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International Robotics Design Competitions: Potential and Pitfalls

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Abstract

The role of international design competitions in an Engineering Curriculum is investigated using a case study involving participation by 9 Union College students in an autonomous robot competition in France. As part of their degree requirements, all Union Engineering majors are required to have an international experience. Participation in the 1998 E=M6 Robot Soccer competition in France, and subsequent study of French engineering education, was used by some to fulfill this requirement.

The Union students cooperated with a team of French students from ESIGELEC who were also entered in the competition. They designed an autonomous robot to play a type of table-top soccer against a competing robot. The Union team included sophomore, junior, and senior students majoring in Mechanical Engineering, Electrical Engineering, Computer Systems Engineering and Computer Science. The Internet was used for communication with their cooperating team in France. The students traveled to France for final debugging and testing as well as to participate in the competition itself.

The potential educational benefits from this type of experience include exposure to open-ended multidisciplinary design, development of teamwork and project management skills, and appreciation for another culture. In addition to expected team related issues such as group dynamics, the students and their faculty advisors needed to address cross-cultural issues relating to cooperation between the teams. The experience was assessed using a questionnaire following the competition. Greater attention by the advisors and the students to team skills would have greatly increased the educational effectiveness of the project.

Introduction

As part of a redesign of its engineering curriculum, Union College began requiring an international experience for engineering majors in 1997. Students may satisfy this requirement by going on a traditional term abroad, by studying a foreign language, by participating in an international coop, or by participating in an international design project. In 1997, Union was planning an exchange program with ESIGELEC, a French engineering school. As a prelude to sending Union students on the exchange, we decided to encourage participation by a group of students in the 1998 E=M6 Robotics Competition in France. Engineering students from ESIGELEC had been participating in this competition for several years, and they were willing to cooperate with a group of students from Union. Several Union students were members of the college's robot club and had participated in the American Nuclear Society student robotics competition in

Augusta, GA in 1997. The E=M6 competition involved over 100 teams from throughout France, and required an autonomous robot to play a type of table-top soccer against a competing robot. Union's was the only international entry.

To make the international experience for the students more substantive, they were also asked write a research paper comparing the French and U.S. systems of engineering education. Traveling to France for the competition allowed them to interact directly with students from many French institutions.

Design Project Experience

Our goal in setting up this project was to create an international and multidisciplinary group of students who would work as a team on a common task. The necessary team interaction would provide an ideal mechanism to encourage cross-cultural and cross-disciplinary sensitivity. The complexity of the task would require careful project management skills, with various subsystems being worked on concurrently by individuals and small groups. The Internet would provide an excellent communication mechanism, supplement the telephone, and allow students to share design ideas. The project would culminate in French and U.S. students working together in France on final testing prior to the competition. Unfortunately, the project did not live up to these lofty expectations.

Once the project began, it became clear that our goal of having the students produce a cooperative design with their French counterparts was unrealistic. Initial testing of Internet-based communication tools seemed to go well, and gave us a false sense of how useful these tools would be in the project. Attempts to conduct video conferencing or even chat sessions with France were usually frustratingly unproductive, due both to limitations of the technology and also to a language barrier. Although most of the French team spoke some English, they were not comfortable with real time communication. Of our nine students, seven had never studied French, and two had only a rudimentary knowledge of the language. This left document exchange as the only viable method of technical interchange. The French team was participating in the competition as part of an extracurricular activity, and since the competition had no requirement for technical documentation, they had no motivation to document their activities. They had entered a robot in a previous competition, and were mainly focusing on modifying it to play "soccer." Given the different goals and perspectives of the two groups of students, we decided to pursue separate, but cooperative designs. This quickly degenerated into two largely independent groups working on quite different designs.

The major need for communication between the teams was when our students needed help in translating and interpreting the rules of the competition. Here, Internet-based language translation software was very useful in providing crude, but useful and immediate translation of rules and rule changes.

The inherent complexity of an autonomous robot makes it an ideal subject area in which to expose students to multidisciplinary team design. Mechanical engineering majors can design the drive train and other moving subsystems, electrical engineering majors can design sensor, motor and actuator circuitry, computer engineers can design microcontroller interfaces, and computer science majors can design software to implement the desired behavior. Students may also focus on a subsystem outside their major to broaden their knowledge.

When done well, such a robot design involves several individuals or small groups working concurrently on various subsystems and communicating regularly to consider systems integration and project management issues. Getting students to work concurrently has been one of our biggest challenges in several years of supervising robotics projects. Typically, our students have difficulty considering component placement until a structure has been built, are unable to design circuits until all the parts are in hand, and have difficulty writing software until all other subsystems are complete. Testing and debugging tend to be done haphazardly as a competition deadline approaches. Thus our team of nine students tended to approach their design problem more sequentially than concurrently and did not make efficient use of their considerable size and abilities. Several of the nine students were using the design project to fulfill the international requirement, while others were merely participating in a club activity. It was difficult for the students to organize themselves due to the differing commitments that each brought to the project. Since the faculty advisors were not explicitly assigning grades to the project, we had little control over students who did not make a consistent effort.

Despite these difficulties, the students did manage to produce a working robot to enter in the competition. Indeed, their design was a simple and elegant solution to the problem. Unfortunately, due to inadequate time spent testing and debugging, consistent and reliable performance was never obtained.

Robotics Competition Experience

The team's trip to France was divided into three segments. We allowed two days in Paris for sightseeing, two days at our exchange school for the students to do final testing and interact with the French team, and three days for the competition.

The E=M6 robotics competition was the highlight of the project, and is unlike any U.S. competition that we have seen. Each team is given a small work area in a large field house. Teams bring everything from small tools to a portable machine shop and redesign and rebuild their robots on sight. Many teams, including ours, worked through the night in attempting to pass the qualifying round in which the robot had to gather a ball and deposit it in the opposing goal. With a strict time pressure over them, our team worked with amazing stamina, but narrowly missed advancing beyond the qualifying round. Over 100 teams competed, representing nearly every engineering school in France. There was a tremendous educational benefit for our students to take part in the competition and witness the incredible variety of robots entered. The finals of the competition were a cross between a game show and a rock concert, with an M.C. and cheering sections for various teams. It is difficult to imagine such a competition taking place in the U.S.

Comparative Study of French and American Education Systems

Before the trip, those students who were using the project as their international experience were given an assignment to write a paper comparing French and American engineering education. While in France, we had intended for them to interview students and gather data and reference material for their paper. After returning, they were to write the paper and present it orally. The following questions were to be addressed in the paper.

What types of engineering education institutions does one find in France? Do they fall within the categories of private and public schools as they do in the US?
What is the tuition and financial aid situation at the various types of institutions? How much do students typically have to pay for an engineering education?
What are the admission criteria for French schools? How does this compare with the U.S.?
What types of engineering degrees are offered and how long does it take to complete various engineering degrees?
How does the engineering curriculum compare to those in the US? How much time is spent on technical subjects? How much on non-technical?
What is the status of an engineer in the French society? Better than a physician? Less than a lawyer? How does this compare to the US?
What is life like outside the classroom at French engineering schools and universities? What extracurricular activities do the students engage in? How important are drugs and alcohol? How often do students travel home for the weekend?

Of the four students who originally joined the project to fulfill the international component of their program, only two completed the research assignment paper. Two others decided to pursue other options for satisfying the international requirement. The papers that were produced failed to take advantage of sources developed during the trip, and tended to be rather superficial. They are currently under revision.

Assessment

Assessment for this project was limited to a questionnaire following the competition. The students were not asked to regularly assess and improve upon the team's effectiveness. Not surprisingly, this led students to have greatly differing opinions of how well the team functioned. Those who did find fault tended to focus on results of poor team work such as not everyone participating equally or missing deadlines, rather than the underlying team issues that led to these problems. Most of the students had considerable experience with formal and informal team work early in their engineering education, but this did not necessarily imply that they had developed good team skills, or that they would apply such skills without guidance. Since some students were participating as part of their academic curriculum, while others were involved as part of a club activity, they had very different levels of commitment to the team. It was difficult to foster the positive interdependence and individual accountability needed for effective team work[2]. The team did not progress beyond what Harper and Harper[1] describe as a first stage team. They were dealing with confusion, frustration, and uncertainty, and did not develop the sense of unity and trust that characterizes the best teams.

Conclusions

Advising this group of students has exposed us to the tremendous potential that international group designs projects have for improving engineering education. Working cooperatively with students from other cultures gives our engineering students greater cultural sensitivity than they would achieve by merely learning about other cultures through standard course work. Although our students benefited greatly from participation in this project, a lack of emphasis on team skills detracted from their success. With hindsight, the involved faculty have developed greater appreciation for research on team effectiveness.

Bibliography

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