AC 2010-1308: USING NATIONAL COMPETITIONS TO FOCUS STUDENT CLUBS

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Scott Bellinger is an assistant professor in the Automation Technologies program at the National Technical Institute for the Deaf (NTID). Scott served as the Director of Manufacturing Technologies at RIT's Center for Integrated Manufacturing Studies (CIMS) before joining NTID. He has more than twenty years of experience in developing manufacturing systems with a specialty in factory automation. He served as Applications Engineer, Proposals Engineer, Project Manager and Application Engineering Manager at Hansford Assembly & Test Systems (NY); Director of Applications Engineering at Wes-tech Automation Systems (IL); and Vice-president of Engineering at Cox Automation (IL). He started in the automation industry as a machinist, machine builder, robot programmer and controls engineer. He has trained engineers and technicians in machine design and controls implementation and has taught PLC and CNC programming. Specializations include assembly equipment conceptualization, flexible automation, DFM/DFA, and testing/monitoring systems. Scott has received an MS in Manufacturing Management and Leadership from RIT in 1997 and a BS in Electrical Engineering and Computer Science from the University of Illinois-Chicago in 1984.

Scott built his first electric bicycle in 1977 and has been actively developing improved electric vehicles ever since. He founded the RIT Ebike club in 2006 and has been the advisor since inception. Scott led the club to the 2006 Tour de Sol ebike competition in Saratoga Springs, NY. The team placed first and second in the student category with both entered bikes finishing 1, 2 in the three hour marathon race.

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Using National Competitions to Focus and Energize Student Clubs

Abstract

This paper explores the multi-disciplinary aspects and benefits of extracurricular team events. The primary audience for this paper is engineering and engineering technology teachers, teacher supervisors, teaching assistants and administrators.

An Electric Bicycle club was formed comprised of students from multiple academic disciplines. The group included both deaf and hard of hearing participants adding diversity to the communications requirements and richness to the results. Team collaboration across disciplines and between differing communication cultures was accomplished by providing students coaching and mentoring in project management skills. They were assigned specific tasks such as CAD drawings, part procurement, motor testing, performance monitoring, machining, and final testing. Teamwork was utilized to merge the various subsystems into one unified vehicle. An ideal way to focus the club's enthusiasm and creativity was found in joining the Tour de Sol electric vehicle competition

Strategies are presented for setting up a successful technology based club with students from different academic majors. Creative methods for linking classroom teaching to club activities are offered. Coaching and mentoring techniques for focusing the students efforts without taking control (important for student led clubs) are presented.

Background

Educating students for success includes developing skills for working effectively in multi-disciplinary teams [1]. A variety of approaches to foster teamwork have been discussed in the literature including the use of interdisciplinary design teams and multi-disciplinary design courses [3,10]. The benefits multi-disciplinary teams have been examined [9] and a few best practices identified [5]. A common theme is the challenge of communication and team dynamics. At Rochester Institute of Technology, home to the National Technical Institute for the Deaf, an opportunity for a multi-disciplinary team consisting of hearing and deaf/hard of hearing students was presented when I brought my personal electric bicycle (ebike) in to demonstrate speed control for a class. I noticed students were intrigued and showed a keen interest after riding it around outside. I had heard of a national event called the Tour de Sol that had recently expanded their events to include an ebike competition. At the time I was studying American Sign Language (ASL) to improve communication with my deaf and hard of hearing students (d/hh). I realized that if I started a club focused on electric bicycles and some of my d/hh students joined, it would provide a unique opportunity. My students would get experience in putting classroom theory to practical use and I would get a chance to improve my ASL skills in an informal setting. I suggested we form an Ebike club with the goal of designing and building a vehicle to compete in the Tour de Sol.

Multidisciplinary Club Formed
The core club team was comprised of students studying business, laboratory science, mechanical engineering technology and my own automation technology students. Early on the decision was made to split into two groups. One would design the motor/controller/battery system while the other would be responsible for the frame design and fabrication. Groups were self-formed through student discussions with guidance from the team advisor in outlining the tasks required and skills most useful for each team.

Learning through Prototyping

The controls group started comparing different approaches such as direct drive hub motors versus a chain or belt driven system. The frame group brainstormed on possible frame styles and battery mounting options. Both groups soon realized they needed to all work together until a concept was chosen because the two systems must ultimately end up as one. Evaluation of a matrix listing pros and cons of different aspects of each approach helped narrow the possibilities down to the best two. The first concept used a direct drive 3 phase brushless hub motor laced to a wheel. The second concept used a higher speed 3 phase brushless motor driving a wheel via chain or belt drive with a speed reduction.

To evaluate the chain drive option, a prototype bike was built using a BMX bicycle frame. The efficiency of an existing ebike (Silverboy) was compared with the new chain drive and it was the team determined the simple direct drive hub motor on Silverboy performed better using watt-hours per mile as the measure of efficiency.

Figure 1 BMX prototype with chain drive

Even though the chain drive approach was a ‘failure’, having a working prototype really gave a boost to the team as this taste of success encouraged them to persevere on the race specific ebike design.

With the concept finalized, design could begin. The controls group researched potential sources for motors and controllers. The deaf students used email or telephone relay service to communicate with vendors. This process involves the deaf person using a TTY keyboard and typing to a remotely located ‘Communication Assistant’ (CA). The CA calls the vendor, announces that this is a relay call, and voices the deaf person’s typing. The vendor responds verbally and the CA types the response back to the student. The conversation continues in like manner and when finished all three parties hang up. It is not commonly known in the hearing community but all states offer a free relay service for deaf customers.

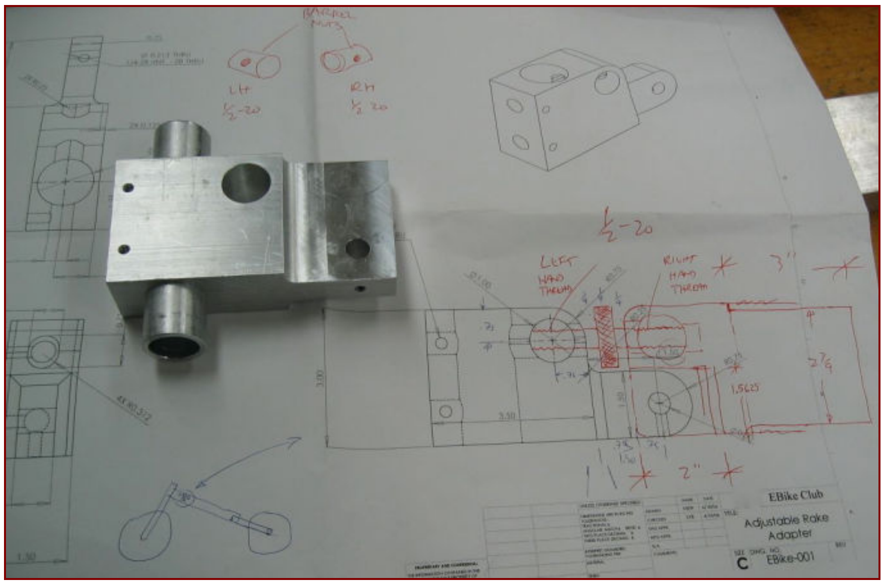

Figure 2 Frame, CAD design of rake adjuster

The frame group explored various design options. They settled on a long and low 2-wheel frame using 20” BMX bicycle wheels. Due to time constraints we decided to design and fabricate the frame but to purchase the front fork, wheels and brake components. The mechanical engineering technology student used 3D CAD software to design the frame. A unique adjustable rake head tube was designed so that the optimal rake angle could be determined experimentally after the bike was complete without requiring disassembly, re-machining and/or welding. Front forks and front wheel were purchased through ebay while rear wheel, brakes and cables were procured from local bike shops. A disc brake was used for the rear wheel and drum brake for the front to safely stop the overweight bicycle with 40 pounds of battery and a 12 pound motor.

Figure 3 Frame, wheels and motor assembled

While waiting for the motor, controller and parts to arrive, frame fabrication took place. Some of the manufacturing students fabricated machined components in one of the university's machine shops while another welded up the rectangular aluminum tubing frame. The controls group made up a wiring harness and selected a protected frame location to mount the controller.

The ordered parts arrived and final assembly was completed with only one day left before departure for the Tour de Sol. A few test rides allowed the adjustment of the rake angle and brakes. At this stage, the team realized there was no good place to put the riders feet. Back in the shop some rear foot pegs were welded in place. With wiring secured and an old motorcycle seat bolted on, "Lowboy" was born.

Figure 4 Lowboy completed one day before race

The Competition

There were 21 entrants altogether including recumbents, electrathon vehicles, tricycles and fully enclosed vehicles. There were categories for 1 hour, 2 hour and 3 hour attempts for both student and commercial classes. All competitors started simultaneously. There were some early failures mostly for mechanical problems. After 30 minutes, 18 were still viable. At the one hour mark, there were about 12 still competing.

Figure 5 During the race

By the second hour, there were only 8 left. When the three hours were complete, 5 had gone the distance with Silverboy in first place student class and Lowboy in second. Only one vehicle went more laps, Optibike, a $5000 commercial ebike with an athlete rider.

Observations and Lessons Learned

Throughout this process I learned techniques for being an effective advisor. I found that flexibility in leadership was important. At times I would be somewhat strong in my suggestions and recommendations if I felt there was little chance of success down a path being considered. Other times I would help students evaluate options by asking clarifying questions and suggesting "what if " scenarios, ultimately letting the students decide. Sometimes I could just say "someone needs to take care of …" and the team would respond without further involvement by me. Student skill and experience also guided my interactions with the club members. Some needed frequent direct supervision while others were self-motivated and highly skilled requiring only occasional coaching. My role as advisor was to facilitate without directly leading.

One lesson learned was the failure of dividing into separate focused teams too early. It is better to wait until the general approach is defined and goals established before dividing the members into subgroups. Another unexpected challenge was financing. It is best to find out early on what funding options are available through the department or college and from external sources.

I found that students naturally gravitated towards tasks that utilized their existing skills. The business student took on fund raising. The mechanical engineering technology student volunteered to do the 3D cad drawing. The electrical engineering technology students joined the controls team. For tasks outside of the students' expertise I would contribute myself by teaching them or direct them to other sources for solutions. It provided many opportunities to tie-in classroom theory to the clubs activities. I found the students eager to learn.

One good strategy to use if your organization includes deaf or hard of hearing students is to ask them for suggestions on how to facilitate interactions. Responsibility for communication is half theirs and they have been interacting with the ‘hearing world’ for many years and have developed methods that work for them. They are quite willing to share their experience and expertise. It was beneficial to me to discover the option of using the free national Relay Service for deaf-hearing phone interactions. All states offer a free relay service for deaf customers. By the end of the competition I had become very comfortable communicating with the d/hh students and had improved both my expressive and receptive ASL skills.

Incorporating flexibility into the design approach proved to be a valuable benefit. The adjustable rake steering required more time up front in the design and fabrication stages. However, the time to determine the optimal rake angle for this vehicle was done in less than one hour. If the traditional route of design, fabricate, build, test, evaluate, redesign, fabricate, build, test, etc. had been followed, the optimization would have taken a week. When building prototypes, extra flexibility, even at the expense of design and fabrication time, can sometimes bring successful results more quickly.

With any university club there will be curious students that will show up to observe the activities. Some will become occasional contributors while others get excited and really embrace the club. We had 15 students enrolled in the club but 8 dedicated core members. I was truly impressed with their creativity and hard work. We met 2 to 3 times a week often at night or weekends. They really enjoyed the several day field trip to the Tour de Sol and were thrilled to win the student class event but I’m sure they would still have been thankful for the experience even if we hadn’t won. Several told me it was their most memorable time at college. I found the deaf and hard of hearing students to be very generous and accommodating in their communication effort. We used the white board often to share ideas and designs. If I didn’t know a particular ASL sign I would fingerspell or write the words and they would teach me the appropriate sign. Email was an excellent tool for sharing and collecting ideas. They were proud to show off our ebikes and explain our design to the other hearing contestants.

Figure 6 Awards in hand

I highly recommend the formation of technology based clubs to motivate and educate students outside of the classroom. I found it to be a rich experience and we are considering hosting a similar event at our university as the Tour de Sol no longer exists.

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