A Preliminary Report on Establishing an Industry Based International Capstone Exchange Program

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This article presents preliminary results on the establishment of an industry based international capstone exchange program. North Dakota State University in the United States, the University of Applied Sciences and Arts Hannover, Germany and Linköping University in Sweden as well as industrial sponsors in each country will be participating. Three models for industry based capstone courses are presented along with characteristics of projects well suited for an international exchange program. At this point, the project exchange is ready to take place in the spring 2012 semester, so results at this time are mainly given regarding how to set up such an exchange. Some early conclusions and areas for potential improvement are included as well. More results from the first instance will be available at the time of the conference.

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Introduction

Over the past several years it has become clear that including a capstone team experience in computer science degree programs has great value for students. This typically means implementing a significant software development project. Having this project be a *real-world* experience done for an industrial sponsor, when possible, adds a level of reality and practicality to the learning. Although these capstone programs are very successful, they could be improved in one important area - including an international experience - that would make them an even stronger learning experience. Working across international boundaries would provide many learning opportunities (e.g. understanding the global context of situations and cultural differences in the workplace, dealing with language barriers, time zone issues, and different technology preferences). It is increasingly common for industrial teams to work with teams in other countries. By having exemplary project teams in each class work for a sponsoring company in a different country many students gain insight into how international teams work. For organizational reasons students work remotely from their home school; this also reflects a typical situation in their work place.

Although this idea sounds straight forward, getting it to work in practice can be quite a challenge. It is not easy to find companies in other countries willing to sponsor these student projects. What is needed is a model for how to more easily allow a university to set up this kind of international experience for their students. In order to make this kind of experience available not just to one or two universities but to many universities and colleges we plan to pilot an international capstone project exchange program. The core idea is for a university to collaborate with a nearby industrial company then coordinate with a partner university/industry to do a project exchange.

Background

Each participating university has been carrying out industry based capstone projects in their curriculum for some time already. In those instances each organization has its specific characteristics:

Hannover Program

The CS department at the University of Applied Sciences in Hannover traditionally has a very close relationship to software industry by requiring its faculty members to have at least three years of professional experience outside academia. This is reflected in the department both in several industry-sponsored research projects as well as in the B. Sc. and M. Sc. programs in computer science. An integral part of this applied approach is a capstone project in cooperation with external partners in both programs. In the bachelor's program it is a one-year project which students typically complete in their final year of studies. Theory of software engineering and software projects is covered in classes outside the capstone course which is typically taken before and in parallel with the first semester.

Several projects are offered each year by different faculty members (most in cooperation with industry) and students are assigned to the projects based on a

bidding and auction process. Thus in order to attract the best students and provide a successful capstone experience one should keep general success factors in mind[4]. External partners provide the general project idea and requirements. Throughout the projects they act as a customer towards the student team. The technical and organizational lead of the project is in most cases adopted by the faculty member. Some or all of these tasks may be delegated to students on the team. Student teams typically consist of 6-10 students leaving some room for different roles for the team members. Students are expected to spend about 1 day a week on the project as it counts 8 ECTS (European Credit Transfer and Accumulation System) credits.

Team and project are organized according to the particular development process model chosen, and meetings with the customer may occur more or less frequently. External partners never act as project managers or technical leaders.

NDSU Program

The NDSU B.S. program has required undergraduates to complete a one semester three US credit capstone course since 2004. The capstone course is centered on team based software development projects conducted for local or regional businesses[1].

In a typical semester, several international students are distributed throughout the capstone teams so students do gain experience working with people from other countries. Students also gain experience working with remote development - on projects for companies in other cities. However, until now there have not been any projects with companies in other countries.

Since 2004 NDSU has worked with over twenty different companies throughout the Midwest (3M, IBM, John Deere, Microsoft, Polaris, Rockwell Collins, etc.). Teams of three to four students are assigned to complete projects for sponsoring companies. These projects cover the entire software development life-cycle from requirements definition through final delivery to the customer. NDSU works with these companies to arrange for development projects centered on applications of immediate practical value to the sponsoring companies so that student learning experiences are similar to activities that they will be responsible for after they graduate. This requires students to directly confront the need to provide value to their customer and gives students a broad view of how development projects begin and fit into the spectrum of activities and concerns with which a company must deal. Additionally, this approach helps to motivate students as they realize that the software which they develop is important to the sponsoring company.

Company sponsors/mentors prepare project proposals which are reviewed by the capstone instructor. Projects are presented to the students who then can bid on which project they would prefer. Teams are assigned by the instructor. The company mentor interacts with their team on a weekly basis providing technical and business guidance to the student team.

Linköping Program

Project work has been an essential part of the curriculum of Computer Science and Engineering since its inception in 1975. In the third year of the curriculum there has always been a software development project performed in groups of 6-8 students with an external customer. The course is highly appreciated by the students since it provides an opportunity to gain some experience from all phases of software development, and that the experience also covers methods, documentation and inter-group communication.

The course runs over the spring semester and is worth 8 ECTS credits. This is translated to 200 working hours per student, which is also a prerequisite for passing the course (+/- 10%). The challenge is to balance different interests and abilities of the project members to make all students reach 200 hours. Typically some 30 proposals are available for 10 groups to select from. Students normally favor clearly specified projects with new technology and interesting applications.

In the proposal the customer presents the general purpose of the product and 3-5 important, high-level requirements. Customers are supposed to work about 25 hours, giving interviews in requirements analysis, evaluate prototypes, and provide contacts to end-users.

In the project the students follow the OpenUP[2] process with some extensions. The process is fairly complete, contains much free information, and is a good compromise between the agile and gate stage based approaches. Each group has a tutor, with whom they meet approximately once a week. He supports the group with answering questions about tools and processes. Issues with the customer are handled by the examiner. The course is finalized by writing an experience report.

Current Exchange Program

In its first instance in spring 2012 the exchange program will be operating with one company in each country hosting a project for one team from a partnering school abroad. To increase the international experience for the student team all projects will be operated close to the NDSU model. For the Hannover student team instructor involvement will be somewhat higher reflecting the

typical execution model there. Linköping is similar to Hannover, but emphasizes processes and resources.

Establishing Industry Sponsors

One of the most difficult tasks of establishing an international cooperation is finding industry sponsors willing to host such an international project. We succeeded by talking to industry sponsors that had already offered national projects in earlier years. This seems to be a good idea as these sponsors are aware of the specific characteristics and limitations of a student project (e.g. limited time per week, uncertain success, and potential drop-outs during the project). Thus these sponsors *just* have to be acquainted with the additional risks and complexity stemming from the international context. Examples on these factors have been discussed in related literature already[3].

Also one key point in recruiting companies has been to find mentors or sponsors who had previous personal experience with international projects in their professional career. People who feature this are typically more likely to envision the benefits of international experience. Thus they are willing to offer students a chance to gain this experience as well.

Determining Feasible Projects

Another challenge (even bigger than in national industry cooperation) is finding a feasible project. Here also using sponsors who are familiar with student projects from previous cooperation helps a lot. Among the key factors of a *good* project we see the following:

- The result provides good benefit for the sponsor/mentor, but having the project completed is not on the critical path for the company: Nice-to-have software is typically a good choice where the company likes the project, but it is currently prioritized too low to get it done internally.
- The sponsor believes in the idea that industry cooperation is essential for students in the program.
- The role of the mentor needs to be adjusted to match the needs of the specific university model.
- The project does not require too much domain knowledge: due to the missing experience of most students and the very limited time of the project there is not much room for acquiring domain knowledge for the team.
- Clearly pre-defined, narrow interfaces between the software in the company and the student's software are beneficial. If necessary, remote access to specific systems in the company should be established well in advance.
- Topics involving a new technology to be applied to the domain context are often a good choice: sponsors can gain insight and experience in new technologies they would otherwise not be able to evaluate. Also new technologies are very appealing to students which should create a cool project. This in turn helps in recruiting a strong student team.
- Scalability: the task should be easily scalable as the design and development skills of the team are not known up front. Therefore the task should give a weaker team the chance to complete a meaningful project while at the same time offering an opportunity for a stronger team to really build an impressive product.
- The mentor should be a good coach: as the mentor is coaching the student team and taking responsibility for the personal development of the team members he should enjoy working with learners. Also and specifically in an international context he should be very flexible in arranging online meeting times even outside the 9 to 5 range. He should also be adept to new technology as virtual and online meetings will be the primary way to interact with the students.
- IP issues could be a big issue if not dealt with up front. One way to approach the issue is to define projects which give the company some insight on how a new technology could fit into their roadmap rather than providing an important product to the company. In the former cases intellectual property is not as important as it would be in the latter.
- Language can also become an issue. It would be next to impossible to have teams working with mentors where there is no common language. However, in many instances, where the project language is common, e.g. English, that problem can be avoided. At least one of the students as well as the mentor and sponsor should be fluent in a common language. Also the language of the software product produced should not be restricted to some different language.

Summary and Conclusions

We are very excited about the possibilities for student learning when international projects are offered. Both students and faculty believe the learning potential is significant and that being exposed to international development is important in the world today.

In addition to students and faculty, we have also seen high interest from within the university as well as from industry. University administration is very supportive of the program as it fits into their desire to expand students' international experiences. Even though it is desirable for students to physically participate in international learning, it is not always possible. Thus this program offers an experience without the need to travel (*internationalization at home*).

Interest in the program has also been very good from sponsoring companies. They have expressed strong

support for the concept and were happy to sponsor teams in other countries. Polaris Industries even came up with a project that had an internationalization aspect.

At the time of writing, we have established the general architecture of the exchange and student teams and industry sponsors have started to work on the international projects. At the conference, we will be able to talk much more about the actual experiences of the students, instructors and sponsors as the first set of projects is almost completed by then.

Conclusions

Getting international capstone projects going has taken a fair amount of time and work. It has been about two years since the first discussions took place at the Capstone Design Conference in 2010. However, we feel that a good model has been established, where a university and local company team together and are paired with a corresponding university/industry team in a different country.

As the international capstone exchange has just started only the program setup aspects can be explained with confidence. Feedback is collected during the semester from students, instructors and industry on all aspects of the program. There are mechanisms, such as project audits and surveys, put in place to track issues and lessons learned. Once all data has been collected, a more complete analysis will be published. Nevertheless some initial qualitative findings are:

- Availability of free or cheap video conferencing tools like Skype or Google+ makes regularly scheduled team meetings with the industry partner possible. A very important feature (maybe specific to CS projects) has been the possibility to share the desktop in video sessions. This feature significantly improved understanding and simplified discussions.
- A lack of equipment (e.g. laptop) by students should be accounted for by providing university owned equipment. This is particularly important as the video conferences often take place at uncomfortable times so that the student team will participate from home.
- The time difference leaves only rather small slots for online conferences. This may somewhat limit the interactivity when compared to national projects and thus increases the need for offline communication. This has to be considered when defining the development process and required documents. It may also be supported by electronic tools such as commonly used Wikis or forums. In addition times for daylight savings time vary.
- Even though language has not been a problem for daily work, some legal documents such as an NDA have been difficult to understand and students need more support for this than in traditional courses.
- Companies should, even more than in local projects, spend time up front to exactly define and write down requirements for the team. In addition they might provide the team with directions regarding technology, design patterns, and code libraries to be leveraged. This is a help for the team and also assures that the product may be used further by the company.

Potential Improvements

There are several areas where improvements in our program could be made after we gain more experience. Examples include determining a good way to evaluate the impact of the program on student learning and establishing an official Intellectual Property policy. Care needs to be taken when making IP agreements between students, universities and companies. That is particularly true for international cooperation where different national legislation may be in effect.

Work could also be done to plan for options when capstone program models are very different between universities (e.g. charge vs. free, one semester vs. two semesters). In addition, an evaluation should be done to determine the need/importance/benefits of face-to-face meetings between instructor/sponsor and student/sponsor vs. just using online tools.

Long Term Goals

In the long term, we would like to see this model expanded to other universities and departments. This could possibly involve the establishment of a pool of industry/university partners that are interested in international capstone exchanges. Industry/university partners could then be paired with other industry/university partners that meet some level of compatibility (one or two semesters, CS/EE/ME/etc., free/fee, etc.). This would allow interested universities a fairly easy mechanism for setting up international capstone exchanges. It is to be determined who would administer such a pooling/matching system.

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