AC 2011-571: THE BUILDING OF TEAMS DURING AN IT COMPETITION: SUCCESS WITH COMBINING MULTIPLE SCHOOLS INTO TEAMS TO PERFORM COLLABORATIVE CHALLENGES DURING A TWO-DAY COMPETITION.

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The Building of Teams During an IT Competition: Success with Combining Multiple Schools into Teams to Perform Collaborative Challenges During a Two-Day Competition

Abstract

In a majority of the competitions available for students, both high school and post-secondary, the focus of the event is on winning at all costs and the unit of competition is a team composed of students from a single institution. This isolates the team members and reduces the social impact of meeting other students, teachers, faculty members and mentors from other schools. The IT-Adventures program has the serious goal of increasing interest in and awareness of information technology among high school students. However, the end of the year competition which is called IT-Olympics downplays the competitiveness in an effort to make the whole experience enjoyable. The target audience for this project is high school students, especially those students who previously have not exhibited an interest in studying IT. The authors have found that collaborative real-time challenges where teams from different schools are required to share resources and join forces on design challenges are very successful. The students exhibit more social interaction after these collaborative real-time challenges and this adds to the "party" atmosphere of the entire competition. Additionally, community was built within each of the venues by having the teams participate in the collaborative real-time challenges. This paper describes the collaborative real-time challenges implemented in the IT-Olympics competition and provides demographic and interest data collected from the students participating in the IT-Adventures program.

Faculty of post-secondary education in any science, technology, engineering and mathematics (STEM) discipline recognize that nationally enrollments in science and technology are declining. Being part of an Electrical and Computer Engineering department at a land grant institution, the authors are specifically focused on the STEM topic of information technology (IT) and concerned with the downturn in the number of graduates to fill professional IT positions. The IT-Adventures program (www.it-adventures.org) is one of the authors' responses to the original "Gathering Storm" challenge to increase the number of students to pursue a degree in a STEM-related.

The IT-Adventures program, which is now in its fourth year, is an innovative program dedicated to increasing interest in and awareness of information technology among high school students using inquiry-based learning focused on three content areas: cyber defense, game design programming, and robotics.[1] The target audience for this project is high school students, especially those students who previously have not exhibited an interest in studying IT, as well as high school teachers, not necessarily information technology teachers, who would like to enhance their skills and teaching abilities in the IT area. There are already programs available in IT-related areas such as the Lego First Tech Challenge and the Cyber Patriot Games where students who have IT knowledge and experience can gain more knowledge and can compete in the sponsored events. Those students and their programs are comparable to varsity athletes competing in a varsity sport. The students need to be very good to be able to participate. The

IT-Adventures program is modeled after an intramural or recreational sport. Every student can have the opportunity to explore IT and to learn from it, not just the ones who already excel in mathematics and science in the classroom. This wide exposure is especially important since computer-related courses are nearly non-existent in high schools across the U.S.[2] The IT-Adventures program combines educational programming, competitive events and service learning projects to engage students in learning significant IT content, as well as enhances teacher understanding and facilitation of IT experiences. The underlying tenet of the program is through increasing understanding of and excitement for IT at the high school level, the authors can increase the number of students enrolling in IT-related programs at post-secondary institutions and increase the number of graduates who will fill future IT needs. A secondary and arguably as worthy goal is to make the whole experience fun just as intramural sports participation is.

Extracurricular IT-Clubs which allow students to study one, two or all three venues are formed by high schools in the fall of the academic year. Students spend the year using the learning materials provided by the IT-Adventures program, asking their own questions about the content areas, exploring additional resources and determining how to solve the challenges presented to them. The capstone event for students who participate in IT-Adventures is a two-day competition named the IT-Olympics. Students showcase the IT knowledge they gained during the past year by exhibiting a primary challenge solution they have worked on prior to the event, undertaking real-time challenges that are introduced during the competition and making presentations about their clubs' IT-related community service projects.

This paper focuses on one of the two types of real-time challenges provided to the teams competing in the two-day IT-Olympics event: collaborative challenges. In a majority of the competitions available for students, both high school and post-secondary, the unit of competition is a team composed of students from a single institution participating in the event. This isolates the team members and the social aspect of meeting other students from other schools. However, in two of the three learning areas for IT-Olympics, game design programming and robotics, the authors have found that collaborative real-time challenges where teams from different schools are required to share resources and join forces on design challenges are very successful. The students exhibit more social interaction after these collaborative real-time challenges and this adds to the "party" atmosphere of the entire competition. The authors have had a very positive response to these kinds of collaborative real-time challenges from the participants, as well as the teachers and mentors for the high schools. Additionally, community was built within each of the venues by having the teams participate in the collaborative real-time challenges. This paper is divided into 5 sections: Introduction, Description of Collaborative Real-Time Challenges, Student Data, Lessons Learned and Future Directions.

I. Introduction

As stated above, extracurricular IT-Clubs are formed in the fall of the academic year. The IT-Adventures program provides materials to the IT-Clubs based upon what the students wish to study. The book *Learning to Program with Alice*[3] and the Alice software, as well as the learning materials available from Carnegie Mellon University, were used in for the game design programming content area. For IT-Clubs interested in the robotics content area each was given the Lego Mindstorms NXT base education kit[4] and the educational resource kit.[5] Additionally, the Mindstorms NXT software was provided. The book *Building Robots with Lego Mindstorms NXT*[6], as well as two sets of DVDs entitled *Robotics Engineering Vol I*[7] and *Robotics Engineering Vol II*[8], were also supplied. Because there were no materials available for purchase in the cyber defense venue, a graduate student created nine lectures that covered services that would need to be run for the cyber defense competition, as well as basic networking concepts. The lectures were distributed via DVD and also available for download on the program's web site.

After spending the academic year exploring with the materials and resources provided, students come to Ames to participate in the two day IT-Olympics competition. IT-Olympics is set apart from other competitions in several ways. First, it is a competition that makes IT accessible to a wider variety of students, including those who have not previously been involved in a computer-related class or interested in IT-related projects. Second, it judges teams on three components: their community service project, the primary challenge, and the real-time challenges. The community service score is determined based upon the quality of the community service project, as well as the slide show and the oral presentation made during IT-Olympics. The primary competition is the portion of the competition that allowed teams to demonstrate technical abilities in interpreting and building a project where the specifications were given three months before the competition. The primary challenge is what most competitions focus on. However, because teachers and parents can highly influence the end product of a primary challenge, IT-Olympics adds another set of technical challenges for students. Real-time challenges are projects are given to the teams during the two-day event, the details of which are not known until the challenge is presented. This provides students the ability to discover how well they were able to innovate and design with a time constraint and only available resources. It also keeps the students engaged and thinking during the entire competition. Third, while teams obviously want to win the competition, the extreme competitiveness of the event is downplayed and an emphasis is placed on the fun and excitement of the event, to the point of turning it into a carnival atmosphere. The IT-Olympics is not just a competition, but rather a celebration of IT which is open to the public. Family members, high school counselors, teachers and the general public can watch the students in their quest to be the best or can explore IT careers and opportunities on their own. The competition floor is encircled with vendor booths for students to explore and talk to companies about IT careers or new technology. Even younger family members can enjoy the event. There is an interactive Lego area just for their enjoyment.

The real-time challenge concept stems from the two years of pilot project high school cyber defense competitions that were the precursor to the IT-Adventures program.[9] Cyber defense competitions have various incarnations from capture the flag competitions where students try to earn entrance into systems and gain access to specific files to competitions where students defend sets of systems that either they configure or have been preconfigured for them.[10, 11] The high school cyber defense competition is a hybrid contest in which students configure their own networks and defend these networks from attackers for a period of time with additional real-time challenges occurring approximately every two to four hours to keep them working the entire time of the competition. They are asked to install new services or new features for the end users in the fictitious company that they are supporting as part of the cyber defense competition back story called a scenario. This allows students to evaluate end user requests for security, as well as test their ability to configure new services in a timely manner without opening new security holes for the attackers to use against them.

In the 2007 High School Cyber Defense Competition a collaborative real-time challenge was attempted. Each team was asked to provide one skilled team member to another team for one hour to help them solve any problems they were having with the attackers or to help in any way. This was not successful collaborative attempt. The team member switch occurred late in the competition when the teams' networks were under heavy attack or had been severely damaged from attacks. The students had also been socially engineered earlier in the competition and they were suspicious of anyone who was not on their team. They feared that the new student from another team would destroy their systems further or would take their information including passwords and share it with the attackers. Also, because each network is an unique design and setup with no two teams selecting the exact same operating systems, firewall configuration or network implementation, even if the students would have been allowed access, their help would have been limited due to the steep learning curve of the team's specific configuration. The teams, therefore, did not use the person or listen to any help they would offer.

In retrospect, a cyber defense competition in which the students are under attack did not lend itself to a collaboration among teams. However, in the cyber defense competitions there is already a sense of team work and community because there is a common enemy -- the attackers. While students find it difficult to collaborate on configurations of their competition network, they already have the camaraderie of playing against the attackers and seeing how the attackers infiltrated the other teams systems.

As the IT-Adventures program expanded to include three venues, the authors revisited the question of how to build a sense of community in the two new venues of game design programming and robotics. Also, in the real world many projects are very large and are only successful by splitting tasks among teams of people who had to work together to solve a problem or develop a product, therefore the authors continued to consider implementing collaborative real-time challenges. The next chance to work on collaboration was at the first IT-Olympics competition (April 2008). Due to the complexity of adding two new venues (game design programming and robotics), no attempt at collaborative real-time challenges was made at that time. But, in April 2009 (the second IT-Olympics), a collaborative real-time challenge was run in the robotics venue. At the third IT-Olympics (April 2010), three collaborative challenges were executed; two in robotics and one in game design programming.

II. Description of Collaborative Real-Time Challenges

The robotics venue was chosen to implement collaborative real-time challenge in the second IT-Oympics for several reasons. The primary reason was the number of sensors in a Lego Mindstorms NXT kit is limited and it is easily argued that for complex robot builds two or more of the same type of sensor may be needed. A combination of two high school teams would allow the teams to have all the necessary parts to build a more complex robot. The secondary reason, of course, was to build interaction for the students so that they would experience the camaraderie seen in cyber defense.

The leader of the robotics venue created a collaborative real-time challenge in which the students would build an autonomous car that could follow a provided pilot car through a maze. The pilot car would send a signal of left or right to indicate the way the following car should turn and also would emit a beep when it was backing up. Two student teams were asked to work together to design an autonomous car to follow the pilot car. Both teams would earn the same technical score, however, the team members would score the other team members on collaboration, as well as contribution to technical solutions. This compensated for several items. First, depending upon the design, multiple motors and sensors could be used to construct the autonomous car. This allowed for the challenge to be run without needing to purchase additional kits for the students to use. Second, the advisors and students saw it as fair that they could provide input into the score for their partnering team. This alleviated fear that a strong team would be pulling a weaker team into a higher scoring category. Third, it allowed students from different high school teams (teams could not partner with a team from their own high school) to interact with other students, sharing ideas, learning teamwork and overcoming failures. A observed effect that occurred after pilot car real-time challenge had completed was the students from different teams continued to interact with each other. This long-term social interaction was an unanticipated, but welcomed secondary effect. The authors anticipated the students interacting during the collaboration, but the interactions would cease at the end of that challenge.

The success of the pilot car collaborative challenge in the second year opened the door for two collaborative real-time challenges in robotics and one in game design programming for the third IT-Olympics (April 2010). The first collaborative real-time challenge in robotics was again the design of a car, but this time the two teams would create a car that would use a second Mindstorms NXT brick as the car controller utilizing Bluetooth communications The car had to be able to remotely drive through a maze to find an item and retrieve it without the team member who was driving being able to see the maze, item's shape or item's color. The students were given base build instructions for their car and basic instructions on how to pair the two bricks via Bluetooth, but modifications were needed to manipulate the "mystery" item, as well as provide output to the controller brick to help the driver understand how to steer the car. The most successful collaborating groups were those that split the project into smaller tasks such as the design of the base car, the addition of sensors to the car, and the data output on the controller brick for the driver which were then assigned to different student pairs to working individually on each task. These successful groups also came back to testing as a large team, providing feedback to each other.

The second robotic collaborative real-time challenge was originally billed as the "Grand Finale" for the competition and occurred just prior to the awards ceremony. For the first two IT-Olympics (April 2008 & 2009), drag races where the student teams created a race car from the Mindstorms NXT kits were the "Grand Finale". While the drag races provided spectacular designs and spectacular crashes, a new "Grand Finale" was selected for the April 2010 event. Teams were each given a design task for a giant Rube Goldberg machine for sorting colored balls. The red balls were to go down one path and the blue balls were to travel a different path. The paths were to cross over each other and reconvene at the end. Each team had areas marked on the floor with tape in which they had to build their portion of the machine. While the teams worked well together sharing input and output information, there was a bit of confusion about which team was the input data and which team they needed to pass data to. This occurred primarily because the teams would leave the staging area to work in a larger space to build their section of machinery and then return to their section of taped space with their piece of the machine. Not all teams were at the taped space at one time and students were easily confused about the timing. A way to reduce the confusion in the fourth IT-Olympics scheduled for April 2011 is being implemented and is discussed in the Lessons Learned section.

Again, the two collaborative real-time challenges were met with great excitement and overwhelming enthusiasm by the students. The Rube Goldberg machine, while not performing the color ball sorting task to perfection, was wildly entertaining and caused many teams members to talk to each other about how it functioned and how to redesign the machine where it was flawed even if that was not their section to work on or on which to receive points. It, therefore, achieved its purpose of making the students work together even beyond earning points and trying to win the competition.

Although the robotics Rube Goldberg machine was billed as the "Grand Finale," the leaders of the game design programming could not be outdone by the robotics folks. They attempted for the first time to get the game design programming teams to interact with each other in a round robin virtual dodgeball tournament which was their division's "Grand Finale". Primarily the game design programming teams come to IT-Olympics with a real "heads-down" attitude. They are given new real-time challenges which require a new program to be written in Alice approximately every two to three hours. These teams tend to be smaller than in the other two venues with three to four people being the average size. The game design programming area on the competition floor is relatively quiet compared to the other two venues. Students competing in the game design programming venue tend to be gathered around the computers with their heads down talking about their assigned tasks. The goal of the dodgeball tournament was to get the students to interact with each other.

In the dodgeball tournament real-time challenge the teams were given a base program in which they could code the actions of four dodgeball players. These four players comprised their team and were positioned on one side of a rectangular dodgeball court (the video screen). A total of four teams competed against each other at time. Because the players were autonomous, they needed to be programmed to sense and throw the dodgeball, as well as move around their side of the court. There were player types such as a goalie who had a wider catching radius and an attacker who specialized in killer throws which they could programmatically select for their four players. The teams earned points for catching the balls thrown at them, dodging balls thrown at them, and hitting opponents with balls. However, they lost points if their thrown ball hit one of their own players. The students could also program in the range of motion for each of the four players. The trajectory of the ball was stable for each round of elimination, but could be changed by the game design programming leaders as play increased in difficulty. Initially, teams were given two hours to create their dodgeball team and then round-robin tournament play commenced. After each round, the teams could make changes to their program and then return to competition. The rounds engaged the students in the game design teams to meet and laugh and cheer for each other since there were 16 teams in competition and only four teams could play at a time in an elimination round. Since the tournament play was projected on screens in the open space near the game design competition floor, students in other venues, as well as the general population could watch the tournament. And, not to be outdone by the robotics' Rube Goldberg machine, the leaders for the game design programming venue asked to project the final round of the dodgeball tournament on the central projection system used during sporting events complete with a ring announcer and full house microphone. While the central projection and boxing-style announcer voice work was done for fun, it also provided a much needed recognition of the work completed by the students in the game design venue. Although the games created by the teams in the game design programming venue are loaded to machines for the public to view after each real-time challenge, the general public doesn't always understand how to play the games or the point of them and other students in other venues are too caught up in their own real-time challenges to explore the games. So, this projection of their work helped other students see their work and gave the students participating in the game design programming venue the same recognition as the robotics students. As can be imagined the dodgeball tournament was wildly popular with the students in the game design programming area and involved the students with each other.

III. Student Data

The IT-Adventures program is evaluated annually with three years of data currently available. Students are registered to participate in the year-long program in the fall of the year by their IT-Club advisors and demographic data is collected on each student at that time. Additionally, questionnaires are administered to the students to gather information on their interest in IT. For the first year of the IT-Adventures program (2007-2008), the survey was conducted as a post-test only design with students being administered a paper questionnaire at the end of the two-day IT-Olympics event. For the second and third years of the IT-Adventures program, IT-Club advisors provided the students' email addresses as part of their registration records in the fall. The 2008-2009 and the 2009-2010 surveys were conducted online in a pre-test/post-test design. Registered students with valid email addresses were emailed an invitation to participate in the survey in the fall at the beginning of their IT-Club activities and again in the spring after participation in the IT-Olympics two-day competition. Students who did not respond to the initial email invitation were sent reminder emails weekly for six weeks following the initial contact. In the email contacts students were told that by completing the survey their email addresses would be put into a drawing for an iPod Nano and if they completed both the fall and the spring survey, their email addresses would be entered in a drawing for an iPod Touch. Both survey instruments, as well as all contact with the underage students, were approved by the university's Institutional Review Board (IRB) which undertakes approval of all human subjects work and all of their requirements for evaluating the IT-Adventures program were adhered to. The response rates to the student survey ranged from the high of 57.4% achieved with the paper survey handed to the students at the end of the IT-Olympics in April 2008 to a low of 40% in the electronic survey through email contact in April 2010.

While the collaborative real-time challenges were not separately evaluated from the program, data are provided that shows the IT-Adventures program is reaching different types of students with each of its venues and that any attempt to widen the pool of students entering an IT-related area will take multiple venues and approaches such as the collaborative real-time challenges and inclusive competitions such as IT-Olympics to be successful.

Descriptive Information on Participants
As shown in Table 1, enrollment in the year-long IT-Adventures program grew sharply in the second year, but with the economic downturn, state budget problems and pressure on high schools educational budgets for extracurricular clubs, especially to support a teacher as an advisor and travel to the IT-Olympics, the program was unable to grow exponentially in the third year by attracting new schools and new students. The total number of schools and students participating in the year-long program and doubled from year 1 to year 2, but contracted slightly in year 3 due to the poor economic conditions for schools in Iowa. Similarly, the number of schools that participated in the two-day IT-Olympics and the number of students attending the event, increased by a factor of 1.35 and 1.5, respectively, between the first and second years, but remained nearly constant for the third year. The number of schools that register for the year-long program and that come to IT-Olympics are different for a variety of reasons including conflicting sporting events or banquets, prom, student disciplinary problems or funding issues for travel to the event.

The distribution of students who participated in the IT-Olympics competition was disproportionately upperclassmen the first two years, but by the third year had almost evenly distributed among the four classes of high school. Of the students who attend the IT-Olympics event and are not seniors, on average 62% return to the program the following year to continue the program.

While students can study all three venues during the year long activities, they must chose one venue in which to compete at IT-Olympics: cyber defense, game design programming or robotics. Since the two pilot projects in 2005-2006 and 2006-2007 focused exclusively on cyber defense, it was anticipated that this would be the largest venue in IT-Olympics for the first two years. As shown in Table 1, more than half the students who came to IT-Olympics participated in the cyber defense venue for the first two years. However, in the third year (2009-2010), there was a significant shift to students and teams participating in the robotics competition. Nearly 50% of the students this past year participated in the robotics venue with gains also made slowly over the past three years in the game design programming venue. As the IT-Adventures program continues it is anticipated that the distribution will normalize with approximately one-third of the students enrolled participating in each venue.

The IT-Adventures program and the IT-Olympics event is heavily dominated by male participation with 80% of the participants in the event being male, however, the game design programming and robotics venues attract higher female participation than the cyber defense venue. In Table 2, when evaluating the gender distribution among the three venues, cyber defense is consistently at 88% male participation, however, game design and robotics fluctuate between 7.5 to 20% female participation, although these are not statistically significant differences between the venues.

While most of the demographic information came from the registration records, students were asked about the number of computer courses they had taken in high school for the second and third years of evaluation. The years were not statistically different and show that nearly 20% of student participants have taken no computer courses. An additional 25.7% had only taken one course and 19.7% had taken two courses. A quarter of those who had taken one course, identified the course as an application course such as using Microsoft Office. Likewise, a quarter of those who had taken two courses said it was an application course. Application courses are more akin to the typing courses of yesteryear and do not provide a true overview of potential IT careers available to students.

In years two and three of the survey, students were also asked about the number of math courses they had taken. Again, there were no significant differences between the years and show that nearly 70% of the students participating had taken three or more years of math. The question listed math courses (Algebra I, Algebra II, Trigonometry, Geometry, Calculus) and asked students to mark each of the courses they had taken, including any course they were currently enrolled in. It also allowed Other to be marked and filled in as an open-ended response. Nearly 14% of the students marked that they had taken five math courses to date.

Table 1. Demographics on the IT-Adventures Program

	2007-2008	2008-2009	2009-2010
Year-long Enrollment			
High Schools	38	46	44
Students	230	459	396
IT-Olympics Attendance			
High Schools	25	33	32
Students	213	330	322
Cyber	139 (65.3%)	174 (52.7%)	103 (32.0%)
Game Design	34 (15.9%)	55 (16.7%)	59 (18.3%)
Robotics	40 (18.8%)	101 (30.6%)	160(49.7%)
Year in School			
Freshman	35 (16.4%)	54 (16.4%)	81 (25.2%)
Sophomore	36 (16.9%)	81 (24.5%)	66 (20.5%)
Junior	88 (41.3%)	86 (26.1%)	106 (32.9%)
Senior	54 (25.4%)	109 (33.0%)	69 (21.4%)
Teams	46	76	70
Cyber	24 (52.2%)	38 (50.0%)	20 (28.6%)
Game Design	9 (19.6%)	14(18.4%)	16 (22.9%)
Robotics	13 (28.3%)	24 (31.6%)	34 (48.6%)
Gender			
Male	173 (81.2%)	266 (80.6%)	259 (80.4%)
Female	25 (11.7%)	48 (14.5%)	41 (12.7%)
Unknown	15 (7.0%)	16 (4.8%)	22 (6.8%)

Table 2. Gender Distribution in Participants Among Venues

		2007-2008	2008-2009	2009-2010
Cyber				
	Male	111 (88.8%)	149 (87.6%)	88 (88.9%)
	Female	14 (11.2%)	21 (12.4%)	11 (11.1%)
Game Design				
	Male	25 (75.8%)	41 (83.7%)	45 (84.9%)
	Female	8 (24.2%)	8 (16.3%)	8 (15.1%)
Robotics				
	Male	37 (92.5%)	76 (80.0%)	126 (52.7%)
	Female	3 (7.5%)	19 (20.0%)	22 (14.9%)

Confidence in Using Technologies

To determine if the students who participated in different venues felt more or less confident using technologies, a series of 11 Likert scale items were created, based upon work completed by Compeau and Higgins.[12] The students were asked to use a 7-point scale ranging from strongly disagree (1) to strongly agree (7) to rate their confidence in their selected venue given different types of help they could hypothetically receive. Using a general linear model (GLM) three statistically significant differences among the venue groups were found. The GLM results are shown in Table 3. Using the Tukey test for honest significant differences (HSD), a pairwise examination between the three groups' means was conducted post-hoc to find where the variance occurred. The results of these tests are in Table 4. The relative effect size is shown by the partial Eta^2, where a value of .01 is a small effect, .06 is a medium effect and .14 is a large effect.[13, 14]

In examining the results of the GLM, the differences on all three significant items were small, but all occurred between cyber defense and robotics participants. "If there was someone giving me step-by-step directions" [$F(2,293)=6.217$, $p=.002$], "If someone else had helped me get started" [$F(2,292)=4.942$, $p=.008$], and "If I had performed similar activities before this one to accomplish the same task" [$F(2,293)=5.404$, $p=.005$] are all items where students would like additional guidance on the challenges they are undertaking. This makes sense when the post-hoc Tukey HSD is examined. It shows that the means between cyber defense and robotics were significant at the $p<.05$ for all three items (see Table 4 for mean comparisons). It is understandable that the means for these items which all center around getting help or having previous experience are found in the cyber defense area. In the cyber defense venue, the students are required to configure a network, install servers and provide services to end users. Although the students can pick the operating systems and determine how to configure their network, all networking and servers require following protocols so they work properly. Sometimes the rules and structures in the protocols can be very challenging for new participants to understand and follow. Therefore, it makes sense that these students would value step-by-step instructions, a person who could help them get started and having performed the task before. However, by the nature of using a Lego Mindstorms NXT robot which has multiple parts and connectors which allow the students to be very creative about their design and build, few formal rules and protocols need to be followed other than understanding the programming software and the sensors.

Table 3. Statistically Significant Differences in Confidence Levels from GLM

Type of Help	df	F	Sig.	Partial Eta^2
If there was someone giving me step-by-step directions	2	6.217	.002	.041
If someone else had helped me get started	2	4.942	.008	.033
If I had performed similar activities before this one to accomplish the same task	2	5.404	.005	.036

Table 4. Tukey HSD for Confidence Measure Differences Between Groups (Responses were made on a 7-point Scale where 1 = Strongly Disagree and 7 = Strongly Agree. Means that do not share subscripts differ at p<.05

If there was someone giving me step-by-step directions	Cyber Defense	5.49_a
	Game Design	5.10_{ab}
	Robotics	4.55_b
If someone else had helped me get started	Cyber Defense	5.38_a
	Game Design	4.89_{ab}
	Robotics	4.79_b
If I had performed similar activities before this one to accomplish the same task	Cyber Defense	5.94_a
	Game Design	5.50_{ab}
	Robotics	5.42_b

Involvement with Current Technologies

To gauge whether the students' involvement with current IT technologies would vary between venues, they were asked a series of 13 questions, on a 7-point Likert scale ranging from strongly disliked (1) to strongly like (7), about certain IT-related activities. This series of questions was based upon work done with interest markers by Liao, et al.[15] Two of the medium size effects are related to traditional hardware interests of those who have chosen to work in an IT-related job as shown in Tables 5 and 6. "Maintaining hardware and software for my family and/or friends' computers" [F(2,291)=10.559, p=.000] and "Researching components and building my own computer" [F(2,292)=20.422, p=.000] are activities related to stereotypes of IT students and professionals. The post-hoc Tukey HSD shows that the means for "Researching components..." for robotics (M=4.75) and game design programming (M=5.07) were statistically different from those in cyber defense (M=6.01). Likewise, the mean for cyber defense for "Maintaining..." (M=5.68) was statistically higher than the mean for game design programming (M=4.91) or robotics (M=4.90).

Two additional items with medium size effects and one item with a small effect show robotics students are less likely than the students in the other two venues to enjoy traditional software IT activities or coursework. "Taking a course in computer technology" [F(2,291)=14.811, p=.000] in high school generally means taking software course such as a programming class on Visual

Basic or an applications class on Office. In a larger school in a larger district it may include a Cisco Academy course, but in Iowa that is only in very urban populations. The Tukey HSD shows the mean for robotics (M=5.11) is significantly lower than the means found for game design programming (M=5.64) or cyber defense (M=6.10).

The second item on which robotics students are significantly less interested in is "Maintaining a web site" [F(2,293)=8.582, p=.000]. Again, this is a medium effect if the Eta^2 is rounded up from .055 to .06 and Tukey HSD shows that robotics mean (M=4.18) for this item is statistically different from both cyber defense (M=5.04) and game design programming (M=4.77).

While "Keeping up-to-date on the latest software" is only a small effect [F(2,293)=5.495, p=.005], again the Tukey HSD shows that the means for the students participating in the robotics venue (M=4.92) again differ significantly from those in the game design programming (M=5.52) and the cyber defense (M=5.62) venues.

On the two items "Improving computer performance" [F(2,292)=4.250, p=.015] and " Writing my own programs" [F(2,292)=4.157, p=.017] small effects are observed. When the Tukey HSD was examined the statistically significant differences between venues occurred between robotics (M=5.53, M=4.47) and the cyber defense (M=6.04, M=5.09) venues.

The enjoyment of the IT-related activities examined in this portion of the survey appear to point to a continuum of student interests. It appears that the cyber defense students tend to be the most oriented toward traditional IT-related activities that involved hardware, software, taking courses, building computers. The robotics students, while still above the neutral point on the Likert scale (Neutral = 4) and therefore, liking the activity, like these traditional IT-related activities less than the students participating in cyber defense. The interests of students in the game design programming venue fall somewhere in the middle of the range.

Table 5. Statistically Significant Differences in IT-related Activities in the GLM

IT-related Activities	df	F	Sig.	Partial Eta^2
Maintaining hardware and software for my family and/or friends' computers	2	10.559	.000	.068
Researching components and building my own computer	2	20.422	.000	.123
Taking a course in computer technology	2	14.811	.000	.092
Maintaining a website	2	8.582	.000	.055
Keeping up-to-date on the latest software	2	5.495	.005	.036
Improving computer performance	2	4.250	.015	.028
Writing my own programs	2	4.157	.017	.028

Table 6. Tukey HSD for Confidence Measure Differences Between Groups (Responses were made on a 7-point Scale where 1 = Strongly Dislike and 7 = Strongly Like. Means that do not share subscripts differ at p<.05

Maintaining hardware and software for my family and/or friends' computers	Cyber Defense	5.68_a
	Game Design	4.91_b
	Robotics	4.90_b
Researching components and building my own computer	Cyber Defense	6.01_a
	Game Design	5.07_b
	Robotics	4.75_b
Taking a course in computer technology	Cyber Defense	6.10_a
	Game Design	5.64_a
	Robotics	5.11_b
Maintaining a website	Cyber Defense	5.04_a
	Game Design	4.77_a
	Robotics	4.18_b
Keeping up-to-date on the latest software	Cyber Defense	5.62_a
	Game Design	5.52_a
	Robotics	4.92_b
Improving computer performance	Cyber Defense	6.04_a
	Game Design	5.84_{ab}
	Robotics	5.53_b
Writing my own programs	Cyber Defense	5.09_a
	Game Design	5.02_{ab}
	Robotics	4.47_b

IV. Lessons Learned

What the Data Tells Us

The data gathered in three years of evaluation point to the fact that the different venues attract different kinds of students. Those students who are most like the varsity players who are predisposed to IT concepts appear to gravitate toward the cyber defense venue. This is by far the hardest venue to participate in and has the most IT-related concepts that need to be known and adhered to in the competition. However, with the way the IT-Olympics event is run, downplaying the competition and having the attacker being the common enemy, the party atmosphere is maintained. Additionally, there is no rank ordering of all teams in the competition released. The top three teams are announced at the awards ceremony and the their scores are posted on the IT-Adventures website. Individual team scores are entered into the database where the IT-Advisor can retrieve only their team score and compare their score to the winners' scores. The authors found after the pilot projects where full rank ordering of team scores were provided to everyone, teams with the lowest scores would drop out of the program for the next year, believing they weren't "good enough" to compete. This did nothing for broadening the pool of students who would potentially choose a major in IT. Therefore, the program was modified to not provide a rank ordering which identified the "biggest loser," but still allowed teams to retrieve a final score and compare themselves without being identified as the "worst team" in the event.

The data also show that students who are most like the recreational league intramural players are those found in the robotics venue. They are not as tied to IT rules and can experiment as if playing with puzzle pieces. And, the students who participate in the game design programming venue tend to fall somewhere in between. This range of interests and confidence in technologies points to broadening the pool of students who opt to experiment with IT and who may be able to find their niche while it may not be programming or hardware design, may find the applications for IT an area they are interested in.

As noted above many students aren't getting IT-related courses in high school and about a quarter of those who have taken an IT-related course have taken an applications course. This helps support the concept that students who participated in the IT-Olympics might not have found another way to explore IT. Additionally, students in the robotics venue who are not inherently attracted to the traditional items that are associated with IT-related careers have found a way to explore IT in a non-threatening environment. One of the items showed that the students in the robotics venue probably wouldn't take a course even if it were offered at their high school, but as an IT-Club and having fun it appears to have helped them explore IT as a possible career possibility.

What We Learned about the Collaborative Real-Time Events

While the Rube Goldberg machine was a success and another is planned for April 2011, designating each team and their corresponding task in the machine on paper will be implemented. This will allow the teams to move to larger spaces to build but refer to the paper to determine what team they need to locate to test their portion of the machinery. This will reduce the confusion about input/outputs and hand off of task processing. Additionally, the concept of passing information via Bluetooth from one Mindstorms NXT brick to the next in the Rube Goldberg machine has been discussed, but the pairing process may not allow this to happen. Additionally, the game design programming venue may be presented with multiple collaborative real-time challenges in the April 2011 competition. The dodgeball tournament was entertaining and built community within the venue. The leaders of game design programming venue were happy with the success and want to expand the collaborative real-time gaming events to continue to increase the interactions between the students in the venue.

While the effects of collaborative real-time challenges on the students and the level of fun is positive, they take more time to develop. For the 2010 game design programming collaborative dodgeball real-time challenge, a graduate student had to develop the template and the logic for the game to allow the four teams to compete against each other, as well as the ball trajectory and the graphics for the players. While it was not an insurmountable amount of work, it still required that student to divert time from other research projects to design, develop and implement the dodgeball tournament. Additionally, since the students literally had to learn how to run the Dodgeball Programming Language (DPL), there was a bit more support that was needed on the competition floor to get the teams of students started on the challenge. Two graduate students plus the two leaders for the game design programming venue were answering questions for the first half of the collaborative real-time challenge. Generally, in a real-time challenge the students are given the task and no additional help or explanation is provided. But because they had to learn something new in a very short amount of time, more support time was devoted to them.

Likewise, in the robotics collaborative challenges, the design of the collaborative challenges took a bit longer. The car and its Bluetooth controller were designed, built and tested by the leader of robotics venue several weeks prior to the competition to ensure the students could complete the challenge. Similarly, the robotics leader built the pilot car and an autonomous car for the 2009 competition again to test to make sure the challenge was possible. Additionally, more help was needed to get the teams started with these collaborative challenges and helping them understand what part of the Rube Goldberg machine they were designing. With complexity in design comes complexity in the specification which is not always easy for high school students to understand in written word. Additional volunteers who understand and have worked with the Lego Mindstorms NXT robots and the Alice programming language are going to be available in April 2011 to help alleviate the pressure off the robotics and game design programming venue leaders. This will also provide support and interpretation to the student participants in a more timely manner.

V. Future Directions

Collaborative real-time challenges will continue to be used in the game design programming and robotics venues of the IT-Olympics competition. The collaboration builds community within the venues and, because of the sheer size, complexity and eye appeal of the real-time challenges, allows outsiders such as parents, teachers, siblings and the general public to easily view and understand what the students are creating. Collaborative real-time challenges also provide recognition for the students in venues which have had a "heads down" approach previously, as was pointed out in the game design programming discussion. Also, collaboration builds upon one of the basic tenets of the IT-Adventures program and the IT-Olympics competition: IT can be fun! Collaborative real-time challenges provide a way to increase the fun of the event for those two venues where it is easy to focus on each individual project for their team and not see what other teams of students around them are doing. In a collaborative real-time challenge, students meet students from other teams in their venue and in other venues who are watching their event.

While collaborative challenges work well in the game design programming and robotics venues, they do not work well in the cyber defense venue. This is primarily due to the complex nature of their individual network design and setup. However, the need for collaborative real-time challenges in the cyber defense venue is not necessary. The common enemy of the attacking team and the existing party atmosphere of watching what the attackers do to their own team, as well as others, the cyber defense venue already has a sense of community in working against the attacking team. The team members already share information among each other about attacks being carried out against them and vulnerabilities they found.

VI. References

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