Making Computing Science Students more Employable with Problem-Based Learning and Cross-Site Teamwork

Authors:

Marie Devlin, Chris Phillips, Lindsay Marshall, Newcastle University, UK, marie.devlin@ncl.ac.uk, chris.phillips@ncl.ac.uk, lindsay.marshall@ncl.ac.uk

Abstract— *Computing Science graduates need a global perspective of the software engineering industry to make them more employable. As well as gaining the technical and academic skill levels expected from their discipline, students must now learn to operate in 'virtual teams'. This paper describes how we changed the curriculum of our Software Engineering Module at Newcastle University to incorporate problem-based learning and distributed team working in collaboration with Durham University as part of the ALiC project, (Active Learning in Computing), a Centre for Excellence in Teaching and Learning project funded by the Higher Education Funding Council for England. The module involves working with our industrial contacts to ensure realism and has received positive feedback. The paper describes the assignments, assessments and collaboration technologies we used during the module and details tutor and student experiences and the lessons learned.*

Index Terms—*Collaboration Technologies, Employability, Problem-based Learning, Virtual Teams*

INTRODUCTION

Active Learning in Computing (ALiC) is a Centre for Excellence in Teaching and Learning, (CETL), project funded by the Higher Education Funding Council for England. It is a collaborative effort between four partner institutions: Newcastle University, Durham University as CETL lead, Leeds Metropolitan University and The University of Leeds. Together these institutions provide a broad representation of the student population and the variety of curricula available in Computing Science higher education in the UK today [1]. During the project, the ALiC team is exploring innovations in group and individual project work in Computing Science in order to better prepare our students for the realities of working in their chosen profession.

Cross-site working is particularly characteristic of the way Software Engineers work in industry and software is often produced collaboratively between teams located at different geographical sites. One crucial element of AliC's approach to enhancing students' employability and ensuring they gain the transferable skills required by employers is the introduction of cross-site and virtual teamworking to the Software Engineering Team Project in our level 2 Computing Science programmes. The trend towards cross-site work in industry is emulated via a shared software development project between Newcastle University and Durham University in which teams from each site form 'companies' and develop their software product together. The teams use collaboration technologies such as video conferencing to communicate. The work reported here focuses on Durham and Newcastle's collaborative effort to implement the cross-site project and on some specific aspects of our work at Newcastle. In the paper we describe the Cross-Site Team Project between Durham and Newcastle, including our motivations for curriculum change. We give a description of the project assignment that was used during the academic year 2006-2007 and outline our assessment procedures. We describe how we involve employers in the project and give a description of the collaboration technologies used by the students to work across sites. The paper then gives detailed feedback from Newcastle students and staff on their experiences during the project in 2006-2007 and the lessons learned.

MOTIVATIONS FOR CURRICULUM CHANGE

All employers want employees who can communicate well and work in teams, take direction yet are self-motivated, problem solve and find things out, make intelligent judgements, test ideas and turn them into plans, meet deadlines, pay attention to detail etc. and therefore having some or all of these skills makes a person employable [2]. However, as offshore computing

becomes more prevalent and corporate activity becomes more complex, dynamic and global, employers also need workers who are adaptable and flexible so they can cope within these fast-moving, demanding environments [3,4]. The use of virtual teams can help an organisation respond quickly to changes in their customer needs and many are turning to their use in order to make the most of their human knowledge and resources. A virtual team is "a group of geographically and/or organizationally dispersed co-workers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task" [4]. Virtual teams allow organizations to remain competitive by providing access to the most qualified individuals for a particular job regardless of their location and will play a major role in the organizations of the future [4,5]. When designing group work in the Computing Science/IT curriculum universities should therefore consider using virtual teams if they are to successfully assist their graduates in developing the technical and transferable skills that employers in the sector are seeking. As part of the Software Engineering, (SE), module on our Computing Science and Information Systems programs at Newcastle, the Software Engineering Team Project is compulsory for all level 2 students. The project runs for one full academic year and involves students working in teams together to create a software product. Assessment of the project deliverables takes place on a continual basis throughout the whole academic year and there is no end of year exam. Normally, prior to 2005, students taking the module would work within teams of their peers at Newcastle only. We wanted to make the project more realistic and promote greater alignment of our students' group-work activities to those required for their future work-based practice so, in 2005, we piloted our initial cross-site version of the project [6] where students worked with students from Durham University in cross-site teams and this version of the module has now been running for two academic years.

THE CROSS-SITE TEAM PROJECT

In 2006-2007 we formed twelve 'companies', each comprising a team from the level 2 cohort at Newcastle University and Durham University. On average 4 students from Durham and approximately 5-6 students from Newcastle in each company. Newcastle had 68 students registered for the module and Durham had 48 so we ended up with 12 companies which meant 12 local teams at each site. In order to ensure that each company would have a good chance of solving the problem both Newcastle and Durham assigned team members based on their programming scores from their first academic year, ensuring that each local team had an evenly distributed mix of programming ability.

Both sites advised the students on research resources for the technologies they could use to solve the problem in the initial stages of the project but did not suggest how the problem could be solved. We provided guidelines on virtual meetings and the collaboration technologies they could use to work together with their company colleagues and these included video conferencing, online forums and code repositories hosted by Newcastle Elearning Support System, (NESS), as well as access to Skype [7] and Instant Messaging. A schedule for the major deliverables of the project and some sample documentation was also provided at each site. Durham ran an icebreaker session for their onsite teams at the start of term and students at Newcastle were given an overview of the project in a lecture setting. We also held a joint team games event in Durham at the start of the project so companies could get to know one another before they really started working together. The students from both sites had little or no experience of virtual teamworking.

Newcastle took a more problem-based learning approach in the SE module design than our colleagues at Durham. Our students had to rely on their existing programming knowledge and direct their own learning in order to solve the problem. We 'front-loaded' the lecture component of the module and gave our students 10 one-hour introductory lectures in the first 5 weeks of term and some guest lectures by employers, (see section Working with Employers), whereas Durham spaced their lectures throughout the academic year and took a more traditional lecture/ lab-based practical approach to the delivery of the course material. Our initial lectures provided an overview of the software engineering process, software process models and tools and techniques that can be used to manage a software development project. The module leaders provided some guidance on choosing a suitable team structure and conducting local and virtual meetings. Unlike the module structure at Durham, we did not run formal weekly practical sessions for the module, nor did we provide demonstrator support. However, we arranged the Newcastle timetable so that students were available to work on the project at the same times as Durham had their practical sessions.

Each team at Durham was managed by a level 3 student as part of their Project Management module and their contribution was assessed whereas at Newcastle we used staff monitors. Monitors were members of staff whose role was to observe formal team meetings. The monitors were not responsible for managing or directing the project in any way and were not allowed to take any team role. They were allowed to answer questions or give some general guidance to the students but the level of detail was, by necessity, limited because we wanted our students to be autonomous and learn from their own experience.

Working with Employers

For a number of years now at Newcastle many local and national employers have helped us to conduct a series of mock job interviews with our level 2 students as part of the SE module. The students submit a covering letter and CV for a fictional position within one of these companies and the staff from those companies conduct interviews with the students and give them feedback on their performance. This is to help the students to build their confidence and improve their interview skills before they leave university. Through our contact with these employers and their interest in our work on virtual teamworking in the module, we managed to persuade IBM [8] and another multinational company to give a guest talk to the SE class about their own corporate experiences of virtual teamworking in large-scale industrial projects. We were also very pleased that another large multinational company, Procter and Gamble [9] agreed to conduct a Project Management workshop for the students at the beginning of the academic year. The aim of the workshop was to help students to assess the project risks of multi-site working and to develop good project plans. It was very well received by the students and gave them an idea of the challenges that lay ahead.

Project Assignment 2006-2007

AliC staff at each site take it in turns to provide the assignment for the project each year. For the academic year 2006-2007 our colleagues at Durham provided the assignment for the project. Each company was asked to develop an application that would allow a user to monitor their running performance over distance and time. The companies were provided with two PDAs and two GPS receivers, one for each site-based team. The system had to be capable of collecting training data via the GPS unit in order to allow the user to tailor their own training programme. In addition, the application had to be capable of displaying this information on both a PC and PDA in map/graph format. Neither site told the students how to solve the problem nor mandated the development technologies that they could use to solve it. However, Durham did provide a sample application for parsing the GPS receiver data and transferring it between the PDA and PC for use at both sites as we felt most of the students might struggle with this aspect of the development. The collaborative element of the work meant that each company had to produce one application between them but there were a couple of stipulations for which modules were to be developed at each site. Durham had to produce the database functionality for the application and Newcastle had to produce the map functionality. This is because the Software Engineering module is synoptically assessed in conjunction with the Database module at Durham so most of the work on the database element of the application had to be developed by Durham students. All other task allocations for programming the rest of the modules of the application were negotiable and companies could assign responsibility for their development between themselves as they deemed fit.

FIGURE 1

A COMPANY FORUM IN NESS

Collaboration Technologies

Good communication is absolutely critical to the successful functioning of virtual teams, especially if the task is complex and video conferencing helps facilitate decision making by allowing team members to communicate in an interactive fashion [3]. As the cross-site project was fairly complex and of a significant duration to warrant lots of interaction between sites, we provided video conferencing equipment for the companies. At Newcastle, we have a sophisticated video conferencing suite with capture cameras, four large display screens echo-cancelling microphones, a projector and whiteboard and a document reader that can all be operated from a desktop console. Durham opted for a simpler set-up using a web-cam and microphone connected to a desktop machine. Both sites used Access Grid software [10]. Access Grid provides multimedia capability that allows the interconnection of a high number of geographically distributed groups and is often used by academic institutions in the UK. As well as video conferencing, the software allows students to display and share their work from other applications such as PowerPoint or a Java IDE with the other video conference participants. The companies were encouraged to use the video conferencing facilities and email as their main modes of communication. The preferred development environment was the Eclipse IDE which facilitated version control of the students' software via Subversion [11]. For the purposes of this project discussion forums and document repositories were implemented and hosted on NESS (Newcastle Elearning Support System, Figure 1). NESS is a web-based eLearning system developed by Computing Science at Newcastle that has been in use for a number of years. It allows students to submit coursework, view results, receive feedback from their tutor etc. We also created an FAQ section on NESS for the project.

As Durham and Newcastle are fairly close geographically we did not rule out the idea that companies could meet face to face but we deliberately did not encourage or facilitate this because we wanted to provide them with a realistic experience of virtual teamworking. Other communication methods and applications such as SMS, Skype and Instant Messaging were also permitted.

ASSESSMENT

There are some differences in how the SE module is normally delivered at Newcastle and Durham and when designing the cross-site work we recognised that it was very important that we ensure that students' learning experiences and assessment outcomes not be compromised during our work. One area where there is a great difference is assessment. At Newcastle there is no exam for the module and it is worth 20 credits, (10 ECTS), whereas at Durham there is an end of year exam and the module is worth 40 credits. Needless to say, these differences between the two sites meant that we had to carefully discuss the deliverables, scheduling and marking criteria for the collaborative work. We needed to ensure that individual and team effort at each site was acknowledged and rewarded and that a local teams' assessment would not be compromised by a poor performance from their colleagues at the other site.

We decided there needed to be three categories of assessment: individual (I), local team (T) and company (C) and each of the deliverables for the project were assigned to one of these categories. Category C deliverables each had to be accompanied by a contribution matrix, (created by Durham), which is a table that details members responsible for each section of the company submissions. All category C deliverables were jointly marked by Durham and Newcastle. Both sites also involved students in self and peer assessment within their local teams. At Durham, team members ranked themselves and other team members in terms of their contribution whereas at Newcastle, at two points during the year, members were asked to distribute 100 marks between themselves based on their individual contributions to the team effort. This mark was then used as a weighting for their final individual mark for the module. A high-level description of the project deliverables and mark breakdown for the module at Newcastle is given in Table 1.

The individual component of the module is worth 40% of the total module marks and the team and company components are worth 30% each. Staff worked together to agree marking schemes and criteria for all company deliverables. We marked separately first and then discussed our marks and then together taking in the contribution matrices and eventually reached agreement. We also agreed on general feedback comments to companies as well as release dates and times for company marks.

TABLE 1

% Mark	Deliverable	Description	Category
5	Individual report	Student's learning experience during project.	I
	Individual Log Book	An account of hours spent on activities.	I
	Observations in Meetings	Monitor observations of the individual's performance in formal meetings.	I
25	Company Contract	An agreement of procedures and standards between company members.	C
	Website	Website for product.	T
	Interim Team Report	A Progress report on project status at mid-point.	T
	Company Log Book	Details minutes of video conferences and other company meetings.	C
	Final Team Report	A reflective report compiled by the local team that reviews their performance and what they learned.	T
25	Strengths Essay and Ticklist, Team Structure and Project Management Report	Individual assignments that determine the student's views of their skills, ideal team structure and important project management skills at the beginning of the project.	I
35	Project Plan, Team Structure document, Domain Analysis , Design , Integration & Test plans Product	Documentation associated with most Software Engineering projects and Running Application/ Software for PDA and Desktop.	C
	Product Demo, Team Presentation	Demonstration of working product to module leaders. Final presentation at end of project.	T

ASSESSMENT FOR THE CROSS-SITE TEAM PROJECT

STUDENT EXPERIENCES

Focus Group Feedback

We conducted two focus groups to get feedback on the Newcastle students' experiences during the project. We chose two teams for this purpose and asked them to comment on a number of aspects of the project:

- **Technology:** Both teams had used the video conferencing equipment. Sometimes the visual equipment at Durham was unreliable and they often had to resort to audio conferences only. Newcastle's microphones sometimes were inaudible and they sometimes had to adjust the settings when the room had been used by other teams. Both teams had at least one video conference meeting per week on average with their Durham colleagues. Both tried phone calls, text and instant messaging occasionally to communicate across sites but mainly relied on email and using the NESS repositories for working on documents and code. They found working with the PDA and GPS receiver interesting and challenging and had not created software for this type of equipment before.
- **Schedule:** Both teams found the deliverable schedule easy to follow. One team reported that they often only made their deadlines by minutes because their Durham team left work to the last minute or there were communication problems. They had difficulty coordinating and organising themselves across sites. Both teams found the common time slots for working on the project useful but found the company deliverables hard to coordinate because each site had different deadlines for their respective individual and team deliverables. This meant they sometimes had less time than their Durham colleagues to work on company deliverables. Some students found it difficult when Durham were able to work on their part of the project during the Newcastle exam period. All the students found it difficult to keep track of the other site's progress during the project.
- **Module Content and Support**: The students found the initial lectures useful but felt they needed a more technical focus. They had a lot of problems trying to get the sample program for the PDA working and the hardware to communicate and they felt they needed more training on the development technologies in the taught section of the project. They would have liked demonstrator support like their company members at Durham. They also thought that more case studies about real projects would have been useful. They thought the module handouts and slides were good and there were some good examples of documentation on the website. They found their team monitors very helpful, if a bit passive. Many local

teams worked together to solve problems and programmers tended to talk across groups. The teams only really asked for help from the module leader when the whole class had a common problem they could not resolve.

- **Project Process:** The students said that the best bits of the project were working in a team, meeting new people and working with the equipment. They said they liked being able to "put things into practice" and seeing their code running on the PDA was rewarding. Both teams found working with Durham the most difficult aspect of the project for various reasons including lack of communication, personality clashes between some company members, delays in sending work etc. One of the teams felt that perhaps they lacked a company spirit and felt that if they had met face to face more or made more of an effort to get to know their Durham colleagues, the collaboration might have run smoother. They said the module took up a lot of their time but it was a good experience. They commented that the module had also broadened their horizons and they got to know more people on their course by interacting with people from their friends' teams.
- **Skills Learned**: The students said that they had learned to communicate better and to plan and organise their work and that their technical skills had improved, especially in programming and design. They enjoyed learning to allocate tasks and make the best use of the skills within a team, although they found this difficult and sometimes had to reallocate work during the project. They said they learned a lot about working to deadlines and organising their work, sometimes by getting it wrong. They agreed that setting themselves internal soft deadlines during the project had been very useful.

Written Feedback

We hoped that the way we had designed the cross-site work would stretch the students and assist them in gaining the transferable skills that are important to employers as well as their technical skills. In order to find out if we had been successful we needed to know what transferable skills all the students in the class felt they had at the start of the project and what skills, (if any), they felt they had gained/ improved upon at the end of the project. At the start of the year students at Newcastle were told that we would be using data gathered from anonymised deliverables as part of the AliC project in order to review our teaching practices on the SE module. Students were given the option of objecting to this data collection and of having their assignments omitted. None of the students objected.

Before the companies began working together students were given a Self-Assessment Tick List, (Figure 2), based on Belbin Team Roles [12] as an individual deliverable. We wanted them to assess which skills and strengths they felt they already had and could bring to the project. The students were asked to indicate if they thought their skill was a Primary Strength or the Secondary Strength and place a tick as appropriate. They were told to leave the area blank if they considered they did not to have any sort of strength in that particular area. The results from these sheets were collected and anonymised.

Team Roles	Primary Strength	Secondary Strength
Innovator Produces ideas, imaginative, unorthodox, radical, clever, uninhibited. (Can be over-sensitive, prickly. May need careful handling.)		
Investigator Finds things out, always knows someone who …, brings information back to the team, enthusiastic, gregarious. (Can be lazy and complacent.)		
Chair Self-confident, commands respect, good speaker, thinks positively, good at guiding the team. (Can be domineering, bossy.)		
Shaper Energetic, drives everyone along, needs to succeed, make things happen. (Can be disruptive and argumentative, impatient and a problem if things don't go their own way.)		
Evaluator Careful, makes intelligent judgements, tests out ideas, evaluates proposals, helps the team avoid mistakes. (Can become isolated and aloof, pessimistic or over-critical.)		

Teamworker
Sympathetic, understanding, sensitive, shows a strong concern for social interaction, leads from behind. Places the team above personal concerns. (May be indecisive.)

Organiser
Methodical, hard-working, reliable, orthodox, turns ideas into plans which are feasible and gets down to tasks which need doing. (Can be inflexible and uninspiring.)

Finisher
Painstaking, conscientious, follows through and works hard to finish things properly. Meets deadlines and pays attention to detail. (Can be over-anxious and perfectionist.)

FIGURE 2
THE SELF-ASSESSMENT TICK LIST

At the start of the year we had 68 students taking the module but only 67 students returned the ticklist as one student was ill and unable to complete it. The results of the intial skills assessment shown in Table 2, indicate that very few of the students felt they had any leadership or motivational qualities, (Chair, Shaper), and for both primary and seconday skills combined these skills received the least ticks with 50% and 38% respectively of students indicating that they thought they did not have these skills at all. The majority of students, (84%) thought they possessed the ability to be a good Teamworker and also had good investigative skills. These results are similar to the findings in our initial pilot of the project in 2005 [13]. Only 20 students indicated that they thought they possessed the skills of an Innovator as a primary strength but 76% of students indicated that they possessed this skill to some degree. This is a lower number than the previous year where 90% of the cohort ticked this category as one of their strengths.

TABLE 2

Skill	Primary Strength	Secondary Strength	Total % of Class
Innovative	20	32	76
Investigative	30	26	82
Leadership/ Chair	8	26	50
Shaper	16	26	62
Evaluator	25	26	75
Teamworker	31	26	84
Organiser	27	25	76
Finisher	27	24	75
No. of students = 67			

RESULTS FROM INITIAL SKILLS ASSESSMENT

One of the main deliverables at the end of the project is the Individual Report which details each student's experiences during the project and their evaluation of their own performance. Newcastle students were asked to give details of what transferable skills, (if any), they felt they had gained from the project. We left this as an open question and did not present them with any categories. This time 65 reports were submitted. The data from these reports was then anonymised, collected and compared to the results from the initial Self-Assessment Tick Lists. As can be seen in Table 3 the majority of students indicated that they had learned the importance of task allocation and matching the individual skills of the team to the appropriate task.

TABLE 3

Skill	Total /65
Planning and Organising	53
Research/Investigation skills	52
Leadership skills/role	30

Problem-Solving	38
Skills/Task Allocation and Team Structure	61
Positive Cross-Site Experience	42
Roles Suitable to Skills	52
Improved Communication Skills	53
Teamworking	56

SKILLS GAINED/IMPROVED DURING THE PROJECT

Many of these students indicated in their reports that they had learned about the importance of task allocation because they had experienced problems in this area. Some students indicated they learned this because they felt the effort from some of their team members was unequal or they may have distributed the workload unequally among team members during the early stages of the project without knowing of their capabilities.

64% of students felt that their experience of working in a virtual team across sites had been a positive learning experience. However, the majority of students reported that poor communication between the sites had been a major problem and students who reported a negative experience gave a variety of reasons e.g. their Durham colleagues were disorganised or had different approaches to the work or views on the design etc. We expected poor communication and disagreements between the companies. We wanted the students to learn the increased importance of good communication and working relationships within virtual teams. Co-located team working often benefits from ad-hoc meetings and impromptu, informal discussions and collaborations as well as formal meetings and this is not often possible with colleagues located at a geographical distance. Cross-Site and virtual team working means that good communication and productive teamwork becomes more vital when communications must be mediated by effective use of time and technology. Working together in virtual teams was expected to present more of a challenge to students than local teamworking.

Students conducted research on the PDA and GPS technologies used in the initial stages of the project term and 80% of students felt that their research/invesitgative skills had been improved during the project. Those who indicated that their research skills had not improved commented that they felt they did not do enough research or their research was inadequate for the project requirements. Less than 50% of the students tried a leadership role. Those students that did take on a leadership role said they enjoyed the experience and had gained more confidence in their abilities. We were unable to determine conclusively if the students that took on the leadership roles were the same ones who had indicated leadership as a strength in the initial skills assessment. Only 58% of students felt that the project had helped them improve their problem-solving skills. The project was technically challenging and interfacing the technologies between sites during the testing and integration phases of the project seem to have proved the most difficult. Companies were given three weeks in the schedule for integration but thought this was not enough time. Some very positive outcomes are that 85% of students felt that the role/s they had been allocated in their team had been suited to their skills and 88% of students got to try more than one role throughout the project. Also, 81% of students indicated that the project had given them a greater awareness of the need to plan and organise their time and 86% felt that their teamworking skills had improved.

We also wanted to find out which collaboration technologies the companies had used to work together. This data was collected from the anonymised deliverable: Final Team Report.

TABLE 4

Collaboration Method / Technology	Main Method	Second	Tried by
Video Conferencing	7	3	12
NESS forums	0	0	6
Instant Messaging	1	3	6
Phone/Text	0	0	3
Email	4	6	12
Skype	0	0	4
Google Talk	0	0	7
Face to Face	0	0	6
NESS Repositories	12	12	12

COLLABORATION TECHNOLOGIES USED FOR CROSS-SITE WORKING DURING THE PROJECT.

As can be seen from the results in Table 4, all the companies tried video conferencing and used email to work together during the project. Seven companies opted to use video conferencing as the main technology to work together between sites and these companies held video conferences once or twice each week, on average.

A lot of teams commented that the video conferencing technology was the next best option to face to face, even if they sometimes had technical difficulties. All the companies used the NESS repositories to share documents and source code. We believe that the NESS forums were not popular for cross-site work because there was a delay in getting access for Durham students during the first few weeks of the project. Companies decided to use other forms of communication to work together during that time and when NESS forums became available, companies had already established their working patterns. Many students said they were reluctant to use their phones for the project because it cost them money and we did not expect them to use them at all. The teams commented that text messages and instant messaging were good for quick updates on progress or for organising meetings but not for detailed discussions. Students found it difficult to keep track of conversations using instant messaging if more than two people were involved.

Staff Evaluation and Lessons Learned

Groupwork helps students to work on their communication skills, interpersonal skills and confidence and also teaches them to find out more about their behaviour and attitudes [14]. We feel that, overall, the project design and our SE curriculum changes helped the students to work on the skills that employers are seeking. It was very important to us that we enabled students to explore group working issues in a 'safe' environment. By safe, we mean that their academic and personal development was not put at risk because of the virtual teamworking aspect of the project. We feel that we have achieved this but there is a lot of room for improvement.

Employability Skills

The majority of students reported an improvement in their skills during the project but we would like to ensure that all students get to work on the skills they feel they need to improve as well as aspects of the work they feel they are most suitable for. We agree with the idea that the better that people know themselves the more they can put their skills to good use [13] and the Self-Assessment Tick List seems to have helped students make judgements based on awareness of their personal strengths and weaknesses. However, task allocation proved difficult both locally and in the cross-site work. Many companies had difficulty in dividing the work between sites because they were unsure of the skills their colleagues possessed at Durham and vice versa. Task allocation very much depends on the skills and abilities available within the company and only Newcastle students undertook the Self-Assessment Tick List. We are thinking of making this a company exercise next time we run the project. Initial team selection methods and role allocations within teams are areas we need to consider more thoroughly in both the taught component of the module and in the cross-site work and these will be reviewed periodically throughout the project in the future.

Assessment

The project assignment was quite complex and students found it challenging and perhaps too difficult in parts and because of this Newcastle programmers tended to work across teams. Whilst we aimed to encourage students to work together, this is not something we want to encourage in the future as students should work with people they do not know well. We want the separate teams to work together as a unit and to make the most of the skills they have between them. We believe we need to choose a less-complex assignment next time round and/or provide more technical support from staff in order to promote greater team cohesiveness.

We tried to mitigate the risk of unequal contribution within teams by the inclusion of peer assessment i.e. the allocation of percentages to team members based on their contribution, and also, by the use of the contribution matrix for each team and company deliverable. We feel these measures helped to ensure fair allocation of marks based on individual effort but realise we will still need to reassure students about how we assess individual contributions and to make assessment procedures for the project more transparent to them.

Virtual Team Working & Module Content

Ten of the teams indicated in their reports that working with Durham had been one of the most difficult and challenging aspects of the project. The companies only had one official face to face meeting at the start and all of the teams stated that they would have preferred more face to face communication for the cross-site work, if given the option. The proximity of Durham to Newcastle (20 miles) means that face to face meetings are feasible, indeed, six of the Newcastle teams travelled to Durham on more than one occasion to hold company meetings. However, we do not want to encourage the students to do this too often as it dilutes the need for virtual teamworking and cross-site communication, which is part of the skill-set we want them to learn. We recognise that the students may have needed more than one face to face session in order to build up trust between the company members and therefore we intend to include a few more face to face meetings between the student groups in the official schedule especially in the initial stages of the project. This should help the students to get to know their colleagues better and make better judgements about the skills available to them as a company. We have also decided to include a workshop on team roles and task allocation in the taught module content.

At the start of the project, we asked each company to draw up a contract regarding the procedures and standards of behaviour expected from company members. During the project many teams commented that some members did not do the work on time or were absent from formal meetings. We reminded them of these contracts and told them to enforce their grievance procedures for non-compliance. Often the grievance procedures consisted of meeting with the team monitor or module leader to discuss progress. However, we feel that students need more examples of how to deal with conflict within a local team and across sites.

Three local teams experienced a team member leaving part-way through the project and at least two experienced one or more of their Durham members leaving. These teams reported that they coped quite well with someone leaving after initial responses of panic, anger and frustration because they had made contingency plans and set themselves 'soft' deadlines for the work. A team or company member leaving a project part-way through is a very real possibility for most projects and educational projects are no different. We tried to mitigate against this situation by getting students to assess the project risks and make contingency plans in the Project Management workshop run by Procter and Gamble earlier on in the year. This seems to have worked to a degree but students need to made aware of this can happen on more than one occasion and contingency planning and risk assessment are topics we need to highlight more strongly in the lecture material, as well, as the workshop next time.

We are pleased with the students' experiences using the communication technologies provided during the project. However, the poor quality of the video conferencing equipment at Durham caused quite a few communication difficulties between companies and this is something we will improve on for the next time we run the project.

Not being able to check the progress of the cross-site team was also an issue that many of the students highlighted. The companies completed a project plan deliverable at the start of the project but many seem to have ignored this plan after it had been submitted. Next time we are going to provide cross-site access to a shared space online where companies can track their progress. We hope to make further additions to NESS in order to facilitate this.

The focus group feedback and project reports from Newcastle students have provided a very useful insight into our SE curriculum changes and project design and because of this feedback we have decided to run lectures and workshop sessions all throughout the year at Newcastle instead of front-loading the material and make further modifications to the topics we cover. Also, in terms of our teaching approach to the module, we will still try to take a problem-based learning approach as much as possible, but feel that the added complexity of virtual team working across sites warrants greater contact and support from module leaders and monitors.

CONCLUSION AND FUTURE WORK

The project reported here aimed to make undergraduate team working more realistic and relevant to employers and we feel we have provided our students with a very authentic experience. We hope that our project design allows students to explore their skills and potential in a 'risk-free' environment where they can learn from both their triumphs and their mistakes. We recognise the need to guage the correct level of staff guidance we provide during the project in order to maintain a balance between supporting students and helping them become successful independent learners. Including the use of cross-site and virtual teamworking into the project has proved a big challenge but student feedback shows that the majority of students felt the project helped them build on their existing skills or learn new skills that would help them in their future employment. We still need to work on some of our approaches in this work and module content, assignment design and assessment are areas we will continue to focus on and improve. The project will continue in the next academic year and follow a similar structure

to that reported here, (with the refinements noted earlier), however, we are really pleased that Procter and Gamble have offered to act as a 'real' customer for the software product produced by the student companies next year and this should add more realism to the project.

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