International Capstone Exchange – the SUT and NDSU Experience

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We describe out experiences in running an "International Capstone Exchange" project between North Dakota State University (NDSU) in Fargo, ND in the USA and Swinburne University of Technology (SUT) in Melbourne, Australia. An NDSU-based student team worked on an industry capstone project with a Melbourne-based organization (National ICT Australia) and a Melbourne-based student team worked on an industry capstone project with a Fargo-based organization (Upper Great Plains Transportation Institute). We describe the rationale behind the international capstone exchange, how we organized the projects and teams, how the projects and teams fared, lessons learned, and plans for expanding in the future.

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Introduction

Many educators have found that college graduates in computer science, software engineering, and related fields do not always possess the necessary skills or abilities to find employment in the software industry[1, 2]. Over the past several years, it has become clear that including a capstone team experience in degree programs has great value for students[3,4,5,6]. While capstone experiences vary by discipline, in Computer Science, student teams build substantial software systems from requirements provided by an industrial company/sponsor. In doing so, they gain exposure to software tools and methods commonly used by industry which are often not incorporated into their other courses.

Industry capstone projects reflect all aspects of the skills expected of students after graduation, demonstrated by doing a "real-world" project for an industrial sponsor. This improves employability as well as teamwork, communication skills, and other traditional capstone outcomes. In today's world this also increasingly means having an international component. A large number of our students go on to jobs working for companies that are either multi-national or that work as part of multi-national teams.

Ideally, every student could spend a semester abroad and gain experience working for a company. However, that is not always possible. An International Capstone Exchange (ICE) provides an excellent alternative method to gain international experience. ICE offers the opportunity for international capstone projects where the students work from their local university for companies in other countries. Working across international boundaries provides many learning opportunities, such as understanding the global context of situations and cultural differences in the workplace, dealing with language barriers, time zone issues, and different technology preferences.

Since 2012, the Computer Science Department at North Dakota State University (NDSU) has been working with universities in Germany and Sweden to coordinate capstone exchange projects[6]. In 2014, through an Endeavour Executive Fellowship, a relationship was established with Swinburne University of Technology (SUT) in Australia. Teams of students in each of these countries worked for companies in the US, while in the US students teams worked for companies in Germany, Sweden and Australia. This has been facilitated up until now in an ad hoc manner by faculty in each country finding companies in their country willing to sponsor capstone projects to be done by international student teams in a different country. The student teams worked remotely from within their local universities to build a complete software system from a set of requirements provided by the company.

A great side benefit of these exchanges is the potential for establishing relationships between universities and industry on an international level. This has already started to bear fruit in the SUT/NDSU relationship.

Approach

Projects, Supervisors and Teams

We needed projects offered by industry partners that were willing to work with remote teams, in different time

zones, running capstone project processes and timelines different to those previously used, and understood the limitations of student capstone projects. We were fortunate to have two R&D partners, National ICT Australia (NICTA - Melbourne) and Upper Great Plains Transportation Institute (UGPTI - Fargo), who we have worked with on local capstone projects in the past, and who had non-critical-path commercial R&D projects suitable for international student capstone projects. Other companies approached initially were unsure if they could provide a suitable project or industry mentor, though were interested.

Each organization had a project sponsor who set the overall direction and desired outcomes for the project and was involved periodically. Each organization had an industry project mentor who provided week to week team and supervisor collaboration, technical input, and feedback on both technical progress and team performance. Each university provided a very experienced capstone project academic supervisor (the authors Knudson for NDSU and Grundy for SUT). Supervisors were chosen who were willing to experiment with the international capstone concept, had many years of capstone project supervisory experience, and could learn from the process to adapt it for future years.

The SUT student team was assigned their project, rather than use student-based selection. This was to match up team expertise with project skills needs, and to ensure the projects were filled. Relatively high performing student team members were selected (teams did not self-select) to increase the likelihood of a good project outcome. All student team members had prior industry experience from internships, placements, or personal industry work, increasing their "industry work readiness" and understanding of industry culture and demands. The NDSU students were able to bid on projects since all projects offered were guaranteed to be staffed. However, the students were not allowed to bid as a team.

2015 International Capstone Projects

The NDSU team worked with NICTA on the NICTA National Map project (http://nationalmap.nicta.com.au/), adding a range of functionality to the National Map (overlays, extra visualization capability, extra interaction capability) and applying the extended National Map to a range of urban planning data visualization problems. The project aimed to trial several R&D ideas for enhancing National Map and use cases for these enhancements. The SUT team worked with UGPTI on the PAVVET project (http://www.ugpti.org/research/projects.php?view=226 &program=smartse), developing data processing capabilities to consume results from a prior student project, an iPhone app to capture road quality data. The aim of this project was to provide UGPTI data processing and analysis capability from these iPhone data sets.

Co-ordination and Interaction

Compared to face-to-face capstone projects with a local industry client, several major differences are obvious, and some less obvious, when running a remote international capstone industry project. Both teams needed high quality online repositories shared with their industry client mentor and academic supervisor. Teams used Dropbox, Trello, Trac/SVN, GitHub and GitHub Wikis. Weekly reports, agenda, meeting minutes, and self-assessments (risk and progress) were used to track project progress. Skype was used extensively for remote meetings. Skype text comments were captured in the repositories. Each University uses different capstone "processes" to co-ordinate team work with differing frequency, format, and expectations.

The time zone difference of 8 hours was significantly challenging. Some team members had high non-university work, industry work and other personal commitments that had to be balanced with capstone meeting arrangements. It was impossible for students (or academic supervisors) to visit their industry client, limiting some aspects of a conventional capstone e.g. learning from site visits. Cultural differences and expectations occasionally arose around performance and communication expectations. A possible physical team visit between countries after project completion was proposed and is still under discussion to facilitate industry and team relationship building and University relationship building.

Results – SUT and NDSU

Project Outcomes

The NDSU team made several enhancements to the NICTA National Map prototype implementation including a range of user interface and backend processing updates. They successfully visualized a range of AURIN urban planning datasets, themselves from a previous R&D project between SUT and NICTA. The team found the learning curve higher than expected around data wrangling, GIS data, and data transformation. The project was a success with NICTA finding the use case implementation very valuable.

The SUT team developed a server for PAVVET to take iPhone app sourced raw GPS and actuator data, apply a complex set of calculations, and produce a Road Impact Factor indicating the state of roads driven on. They additionally produced a set of user interfaces to manage the server software, extended the iPhone app and fixed several bugs in it, and produced a basic Google Map based visualization. The project was a success with the project mentor expressing high satisfaction with the team's work.

Student Experience

Feedback from both student teams indicated they obtained many valuable and positive experiences from their International Capstone Exchange program. Both teams agreed the experience was challenging but they learned a lot about working with industry, working with remote collaborators, time management, agreeing on project milestones, sharing information with collaborators, co-ordination, project planning and cultural work practices and industrial approaches. Many team members had prior industry project experience and all agreed the International Capstone Exchange provided a richer set of learnings, in addition to the traditional industry capstone experience. Major areas of challenge were seen to be co-ordination, agreeing on processes and artefacts, and understanding requirements without the ability to visit a site or work face to face. Major advantages of an international capstone project were seen to be the experience of working with others from a different culture and country, overcoming the said challenges above, and real experience with "global software development", an emerging field of practice in software engineering.

Synergies

Some interesting and unexpected synergies resulted from the projects. The Australian Map project work by the NDSU team was used in a related project with Australian Urban Research Network (AURIN) data, to aggregate and visualize a range of AURIN datasets, as part of a larger NICTA/SUT collaboration. The PAVVET application was brought to the attention of an SUT Intelligent Transport System researcher who discussed it with the Australian roading authorities, the equivalent of the US Department of Transportation, who became interested in experimenting with using the approach in Australia. A collaborative applied research project is under discussion from this outcome. A further potential application of the PAVVET approach is monitoring rail quality. SUT is a major participant in the Australian Rail Manufacturing Collaborative Research Centre, and a further applied collaboration is possible.

Lessons Learned

There have been a number of lessons learned after running international capstone exchanges for a number of years. We summarise some of the key ones below.

Students, faculty, industry and university administration have all been supportive of international capstone exchanges as these exchanges offer unique learning experiences for students, possible research contacts for faculty, potential employees with some international experience and in general some international exposure without travel requirements. The international capstone concept is likely to find strong institutional support.

Pairing of universities to manage finding industry sponsors works well, especially if the associated professors are excited about the program. However, serious commitment of time and focus is needed to have a successful outcome. When first doing an international capstone exchange it is best if the local company has some experience running local projects and working with local students (having experienced faculty involved is also very valuable). This helps to manage expectations of project outcomes and ensures the company sponsor and mentor are familiar with student capstone project timeframes and deliverables in general.

It is possible to have different models for assigning teams used by paired universities (e.g. one guarantees all projects offered will be assigned a team while another offers more projects than they have students to handle so some do not get assigned a student team). Because of the overhead of arranging international capstone projects, the second approach has the major disadvantage of potentially disappointing international university and company partners (also true for local ones however).

International capstone exchange projects have all the common issues local project have such as how to control requirements changes, but less flexibility to problem solve due to time and distance. To some degree they are thus inherently more risky. It helps more on international projects if companies spend extra time defining the projects up front (because of lack of time to resolve issues quickly). Using diagrams to describe designs is useful since they are less language dependent. Shared desktops also help for this as well as demos. Students often have better thought-out questions knowing they have limited times to communicate. Some travel is being planned for some but adds complexity (insurance, etc.).

No issues have arisen to date by having each team use its own set of software development processes. In fact, part of the team's brief is to negotiate agreeable processes, project infrastructure, and deliverables and milestones with clients. This does mean potential for very unfamiliar processes and tools for company and student team, even if the company has worked with local student teams before, requiring more learning and co-ordination time. Tools like Skype and Google+ work well, improve understanding and simplify discussions but are limited to small timeslots. They need to be supplemented by Wikis or forums that provide longer-life repositories for communication and co-ordination. Simple things like dealing with different start dates for daylight savings times and different importance of certain holidays need to be considered. Missing an agreed Skype meeting by an

hour or arranging a meeting in advertently on a local holiday are easy mistakes to make.

International capstone does complicate project agreements between universities and companies. As with process and tools, companies may be used to local university capstone project contracting and other requirements but these may greatly differ with international capstone university partners. IP issues and NDAs need to be considered and should be worked out ahead of time (of course projects without those issues are always an option). NDSU has done an extensive review of our IP policy for student capstone projects. We now have agreements that allow sponsors to own the IP developed by the students working on their projects. Specific forms are signed by students, sponsors and faculty with students giving up their IP rights and the university laying out their responsibilities and rights (e.g. NDSU does not warrant the design team's compliance with the intellectual property agreement form). Swinburne similarly has developed detailed student, supervisor, company and university agreements for all capstone projects that must spell out IP ownership.

So far we have only dealt with no-cost projects and thus have no lessons learned in dealing with money being charged/paid. Such projects may very likely be further complicated due to exchange rates, IP and other commercial issues.

The authors have not (yet) had to deal with export control issues on projects to date, but note that US and Australian export trade control regulations are different. One pairing of US/Australian universities working in the aerospace area did run into issues in this area and we had to drop the exchange they were planning on.

Future Work

Several extensions to this work are possible including setting up an International Capstone Exchange. This exchange would allow any university to apply for being paired with another university in a different country. Each university would then locate a company in their country that would sponsor a project to be done by students in the paired country. Each capstone team would work independently and according to the schedule of their local university. No travel would be required.

Achieving a cross-country and cross-university capstone project legal agreement is still work that needs to be continued. To date we have chosen the student host university agreement to use, but as noted above these can have issues.

There are also opportunities to extend this model to include optional travel components. For example, it may be desirable to go to the sponsoring company/country to learn about local conditions before starting the project.

Alternately, it may be desirable to be able to go the sponsoring company/country to deliver the final product, install it and do some testing and training.

Conclusions

An International Capstone Exchange can provide an easy to use means for universities to be paired with likeminded institutions for the purpose of establishing international capstone projects. Each university is able to run its projects independent of the other university, without required travel by anyone and on their own schedule.

When participating in an international capstone project, students are able to learn how to work in a manner much like they would if they worked on a project for a multi-national company. These skills are valued both by the students as well as industry.

Faculty involved in these projects can gain insights into research being conducted in their partner university and country. If the proper synergies exist, this can lead to joint research opportunities. This could have the potential for establishing strong long term relationships.

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