Collaborating with Industry to Improve Realism and Employability in Undergraduate Software Engineering

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Abstract — *For many years now the School of Computing Science at Newcastle University, UK has been collaborating with a variety of industrial contacts to improve the employability of its undergraduate students. One way that industry has become involved with students is via a team project for our Software Engineering module in second year. Initially, employers would conduct 'mock' interviews for the students and give them feedback on their CVs and interview performance as part of the assessment for the module. However, in recent years, the involvement of employers in this module has increased, mirroring the growth in demand for graduates with demonstrable transferable skills and practical experience in the competencies required by these companies to compete in the global software market. This paper details our experiences of working with employers in the software engineering module and describes how and why their role in helping us design and develop our curriculum has changed over the last few academic years. We outline the changes we have made to the module to incorporate industry concerns and to help students develop both the technical and 'soft' skills required by their profession. We outline the reasons why employers need to have more input into the curriculum, highlight the issues that might prevent employers participating fully in undergraduate engineering education and suggest some ways these issues can be overcome.*

Index Terms *—Software Engineering, Teamwork, Industry Collaboration, Undergraduate Employability*

INTRODUCTION

The School of Computing Science at Newcastle University, UK, takes the employability of its graduates very seriously. In order to improve our students' chances of maximising their degree and having good career opportunities we try to build an innovative curriculum that will help the students gain not only the requisite technical skills needed for their discipline but also those 'transferable' skills most sought after by local and national employers. The non-technical skills we concentrate on are those that will make our graduates stand out as strong competitors in the graduate recruitment market and these include teamworking, leadership, communication and time and project management. These are skills that traditionally few Computing students gain in any real depth during their degree mainly due to the lack of realism for most project assignments. Therefore a vital part of our effort to improve students' employability is to give them *realistic* experiences of what is expected of them in industry. In order to do this, we involve employers from the Computing and IT field as much as possible in the design and development of our courses. In particular, we collaborate with a variety of industrial contacts in our Software Engineering Module where students undertake a year-long team project. This is the area in our curriculum that gives us enough scope to adapt to the needs of industry and the ideal place to develop both non-technical and technical skills in a realistic environment. In this paper we give details of our experiences working with employers in the Software Engineering, (SE), module, [1]. We describe how and why their role in helping us design and develop our curriculum has changed over the last few years and outline the changes we have made to incorporate employers' concerns. We then outline the issues that may prevent employers participating in curriculum development, highlighting the reasons why employers need to have more input into the curriculum. Finally, we suggest ways to encourage employer involvement in the curriculum, based on our own experiences.

REALISTIC SOFTWARE ENGINEERING

The nature of the work of software engineers means that they have to be adaptable and flexible, learn on the job, cope well with solving problems and manage many things going on at once. Professional practice is also "dominated by team collaboration" [2]. Software engineers need to be able to work as a member of such a team, perhaps a multidisciplinary team and it is in this arena that interpersonal or 'soft skills' as well as technical skills are most needed. The Association for Graduate Recruitment in the UK outline the difficulty some firms have in recruiting students with suitable 'soft skills' as well as academic ability. It seems that employers expect more from students in terms of their proactivity in gaining 'extra' skills and in terms of demonstrating the skills they already have [3]. This argument is further supported by Joseph who states that "there is a growing (and gnawing) awareness that technical skills alone are insufficient for success in IT, particularly in today's dynamic, distributed and complex workplace. Companies are exploring outsourcing and offshoring to become more flexible and contain costs while strategically leveraging IT. Consequently, IT professionals

must acquire a broader set of skills beyond their technical skills" [4]. These broader managerial or interpersonal skills are generically labelled "soft skills"" or as Joseph et al define them – "practical intelligence" .

Traditional teaching methods that involve lectures, tutorials and practical sessions are now not enough to teach students how to transition from the education environment into the software engineering industry or to help them develop this practical intelligence. In order for our students to adapt in an industrial environment and quickly become an asset to their employer, we need to focus on helping them to develop the necessary skills pertinent to employers and have them ready to enter the work place equipped to solve complex and realistic problems from the start.

Most Software Engineering courses at undergraduate level involve a team assignment as part of the core teaching mechanism to help students learn about software development methods, development team roles and the tools and techniques involved in creating a large piece of software. The problem with a lot of these assignments is that they are not realistic in terms of project scope and definition nor in terms of the performance demands made upon students. Students also need encouragement and a 'safe' educational environment in which to develop and practice these requisite skills. By safe environment we mean one in which students can learn by making mistakes and exploring their options rather than one wholly constrained by the academic need for grades and quantification of the quality of their performance. Of course we cannot fully remove the need for grades as we need to place a value on student attainment but we have restructured our software engineering course to allow as much exploration and learning as possible. We still assess students on the development of core software engineering skills such as requirements analysis, design, risk management, implementation, testing and maintenance but as part of the CETL AliC project initiative we changed the module to incorporate a hybrid approach of both the traditional didactic teaching method normally used for more higher education courses and a problem-based learning approach where students learn independently from the tutor and the tutor's role is altered to that of a facilitator. [5],[8].

Prior to CETL involvement the module used to run with Newcastle only students. We introduced a cross-site team working with Durham University students also taking a second year software engineering module as part of their computer science programme [6]. We made this change to make the challenge of developing software more realistic. Teams were formed at Newcastle and paired with a corresponding team at Durham. The students then worked together as a virtual enterprise, across sites, in order to develop the required software. This approach mirrors industrial practice vey well in that cross-site development of software between globally separated teams is becoming common practice because it is efficient and economical in terms of time and labour costs. This approach also means that companies can take advantage of strategically located experts to manage projects without personnel having to relocate and prevent expertise being lost locally. For the university assignment, we emulated this global cross-site working by ensuring our students had to use communication technologies to work together, (i.e. teams were not able to meet face to face), in order to produce the software and accompanying documentation. This step of working and assessing with another university at undergraduate level involved taking a risk with our curriculum. Allowing students to develop across sites in order to be realistic about software engineering practice was a daunting act on the part of both universities and had quite a few 'teething troubles' but it was this innovation in teaching that attracted employers to seek to work with us more closely. This willingness to try new teaching and learning approaches that reflect industrial practice showed employers that we mean business when it comes to making sure our students are fit for the workplace and that we are helping them become more aware of the career challenges ahead. This approach has led to employers offering to help us make our SE project more 'real'.

EMPLOYER INVOLVEMENT

Guest Lectures and Mock Interviews

The Software Engineering Module is viewed as a good place to help students improve their employability as well as learn the theoretical and practical aspects of the discipline of Software Engineering. This is mainly because of the realistic approach to teamworking i.e. the focus on learning 'by doing' and the need for students to learn and act independently of module leaders in order to achieve success. As part of this focus on improving employability we invite speakers from industry to give guest lectures on their particular software engineering practices, standards and experiences. These lectures provide the opportunity for students to ask questions and find out about industrial expectations. The university Careers Service also run a session on writing CVs and covering letters for the SE students. This session always proves valuable to the students, some of whom have no experience of writing their CV before.

Another form of employer involvement that has taken place for a number of years is that the CV session has been followed by a 'mock' interview for each student taking the SE module. Local and national employers help us facilitate this by generating a 'typical' advert for a graduate position with their company. These adverts outline the type of work graduates will be expected to do and also detail the skills and experience required from a suitable candidate. We post these adverts on the School VLE [7], and students from the Software Engineering module must submit a CV and covering letter in application for the 'position' they are interested in. We then arrange an interview slot for each student with the company who advertised the position they applied for and the employers come along to the School and interview all the students on the module. The purpose of this exercise is is to help the students to gain confidence and

improve their interview skills before they leave university. Most of our students have very little or no prior experience of interviews and very few have experience of an interview in the IT sector. Having a mock interview allows the students to practice and develop their interview skills with the benefit of feedback from real employers. The session also benefits employers as they get to feedback to students what they need to do to obtain a real position in the future both in terms of interview techniques and in terms of the development of their technical and non-technical skills. We have been conducting this exercise for a number of years now and have found that our students are quite reluctant to discuss their 'soft skills' at the interview and concentrate mainly on their technical skills, believing these are the only skills the employers are interested in. According to the Confederation of British Industry, (CBI), this is a real issue for graduates. Our students "need to understand how to articulate the employability skills they have developed as part of their course, as well as what they have gained from extra-curricular activities and part-time work" and therefore "developing employability skills should be a core part of a student's university experience" because "students need to understand the skills employers value" [8]. We have consequently devised a series of questions to be asked during the mock interview in conjunction with our volunteer employers and these reflect both technical and non-technical concerns that are relevant to most employers in the sector. The questions used for evaluating non-technical skills include asking students about their experiences of leadership, communication, teamworking and problem solving. The interview sessions allow each student to discuss their experiences and to reflect on their learning in terms of both technical and non-technical skills during the SE module. Most students find the exercise very valuable as is shown by their comments in Figure 1:

"The mock interview was a very new experience to me as I had not had a formal interview before. This meant I gained experience in interview techniques first hand. During the interview my ability to think on the spot and under pressure were tested and I think that I did well."

" *I applied for and attained a placement year with a large motor manufacturer. I transferrred the skills I had learned in this project to an assessment centre group exercise. I also used this module as an example of how I have shown my leadership skills and teamwork abilities within a professional context.*"

FIGURE 1
STUDENT COMMENTS FOR MOCK INTERVIEWS

Mock interviews give our students some practice at interviewing but also an insight into the type of questions employers will ask them when they apply for real positions. They also provide the opportunity to find out the nature of the work each employer does and ask questions. This is important as sometimes students have a narrow view of the career possibilities open to them with their particular skill set and tend to be unsure of the core business needs of employers and where their skills can be useful.

Acting as a Customer

In 2006/07, through our contact with employers conducting mock interviews and their interest in our work on emulating virtual teamworking in the SE module, we managed to persuade IBM [9] 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, Proctor and Gamble, (P&G), agreed to conduct a Project Management workshop for the students at the beginning of the academic year [10]. 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.

The following academic year, 2007/08 we asked Proctor and Gamble to act as a customer for the project and they gave us a real case study from one of their older projects to adapt for the team assignment. The company met with students once to discuss their initial requirements document and then committed to answering student questions one day a week throughout for the rest of the project and they also agreed to a final demonstration of the software products at the end. In practice, this did not work as well as we intended because the P&G were busy and had periods where they could simply not respond because naturally their real customers had to take priority. Student holidays and exam periods also meant communication was not as good as either side had planned due to the reply-time delay for some questions or the availability of both company staff and students during the crucial implementation period of the project. This led us to review our scheduling and also the nature and type of involvement and commitment employers would have to make to for subsequent iterations of the project because we had asked rather a lot of the employers and their time was necessarily limited. This was very much a case of inexperience on our part. Overall though, the teams that took part reported that they took the project very seriously and adopted a professional approach to the work, and so any problems encountered were dealt with quite well. The students said they felt compelled to behave professionally because they were dealing with real employers and not just their lecturer pretending to be the project customer. The students had a positive experience

with Proctor and Gamble as their client, even visiting their site at the end of the project to present their final systems and give feedback on their experiences.

FIGURE 2
PROCTOR AND GAMBLE PROJECT MANAGEMENT WORKSHOP

In the academic year 2008/09 we asked IBM to act as the customer for the student products. This time we scaled down the need for the company staff to be available for questions during the year. We devised the assignment and asked the IBM representative to look at students' work at three set periods during the year, at the time of submission for the initial requirements document, the prototype system demonstration and the final system demonstration at the end of the academic year. This approach worked more successfully. The students could rely on university staff to answer all interim questions about the brief, both technical and operational and the customer could come in and give some good formative feedback on requirements and design document drafts before they were submitted to the university for marking. This way students could maximise their learning and make good use of the employer's time and expertise and the employer needed only to commit to three face to face sessions and some reading of draft documents accompanied by guidelines from us as to the standard expected.

Overall, student experiences on the module have been positive and greatly enhanced by the fact that employers have been willing to share their time, energy and expertise in order to help them learn. We have found that because of these changes and high employer involvement, students take the work more seriously. They really enjoy using industrial-strength tools and techniques and tackling complex and real problems. They like getting feedback from the employer and they behave more professionally when presenting or speaking about their work. Our students have really appreciated the fact that a professional person from industry has looked at and commented on their efforts and employers have been impressed with the high level of skill that students have gained as a result, as can be seen from the following two example statements in Figure 3:

" The feedback from IBM was really helpful when it came to putting in the final requirements document. It was useful as it showed us the areas we needed to improve on. Also, there were areas which we missed when reviewing that were easily found from an outside point of view making this feedback even more valuable." Student Feedback

"I was surprised by just how far most teams had come from the initial demos, both in terms of functionality & the quality of their deliverables. I was particularly impressed by those teams who included most of their team members in the demo. It left me "as the customer" feeling that those teams could be relied upon in pressure situations as everyone knew at least part of their product. All the teams I spoke to found the project a tremendous learning experience in terms of teamwork, project planning and developing/testing non-trivial code" Employer feedback

FIGURE 3
SAMPLE FEEDBACK FROM A STUDENT AND AN EMPLOYER

CHANGES WE MADE

Feedback from employers and students has led us to make lots of changes over the past 5 years to each iteration of the SE module and these are as follows:

- We have made changes to the range and nature of assignments we set in order to make them more interesting and challenging for students but also to reflect current and future trends in the software industry.
- Assignments have been made more challenging and the tools and techniques students use to produce their solutions are of industrial standard. We have made the assignment requirements increasingly open-ended so students can have more freedom in choosing the technologiy and the techniques they feel are best needed to create their solution rather than these being dictated by us. This approach has led to greater student creativity and a wider and more sophisticated variety of solutions to the same problem.
- We have allowed for earlier prototyping of the software in the project schedule whereas in previous years we waited until quite late in the project to look at the students' solutions and until the submission of final products before giving the students any real feedback on what they had created.
- We have specified outcomes for the project at different levels based on the advice received from employers e.g. we have specified basic, intermediate and advanced features to be delivered, and this has allowed more possibility for all students to obtain a successful outcome
- We have changed the reporting mechanisms for the teams and introduced more teaching on Risk Management.
- We now involve more employers from a wider range of companies including games companies, traditional large software development houses, local airlines, educational companies and IT consultancy firms, in order to maximise the potential range of employers who see our students' work and what we do.
- We have added more formative feedback sessions on larger pieces of work e.g. the prototype and draft versions of requirements and design documents and we have used templates from case studies and more formal industry documents e.g the design document we ask for is based on the ANSI/IEEE Software Design Descriptions document [11]. We have adapted this document into our own cut-down version because it is rather weighty and would be beyond the scope of the learning or detail we expect in the design time allowed for the project.

ASSESSMENT	TYPE
Interim Requirements document (formative)*	Formal template provided by university Reviewed by employer & university
Final Requirements document	Formal template provided by employer Marked by university.
Interim Design Document (formative)*	Cut down version of ANSI/IEEE Standard 1016-1998 Section Headings (adapted) Reviewed by employer & University.
Final Design document	Cut down version of ANSI/IEEE Standard 1016-1998 Section Headings (adapted) Marked by university.
Interim Team report	Informal document
Prototype Demonstration (formative)*	Face to Face with employer
Peer Assessments	Team-exercise
Software Submission	Online Submission
Software Demonstration (summative)*	Face to Face with employer

TABLE 1
ASSESSMENTS FOR THE SOFTWARE ENGINEERING MODULE.

Employer input to the draft documents and prototype software can be seen in Table 1 which details the main assessments/deliverables for the project. All the assessments/ deliverables marked with an asterix are formative assessments and therefore achieve no mark. We asked employers to give verbal or written feedback only on these. Employers gave feedback on the final products as well but we summatively assess this aspect ourselves. Involving employers in assigning grades is something we still have not done as this places an added burden and responsibility on the employer and also clashes ethically with academic integrity. However, we found that employers were comfortable with giving feedback on elements of the project they were familiar with e.g. documents they had provided templates for and the applications that the students developed. Moreover, the employers we worked with were more than willing to

assist us in giving general feedback about performance throughout the year. To facilitate this we ran 'focus-group' sessions at the end of each year so that employers and students could discuss their experiences and get general feedback on their performance. For the focus groups, employers and representatives from each of our teams attended an informal session that was run by a neutral facilitator. The facilitator focused on aspects of the project e.g. design or implementation and asked the students to comment on their experiences. The employer gave feedback on aspects of the project they had been involved in and their overall impressions. The students found these sessions really useful because they were able to hear how each team had performed and discuss common issues. They also received advice on how they could improve their performance in future projects.

PARTICIPATION ISSUES

Our experiences since first asking employers to take a greater role in our Software Engineering module have shown us that employer interaction and participation needs to be managed very well, at all levels of the University. In our case both employers and teachers had concerns about the level and types of participation that were appropriate. Our institution is strongly committed to dialogue with employers in order to balance the evolving needs of the sector in relation to the evolving nature of our academic field [12] and in practice this need for balance caused us some difficulty with regard to the question of copyright of products the students produced, confidentiality of the practices and case studies we used and also the level of participation and influence we could allow employers to have on our curriculum. We managed to deal with these issues by consulting our degree program director and our head of school as well as higher authorities in the university to ensure our approach was correct. We also spent a lot of time discussing the nature of the project with the employers in detail so that expectations on both sides were clear.

Single employer involvement can mean there is a danger of focusing on one way of thinking and working and this could limit what students learn in a general software engineering course. Also, standards differ from employer to employer and it is important, in software engineering at least, to retain a view of overall industrial standards and developing practices rather than teach students only one perspective. It may be difficult for some employers to adapt or adhere to more general practices and ways of working for the sake of the project as each will have their own particular agenda. We overcame this issue by defining clearly the technologies and techniques that students had been taught to employers and by changing and adapting the case studies to suit student needs and accreditation requirements. We also managed to retain the essence of the employer's requirements and negotiated with them on what students would deliver. This was difficult at first, but we managed quite well because the employers we involved were very keen to help us.

Another concern of employers was the amount of time needed to be committed to the project. We originally had very high and unrealistic expectations of the level of committment we could expect from employers who naturally had other more pressing demands on their time to attend to. We have managed to overcome this issue by being very specific about the project schedule and deliverables and working closely with employers to find times that suit both parties and also fit in with the natural schedule of student learning. This means planning our module well in advance of the teaching year. Not many employers have time to answer questions directly from the students. We dealt with this by answering the day to day questions from students on behalf of the employer. We acted as inter-mediaries between the employer and the students and only sent questions to the employer that we could not answer ourselves.

Time and knowledge were also issues when it came to designing tasks that were suitable to both academic and industrial needs. We adapted the case studies and project requirements to suit the known skills and prior learning of our students and to the technologies that we support. We took responsibility for ensuring that all project tasks and case studies were suitable for our students' level of study and dictated quite clearly the development technologies our students should use and also the development methodologies we approved of. We have gradually relaxed the technology-support element of the project definition more over the years. This is due to the increased diversity of technologies and platforms being used in industry and the technical skills required of our graduates rather than a relaxation of the levels of technical support given during the project.

Another issue we faced was that some times feedback on peformance was conflicting between lecturers and employers and this confused students because of the difference in expectations. Lecturers have knowledge of their students, the level of achievement they can expect within the whole class whereas employer expectations may be higher and it is important to help employers understand the varying levels of skill or experience in a class. We overcame this issue by showing examples of previous student work to employers.

Each university will have a different approach when it comes to the level of employer involvement it permits in designing and developing their curricula but these issues we highlight here are somewhat general in nature and may apply to all institutions and indeed all disciplines.

HOW TO ATTRACT MORE EMPLOYER INPUT

The experiences we outline in this paper are all based on our work at local module level. However, support for and the feasibility of employer involvement in the curriculum needs to come from university-level initiatives that make it easier

for teachers to implement e.g. most universities have industrial boards for their programmes [12]. These bodies can be encouraged to become involved or help you find suitable employers if you can present your ideas for changing the way aspects of teaching are delivered.

Our increased involvement and interest from employers stemmed from us taking a chance with our curriculum. The cross-site project was innovative because we wanted to change the way we teach to reflect the needs of industry and to engage students more. Making a real effort to be inventive will attract good employers who are concerned about the skills of graduates in their sector. High quality accredited programmes and a good reputation for research and teaching in the university will of course attract attention from employers, but at the teaching-level, projects that focus on issues that are prominent and important to industry should attract attention, especially if they are disseminated correctly. Other ideas for attracting employer input are:

- **Recruitment Fairs** - Employers often take part in recruitment fairs for universities and these are a good place to meet and network with companies in your sector. Staff attendance at these events is traditionally low but these events provide an opportunity to discuss your work and network with potential employers too. Sell the project as mutually beneficial – employers would get to meet up and coming stars in their discipline and also have access to the best graduates, ahead of their competitors.
- **Involvement of the University Careers Service**- We invited our Careers Service to give guest lectures on CV writing and on interview techniques. The careers service have access to local and national employers and are very keen to help lecturers work more with employers. This service can often be undervalued by lecturing staff.
- **Companies with placement offers in your sector or already established at your university** – these companies already have a connection with your university. They probably know enough about your quality and standards because they are willing to invest time in giving your students valuable work-experience. They may be willing to offer more assistance and have more input into courses and projects. Your department may have a nominated placements officer who can mediate between you and the employers and arrange a meeting.
- **Researchers on industry-led or funded research projects –** your colleagues are ideally placed to help you secure employer involvement, especially if your project proposal involves research or development in an area of great interest or concern to the sector. There may also be money available for teaching and learning development in your university too. If employers can see value in the project you propose and know involvement won't cost them money, they may be more willing to participate.
- **Teaching and Learning Office or equivalent** - there is often funding available for guest speakers or innovations in teaching and learning to improve the student experience and staff from this office could put you in touch with employers who are keen to be more involved.
- P**VC for teaching and learning or equivalent** - Those members of the university who have access to committees and panels internal but also external to the university can be very valuable in helping lecturers make contact with willing employers and employability is on the agenda for most universities [12].

And finally, make what the employer has to do *easy*. This takes good planning, clear goals and guidelines, and requires a lot of effort and preparations to be made a long time in advance of teaching but being well organised will prove a more attractive prospect for busy employers.

CONCLUSION

In this paper we have given a brief overview of how we involve employers in our Software Engineering module in the School of Computing Science at Newcastle University. Involving employers in the design and delivery of this module has proved to be a very worthwhile and important endeavour for us and a good experience for our students. The level of employer involvement has increased each time we have run the module in response to the real pressure placed upon graduates to find a job on graduation in today's economic climate. Through the cooperation of employers in the Computing and IT sector we have been able to help our students learn more about the industry in which they will one day be working and to attain both the technical and non-technical (soft skills) needed to be more competitive in the graduate job market. Our experiences have led us to adapt and change the way we engage with employers and also to change our expectations in terms of the amount and type of participation that is suitable for our particular module. We have highlighted some of the main issues we encountered during our particular project and the changes we made to accommodate employer concers. We have also suggested some ways to increase the level of involvement of employers in similar higher education projects. We hope this brief insight into our experiences will be of value to other teachers.

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