IMPROVING ASSESSMENT IN SOFTWARE ENGINEERING STUDENT TEAM PROJECTS

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ABSTRACT

In this paper we outline methods of peer and self- assessment and formative feedback that have been used in a unique software engineering cross-site team project in undergraduate Computing Science departments at both Newcastle and Durham University as part of the CETL initiative – Active Learning in Computing [1] . We outline the team project involved, illustrate how our approach aligns with the learning outcomes of our modules and meets the overall pedagogical aims of ALiC and describe the assessment methods used. Based on our experiences we then provide guidance for the wider use of these assessment methods for team work in the HE community.

Keywords

Assessment, Feedback, Team working, Software Engineering

1. INTRODUCTION

Active Learning in Computing (ALiC) is a five year collaborative CETL project funded by HEFCE involving 4 consortium partners – Durham University (CETL lead), Newcastle University, Leeds Metropolitan University and the University of Leeds. As part of the project, we run a year-long cross-site team project between Newcastle and Durham students taking our respective Level 2 Software Engineering (SE) modules. The students are formed into companies with each company's 'employees' being made up of Durham and Newcastle students. Each company must collaborate and communicate in order to develop and deliver a large piece of software plus the accompanying documentation at the end of the academic year. The activity which has been running for three academic years to date [10, 11] was designed with the aim of mimicking cross-site development practice that has become commonplace in the software industry. It aims to give students an insight into the real challenges faced by companies competing in a global market and to encourage the development of transferable skills that are a vital accompaniment to their technical repertoire. This paper describes the assessment methods that we have used during the cross-site project to determine team and individual effort fairly, and our approaches that involve students in their own assessment. We illustrate how our assessments align with the learning outcomes of our SE modules and the overall pedagogical aims of CETL ALiC. An overview of each of the formative peer and self-assessment methods used during the project are described with our experiences of using them. Finally we provide some guidance for the wider use of these methods in team work assessment.

2. ALIGNING PEDAGOGICAL AIMS AND ASSESSMENT

The fundamental vision of ALiC is to identify and enable ways in which students can become more active in their learning [2]. Through promoting activities such as team working we aim to develop innovative approaches to learning that enable students to move towards independent learning guided by appropriate support materials. Furthermore, any assessments used will be sensitive to this new style of learning, which are larger in scale and scope and encompass all aspects of the curriculum. This new type of learning will provide a solution to the over-assessment problem experienced within the Computer Science discipline.

The cross-site SE team project between Durham and Newcastle is designed to fulfil the standard learning outcomes of both our SE modules i.e. to introduce issues regarding programming in the large including software development models, project planning and management and to provide practical experience in the skills of the discipline such as requirements analysis, team structure, document preparation and the design and implementation of a large software system; the ability to work as a member of a team and to fulfil appropriate roles within the team etc. Other learning outcomes include improved written communication, practice in problem solving, interpersonal communication, assessment of use of initiative, adaptability and team working skills [3, 4]. Table 1 illustrates the mapping between these learning outcomes and the project deliverables. It also denotes which deliverables are individual submissions (I), local team only deliverables (T) and company deliverables (C).

The necessity for cross-site collaboration in order to complete the project places a strong emphasis on students managing their own teams, communicating with their colleagues at the other university site, allocating roles, distributing tasks and responsibilities, and planning the project together, all which emulate what currently happens in the software industry. This also maps directly to the fundamental vision of AliC by introducing a strong element of independent learning by providing a realistic and challenging project that allows the students to practice and develop the employability skills that employers require.

LEARNING OUTCOMES	**DELIVERABLES**
Communication – with customer Problem solving, requirements analysis	Statement of work document (C)– requirements analysis
Use of initiative, planning, use of software development models, problem solving	Project plan (C), log books (T, I), team reports(T)
Software design, software development models, industry standards and practices for design notation	Project document (C) - design
Programming, testing, software development	Software source code and documentation, user manuals etc. Project Document (C)
Adaptability, leadership, interpersonal communication, cross-site communication and collaboration, work as member of team, fulfil roles, time management, organisation	Personal skills analysis (I), individual reports (i), meeting minutes and observations (T), team reports (T), Team contract (T), log books (T, I), evaluating own and others performance (T) and individual reflective reports (I)
Communication	Team presentation (T), written reports (C, T), talking to customer(C), use of technologies (C, T)
Written communication skills, using industry-standard notation	Project Document (C), team report (T), individual reports (I), coding (C), documentation (C)

Table 1: Mapping of Learning Outcomes and Assessed Deliverables

3. ASSESSMENT METHODS

Assessment of team work could be relatively straight forward if we were simply assessing the tangible deliverables and products of team work, and if our marking criteria were just based on the standards of the discipline and not the personal characteristics of the participant. However, team work assessment invariably involves allocating an individual mark for both *product* and *process* which often proves problematic [5]. It is much harder to assess the processes involved in team work as it is necessary to know the contributions of each team member to determine an individual mark. With either collocated or cross-site work it is vital that each individual is assessed fairly so that those who significantly contribute are rewarded and those that don't will not benefit from the effort of their more conscientious colleagues. However, accurate individual assessment is difficult in an environment that allows students to contribute at varying levels whilst also trying to ensure that students gain maximum benefit from the team work experience. Assessment of team activities causes considerable concern to students and can for some result in spoiling an activity that they would have otherwise enjoyed. Working across sites and universities makes addressing this issue all the more imperative.

Each university has its own way of *doing things* which include a different structure of the SE modules and how they are assessed e.g. the module at Durham is worth 40 credits whereas at Newcastle it is worth 20 credits. Assessment in this cross-site work therefore presented a challenge. It was necessary to agree on a set of common deliverables and define the assessment and marking criteria which would fulfil both sets of module aims and learning outcomes. It was also necessary to ensure that we acknowledged individual and team effort at each site and that ultimately a team's assessment was not compromised by a poorly performing team in the other University. It was also very important to make the assessment methods clear to the students at both sites to reassure them that a poor collaboration between two teams would not necessarily be detrimental to their overall marks for the module.

3.1 Joint Assessment of Company Deliverables

Initially, at the beginning of the cross-site work it was decided to summatively assess all the shared deliverables from each company and at the end of the module use individual and team reports and log books to help determine individual effort. It was our intention to reinforce the collaboration between sites by making the deliverable very much a company effort, where this deliverable was given one overall mark, regardless of the location and effort. Whilst the deliverables have been jointly marked by staff at Durham and Newcastle, it was however not possible to use such a simple process as students at each site felt that they had contributed much more than others and felt it very unfair if their section was particularly good but another section actually brought the overall mark down. To overcome the problem of determining contribution from each site and each individual, a contribution matrix was introduced (Figure 1).

Sections	Joe	Kirill	Michael	Tom
1.0 Introduction	Newcastle	Newcastle	Newcastle	Newcastle
1.1 Purpose	CMR	R		R
2.1.1 PC Modules				CMR
2.1.2 PDA Modules	Newcastle	Newcastle	Newcastle	Newca
3.1.1 PC Modules	CMR	CMR		
3.1.2 PDA Modules	Newcastle	Newcastle	Newcastle	Newca
3.2 Inter-process deps.	CMR	R	MR	CMR
3.2.1 PC Modules	CMR	R	MR	CMR
3.2.2 PDA Modules	Newcastle	Newcastle	Newcastle	Newcastle
4.2.3 PC Process Interface			CMR	
4.2.4 PDA Process Interface	Newcastle	Newcastle	Newcastle	Newcastle

Key;
C – create
M – modify
R - review

Figure 1: An abridged sample contribution matrix completed by Durham for the design deliverable

3.2 Contribution Matrix

In order to accommodate students' concerns and make our assessment fairer, we specified a simple contribution matrix should be included by each site with every company submission. This matrix provided the opportunity for each team to describe individual members' contributions for every deliverable i.e. who was responsible for creating (C), modifying (M), editing or reviewing (R) documents and code associated with the project. The matrix clearly shows which parts of the deliverable the local team completed and also the parts that were undertaken by their counterparts at the other university. Teams at each site do not have to agree on the contributions in the matrix, but these are compared across site by staff, and students are aware of this. It has proved a good way to monitor the collaboration between the sites and also to note what is happening locally. The matrices generally helped to reassure students that all efforts were taken into account. During the course of the projects it has been noticed that students tend to view the coding of a system as the most important part of the work and the *soft skills* i.e. documentation, organising meetings, project planning and management etc. are often viewed as less crucial. Completion of these matrices not only has helped to reassure students that effort has been recorded but also makes the students realise the importance of the efforts of all team members, regardless of whether the task is writing code, project management or writing documentation.

3.3 Newcastle: Percentage –Sharing

At Newcastle, a percentage-sharing exercise was undertaken at two intervals during the year. Students were asked to share 100% between their team members based on their efforts during each semester. It was observed that early on, during the first semester, students tended to divide the 100% quite evenly across all team members whereas the second set of percentages allocated during or just after the rather difficult implementation and delivery phase in the second semester is where a noticeable change was reflected in the percentages awarded to team members. This phase was generally more intense and stressful for the students and they needed to collaborate quite closely across sites. At this point they tended to be much more inclined to be realistic and actively discuss and debate locally the distribution of the 100%. Coming to an agreement often proved difficult and students became quite emotive about their contribution and the fairness of the distribution. To help mitigate the possibility of unfairness, staff monitors provided guidance to the students on how to conduct the exercise so all team members felt their views have been heard. In addition, to support the distribution of percentages, the contribution matrices, interim team reports and final reflective reports were used to provide supporting evidence in determining what was happening within a team throughout the project and to ensure that final weightings were based on as accurate a picture as possible.

3.4 Durham: Self and Peer Ranking

Durham students completed four self and peer assessment tasks throughout the life of the project. Each student was asked to place themselves and their team-members on a grid of 15 places (1-5 being for most contribution). In this way they are able to more strongly demonstrate exceptional, or non-contribution. This process made the student evaluate their own performance in comparison to other team members. As in previous work, we found that few students ranked themselves as contributing the least – and that they found it hard to be objective about their individual contribution to the team [6]. In addition to this each Durham team has a project managers (usually two) who are third year students studying a Level 3 Project Management module. These Level 3 students take responsibility for project management of the local team, making recommendations for the co-ordination and allocation of tasks as well as being involved in the setting and tracking of internal deadlines [9]. These project managers, who meet with their team on a weekly basis, are also tasked with completing peer rankings for each of their team members

The contribution matrix, self and peer ranking by students, peer ranking by project managers and staff observations together help to determine an individuals mark for the project. This data builds a picture of a student's contribution over the lifetime of the project. From this each team member is ranked by staff and a personal adjustment of the team mark is made, resulting in an individual mark for the team project.

3.5 Cross-site Percentage Sharing

In addition to the methods of self and peer assessment discussed above, each company was asked to simply divide 100% between the two sites. We where very interesting to see how the students perceived the contribution of their local team in comparison to the other site. . This cross-site percentage sharing was never intended to be used in the assessment of the project. Students were told that they did not need to confer with the other site in coming to their decision but could if they wanted to. Our experiences with this form of peer assessment have shown us that what seems to be a simple task in fact, in some cases, can turn out to be the most problematic. Some of the companies decided they would confer for this distribution and consequently discussions turned out to be quite heated. There was quite a lot of disagreement over which site had contributed the most. Of course, we had some idea that a few collaborations had not been as productive as they might throughout the year and the cross-site percentage sharing process seems to have borne this out, with several companies completely disagreeing over the appropriate division

3.6 Formative Assessment and Feedback

As part of the learning process each company had to submit a draft version for each of the two major written deliverables and feedback would be provided. This feedback was a combination of the comments from coordinating staff at both sites and came in the form of comments on the draft document and verbal feedback to each team at their own site. This dual feedback provided a much richer and varied set of comments and suggestions for improvement of the work before final submission. Many teams found this very useful and acted upon the advice. Other forms of formative feedback provided where comments and advice from monitors (Newcastle) and project managers (Durham) during weekly meetings. At Newcastle each team was given an overview of their progress based on their average grade for team and company deliverables throughout the year – this meant teams knew if they needed to make more effort as final marks are not calculated until the very end of the project. At Durham students had to provide verbal weekly progress reports and agree on internal actions lists for the coming week, Students found these regular meetings quite helpful

and our intention is to increase the level of these forms of feedback and so strengthen student future performance.

3.7 Calculating a Final Individual Module Mark

An example of how the final marks for the module are now awarded at Newcastle and how we calculate an individual mark is as follows: 15% of the module mark is awarded by a team monitor as an individual mark based on individual deliverables. These are: individual report, individual log book, observations of performance in meetings etc. 25% of the module mark is awarded by the team monitor as a team mark based on team/company deliverables. These include the team contract, website, interim team report team log book and final team report. 20% of the module mark is awarded by the module leaders as an individual mark based on individual assignments including the strengths essay and tick list & team structure essay and interim individual report and 40% of the module mark is awarded by the module leaders as a team mark based on company deliverables i.e. statement of work, project document and implementation (software demo and presentation, code). Durham students' marks are calculated in a similar way for company deliverables. The differences in module credits mean that Durham students undertake exams and other individual assessments as part of their Software Engineering Module as the cross-site team project only constitutes a percentage of the module marks. Results from the peer assessments are also used as a small percentage weighting of the individual component of team deliverables at both sites. All company deliverables have common marking schemes across site and are double-marked. The assessment methods we have employed help us to get a fuller picture of local team and cross-site company interactions. We can focus on the results for the technical and non-technical aspects of the tangible deliverables and also the students' transferable skills development. We believe the assessment methods we use are now fairer in that we get a more rounded picture of an individual's contributions via a number of methods, including observation and peer assessment but we are continually trying to improve our process and our assessment design and to make them more transparent to students. This isn't easy, as cross-site assessment and ensuring fairness can be complex depending on the cohort size, the problem specified and the shared assessments and deliverables.

4. USING THESE ASSESSMENT METHODS

Throughout the course of this project we have gathered feedback from students and staff in a number of ways. We have used focus groups, module questionnaires, skills self-assessment tasks, observations in team meetings and through student reflective reports and log books. We have also compared the quantitative module results, student learning outcomes and performance at the end of each year to the previous year and to the years prior to the implementation of the cross-site initiative [12, 13].

The cross-site work puts team assessment more sharply into focus. It also makes it imperative to get it right as the risks involved increase, in comparison to co-located team projects. Whilst the learning experience and skills gained throughout this type of work is invaluable, assessment is the more immediate primary concern of the students. Students need reassurance that the assessment is reliable and fair and therefore it is necessary to use a variety of assessment methods – each capturing different elements of the work.

In using these assessment methods the following guidance is recommended:

- **Agree clear assessment criteria** - As with any assessment, students involved in teamwork must be provided with clearly defined assessment criteria and well-developed marking schemes that show how achievements are to be evidenced and judged. In cross-site work this information must be held in a central location accessible to all. Each company therefore had its own shared protected area within a Wiki and within this shared area each site also had its own protected area.
- **Teach students about peer and self assessment** - Peer and self-assessment provides a lot of benefit to students in that it lets them see how much effort their team has put into joint work and also evaluate their own skills and learning achievements throughout a project. It also helps students to take responsibility for their own learning and to realise the importance of teamworking in their professional skills development. However, students are not experts or have little evaluation experience and therefore peer and self assessment is something they need guidance with. Students can find it difficult to judge their own contribution and often overestimate or underestimate their own performance. Providing this guidance is important especially with the Durham peer and self assessment with rankings being clearly defined. Some students scale widely using the full 1-15 whilst others rank only in the first half of the scale thereby making it difficult to determine the level of overall contribution. Students may also feel uneasy about having the responsibility of assessing other students' work. A session at the start of the year that outlines the purpose of self and peer assessment and allows students to practice this skill would be very beneficial. Also, our use of a simple contribution matrix for every deliverable can help students to

recognise more clearly the efforts of their peers and the contribution of all team members throughout the project and may serve as a way of helping students make better judgements.

- **Continue to actively allay student anxiety -** Whilst company percentage sharing did not directly contribute in determining team or individual marks in the project it was an extremely interesting short exercise which highlighted student perception of their site involvement in the project. Herbsleb et al., have undertaken a number of surveys regarding global software development and report "a strong relationship between delay in cross-site work and the degree to which remote colleagues are perceived to help out when workloads are heavy" [7]. A perception of how much each team contributes and supports their counterparts varies considerably with generally a mis-match between how each site sees the percentage split. From a student perspective, they often simply believe that their own site does all the work and the distribution of work is not equal. Our use of contribution matrices and cross-site contribution sharing has shown us that students need regular staff reassurance about assessment throughout the project and that all their efforts are recognised and that their marks will not be compromised by the other site.
- **Formative assessment needs to be timely and meaningful -** Providing formative feedback of draft documents was helpful to the teams in order for them to improve their performance and consequently the mark awarded for the work. Students appreciated the face-to-face feedback afforded to each team however from a staff point of view this was relatively time-consuming. However, involving the students in this feedback process was an invaluable learning experience that motivated them to take greater responsibility for their work especially when they can clearly see where improvements could be made. We chose to give formative feedback on the larger deliverables throughout the year not only to ensure that students could learn from their mistakes and make adjustments to improve their marks, but also to reassure them of their successes.

5. Conclusions and Further Work

The use of various assessment methods such as the contribution matrix, self and peer assessment via ranking or assigning percentages we believe, help to ensure greater fairness and enable intangible tasks such as communication, organisation, team working etc. to be given value. Involving students in assessment enhances their motivation and enthusiasm by encouraging active participation in the learning process, making assessment a shared, collaborative activity. The contribution matrix will be developed further to deal more explicitly with activities that demonstrate the non-technical, transferable skills components of the project.

It was difficult to find a balance between reassuring students that the collaboration would not impact adversely on their overall attainment without reducing the need for strong collaboration between teams – which is essentially a major part of their learning process. It is still quite difficult for staff to determine an individual's mark even with the wealth of supporting evidence obtained from the various assessment techniques and we are still working on improving this.

Cross-site student software development work such as this goes some way to emulate real world working methods within the software industry and should be continued. There are a number of issues which need further consideration such as the scalability of this type of work and in particular research results which show that "distributed work items appear to take about two and one-half times as long to complete as similar items where all the work is collocated" [8], which can impact on future projects and their assessment.. However this is the subject of another paper.

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