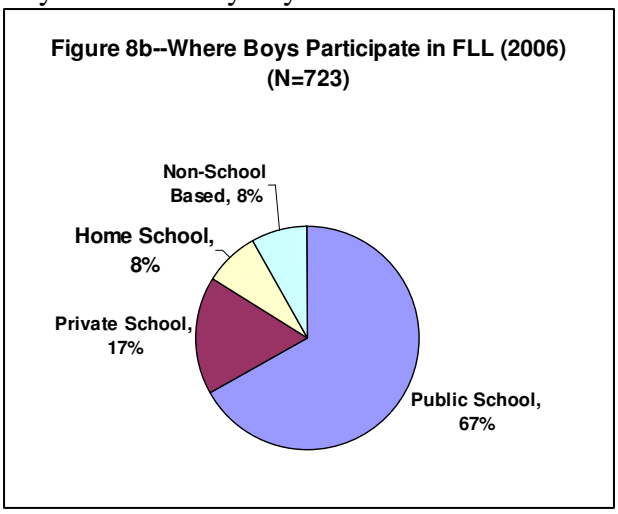
Girls and boys clearly have different experiences with regard to the gender dynamics on the FLL teams (Figure 7). Very few boys (~3%) are in the minority on their team, whereas between 30%



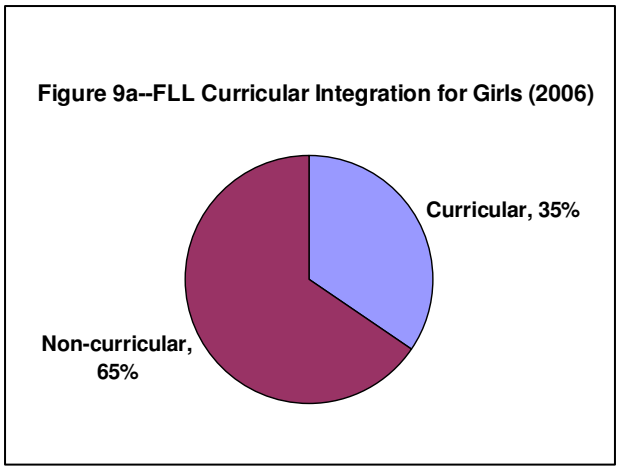
and 40% of girls are in the minority. Likewise many more boys (~50%) than girls (~18%) are in the majority and more boys (~36%) than girls (~16%) are on single gender teams. The primary difference seen between 2006 and 2007 is an encouraging slight decrease in the percentage of girls who are a minority on their team, with a concurrent increase in the percent of girls on balanced teams. Interestingly, schools fielding multiple teams are starting to experiment with putting all of the girls on one team, often creating an all girls team in an effort to get the girls more involved. If this trend continues, particularly within public schools, we expect in the future to see a larger percentage of the girls competing on single gender teams.

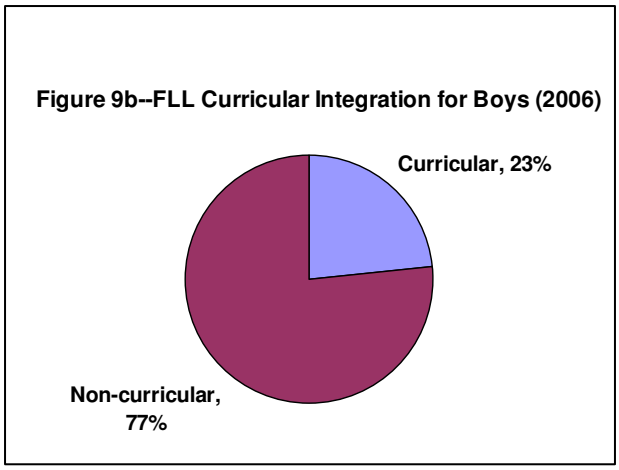
Boys and girls participate in Georgia FLL similarly with regards to type of team (Figures 8a and 8b). In 2007, the percentage of both girls and boys participating in non-school based teams increased to 12-13% (data not shown). One interesting difference is that for girls, teams organized by youth organizations, such as the Girl Scouts and the YWCA, made up 1/3 of these non-school based teams, explaining much of the increase, whereas there were no youth organizations that organized teams that were heavily or exclusively boys.





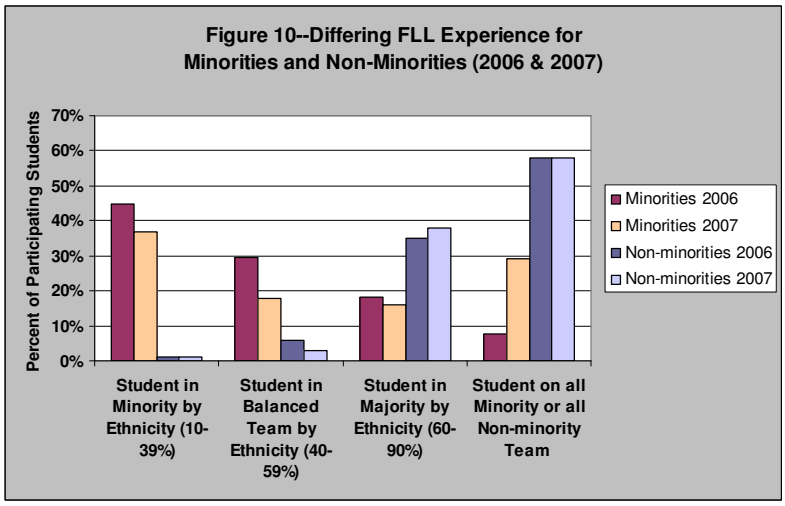
Girls are more likely than boys to interact with FLL as part of the school curriculum, rather than in an extracurricular club (35% vs. 23%) (Figures 9a and 9b) The 2007 numbers were comparable (data not shown). This is not particularly surprising, since the reason that girls are under-represented in robotics is that they are less likely than boys to voluntarily join an activity such as an extracurricular robotics club. However it does highlight the importance of in-school robotics activities as a means of convincing girls to participate.





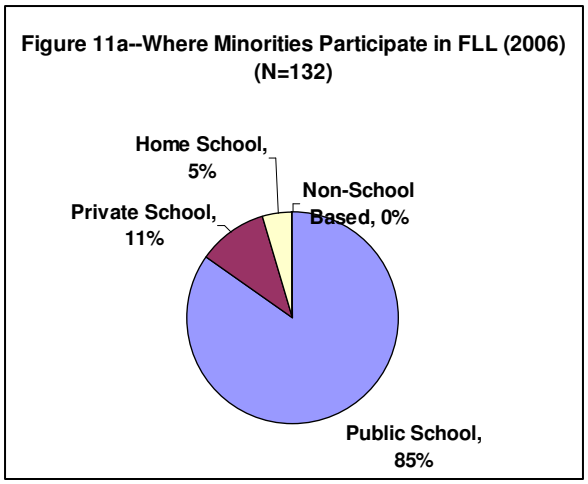
How Minority and Non-Minority Students Experience FLL

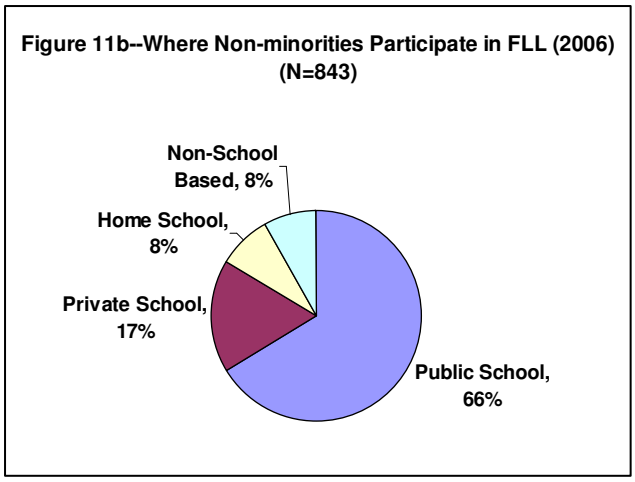
Like girls, minority students are seldom in the majority on their teams, unless they come from a school that is overwhelmingly minority in enrollment (Figure 10). Even teams from schools that are 60-80% minority often have very few minority students on the team (data not shown). 58% of Caucasian and Asian students have no African American or Hispanic teammates, and only 1% of them are a minority on their team. In contrast, 45% of African American and Hispanic students in 2006 were a minority on their FLL team, and 37% in 2007. In contrast to the policy with girls, racially integrated schools that field multiple teams do not tend to group minority students together on one team. Instead, minority students from those schools are most likely to be evenly distributed among the teams. However in 2007 we saw a marked shift in the percent of the minority students who competed on all-minority teams, increasing from 8% to 29%. As noted earlier, this is a result of an increase in the number of middle schools from high minority school systems participating in the Georgia FLL program.



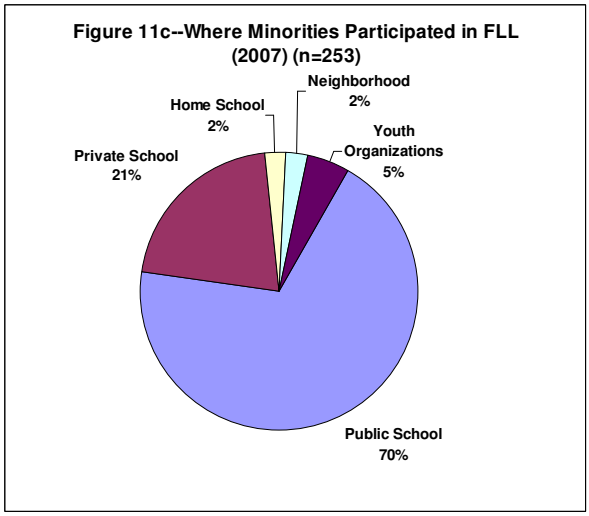
In contrast to the similarity between boys and girls, minority students tend to participate in FLL differently than non-minority students (Figures 11a and 11b). Whereas 66% of non-minority students participated in public schools in 2006, 85% of African American and Hispanic FLL participants were on public school teams, and in 2006 not a single minority student was a part of a non-school based team. Over 40% of the minority students in private schools in 2006 were enrolled at a single urban Girls School. Clearly initiatives that target minority students must focus on the public schools, on the private and parochial schools with substantial minority

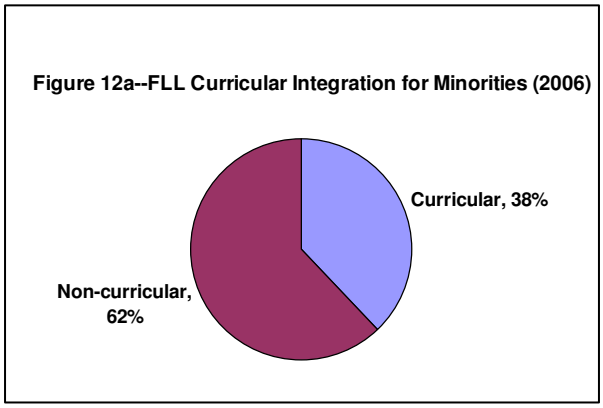
enrollment, and on youth organizations that serve the minority population. In 2007, the percent of minority students who participated in public schools decreased (Figure 11c), notwithstanding the increase in minority teams from the heavily-minority school system mentioned previously. The increase was primarily in the private and parochial schools, and youth organizations, from metro-Atlanta.

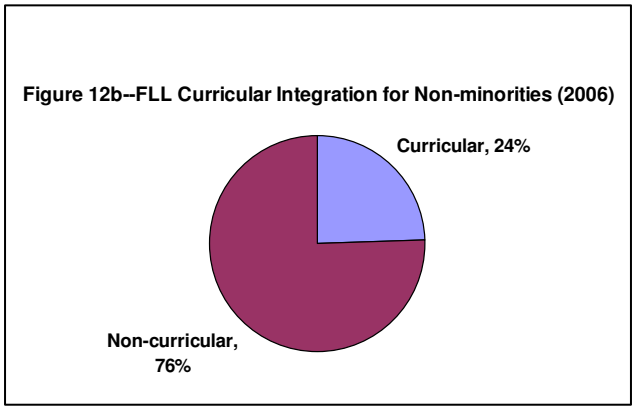




Minorities tend to participate more frequently than non-minorities within the class curriculum, rather than as part of extra-curricular clubs (Figures 12a and 12b). 38% of minority FLL participants in 2006 were on teams that functioned as part of the curriculum, compared with 24% for non-minorities. This likely reflects transportation issues for urban minority students that limit the students' ability to participate in extracurricular clubs, as well as the tendency in even highly integrated schools for the after-school clubs to self-segregate in ways that do not occur in class. We are analyzing case studies of integrated schools that are successful in encouraging minority FLL participation to



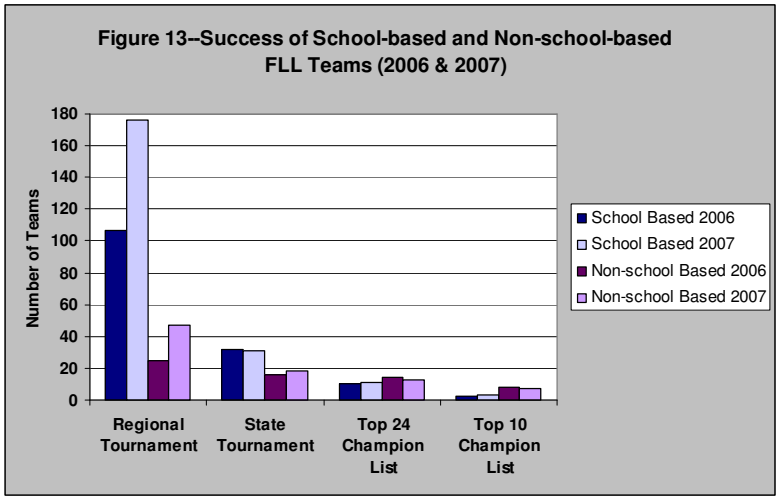




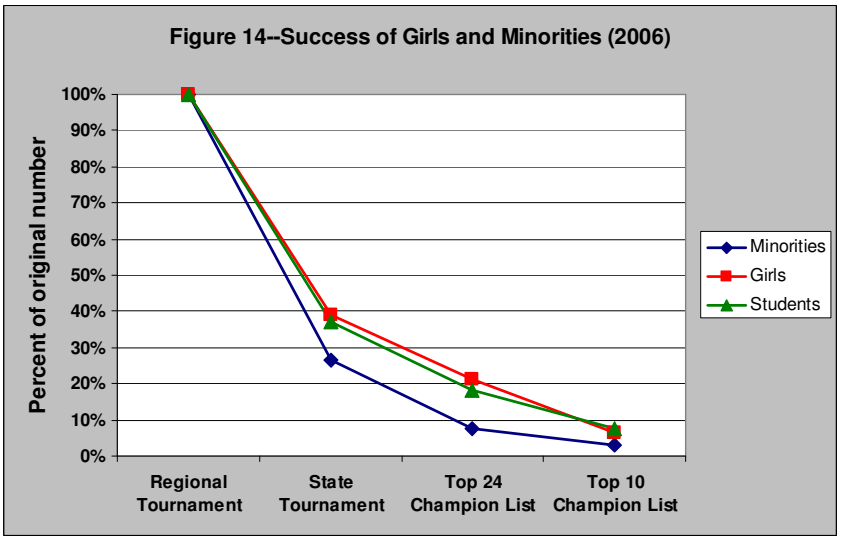
identify practices that result in increased participation by under-represented students.

Differential Success Rate in FLL

As noted earlier, different types of teams have different advantages and limitations in terms of the amount of time and effort that can be allotted to FLL. Figure 13 shows the difference in the Georgia FLL 2006 and 2007 success rates between teams based in schools (public and private), versus those that are non-school based (a category that in this case includes home school teams). There were 132 teams that entered one of the 2006 regional qualifying tournaments, and 223 teams in 2007; 48 made it to the state tournament each year, and these were ranked at the conclusion of the tournament by the number of total points they earned towards the state Championship title. Figure 13 shows how many school-based and non-school based teams made it into the state tournament, and how many were in the Top 24 (50%) and the Top 10 (21%) in the final ranking. For non-school based teams, 32% of the original teams were in the final top 10 ranking in 2006, and 15% in 2007, whereas for the original school-based teams, fewer than 2% were in the final top 10 either year. (Both years 2-3 of the Top 10 teams were school-based, and 7-8 were non-school-based.) Clearly teams that are not constrained by working within a traditional school setting have a competitive advantage in the FLL tournament.



An analysis of the success rate by demographic category (Figure 14) shows that girls are very successful in FLL, matching the success rate of the group as a whole. Only 25% of minority students made it to the state tournament in 2006, however, compared to a 35% rate for the whole group of students, and only 3% were in the Top 10, compared to a group rate of 8%. In 2007, these percentages dropped even further, with not a single minority student on any of the Top 10 teams. Since a higher percentage of minority students participate in FLL in



the public schools, and very few are involved through home school and neighborhood teams, it is not surprising that minority students were not highly represented in the top tier of teams, given the differential success rates for school-based versus non-school based teams shown in Figure 13. These differential success rates challenge us to create an infrastructure that best provides students who participate in FLL through the traditional school settings with experiences that are successful and rewarding, while still maintaining the philosophy of common standards and a level playing field for all participants.

Conclusions and Policy Implications

Collecting detailed demographic and team data on FLL teams allows us to monitor where students from under-represented groups are participating, and to assess how successful they are in the competition process. We can then more effectively develop programs to increase the participation by girls and minorities, and enable them to have a rewarding experience. Though these two goals are linked, different steps can be taken to address each.

Increasing Participation

It is clear from the data that minorities, and to a lesser degree girls, disproportionately participate in FLL through the public schools, often through their school-day classes. We are therefore pursuing initiatives that encourage participation by high-minority public schools, and are working with the Georgia Department of Education, as part of a work-force development program, to develop an approved middle school course that uses LEGO Robotics and FLL as part of the regular curriculum. An increasing number of our public schools now field multiple FLL teams that are completely conducted during class time. Most of these are part of the Gifted and Talented program, making use of an enrichment period for gifted students that has no set curriculum. We would like to make FLL available to students who are not in the Gifted and Talented program, as these are often the students who have the most to gain from a program such as this. Therefore this new course should be one that is available to all children, and it should support and enrich the existing core mathematics and science curriculum. A pilot course that we will analyze uses LEGO Robotics to support basic science and mathematics concepts, and encourages students to participate in the extra-curricular FLL Team program.

Ensuring Success

Obviously students can have very rewarding experiences on teams that do not score well on the traditional measures of FLL success. However competitions are always best, be they in athletics or academics, when teams compete against peers who are working under the same constraints and level of resources. Athletic programs commonly do this by creating leagues based on size of school, level of investment, and exclusivity of program. It is important that we use some of these same strategies in FLL to create an infrastructure that does not immediately pit public school teams that can only work a couple of hours per week against home school teams that are anchoring their days around FLL. That is not rewarding for either side.

The basic constraint within the Georgia FLL program is that we do not have the resources to conduct parallel FLL tournaments for different types of teams, and we want to only have one

final tournament at the state level. However our state program now requires a substantial number of regional qualifying tournaments, and we will probably implement a level of super-regional tournaments for the 2008 season. This network of qualifying tournaments holds the key to creating tournament experiences for students that are fun and satisfying for the largest number of participants.

Most of the population of Georgia is in the metro-Atlanta region, and while the vast majority of the FLL teams come from the general metropolitan Atlanta area, we are working to cultivate teams in other areas of the state as well. In 2007, we conducted eight regional qualifying tournaments, six of which were in the metro Atlanta area, and two were located in different geographic areas of the state. Of the six Atlanta-area tournaments, four were coordinated and run by public high schools (with assistance from FIRST Robotic teams, a school-based science center, or industry partners), one was held at a state university, and one was coordinated and run by home school coaches at a public high school facility. We gave preference in registration at the public school tournaments to schools from that school district, and preference at the home school tournament to home school and neighborhood teams. The university-based tournament was completely open, with a first-come, first-serve policy. Since none of the school system tournaments completely filled their spots, we assigned remaining teams (private school teams, neighborhood teams, and remaining public and home school teams) to tournaments using an informal assessment of team strength, in an attempt to ensure that a reasonable number of the public school teams from the qualifiers made it to the state tournament. This system enabled the public schools to maintain the same number of spots in the state tournament as they had in 2006, even though the number of non-school-based teams had increased, however more must be done to ensure that representation at the state tournament accurately reflects the balance of types of teams participating in the program.

Our plan for 2008 is to implement a policy that assigns an official "power rating" to each team, based on the type of team it is, the time it has available to practice, and it's previous history and success as a FLL team. The qualifying tournaments in the Atlanta area will then pit teams with similar power ratings against each other, with each tournament sending a proportional number of teams to the state tournament. Outside of the metro Atlanta area, teams will be assigned to tournaments geographically, to minimize travel time. This is our "NCAA Basketball Tournament" model, where teams of all sizes and strengths get into the tournament, the honest expectation is that teams from the power conferences (in this case, non-school-based teams) will ultimately come out on top, but Cinderella teams are always possible.

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