Supporting multi-discipline undergraduate group projects

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Abstract

Student group projects are an important part of undergraduate engineering programmes. They provide an opportunity for students to apply the theory that they have learned and experience a situation analogous to that which they will encounter after graduation. A number of significant changes have been made to the group projects run by the School of Electronic, Electrical and Systems Engineering at Loughborough University. One of these changes means that students on different degree courses from across the department will be working together on the same projects. This paper reports on a research project that investigated effective practice in the management and support of major student group projects in the School of Electronic, Electrical and Systems Engineering and also across Loughborough University. Technological solutions were sought that were of potential use in supporting the student group project process. Requirements for a support system have been identified and an eLearning hub, complete with user guides for both students and staff, has been developed. This new support system will help students manage their group projects, thereby gaining the best experience. It will also aid staff in their understanding of the project and their role in it. Lessons learned here, together with evaluation and guidance, will provide useful points of interest for those involved in other student group projects. This paper focuses on the identification of issues to be addressed during the evolution of a group project module and development of a support system for multi-discipline student group projects.

Introduction

This paper reports on a research project that investigated effective practice in the management and support of major student group projects within the School of Electronic, Electrical and Systems Engineering and also across Loughborough University. The research project was funded as part of the Loughborough University Teaching Awards Scheme 2009 and supported by the engCETL (Engineering Centre for Excellence in Teaching and Learning) at Loughborough University through their student summer placement scheme.

Student group projects have always been a key part of the third year undergraduate Masters programmes within the School of Electronic, Electrical and Systems Engineering at Loughborough University, especially the systems engineering (SE) programme. The basic structure of the SE programme is outlined well by Parish and Newman (1999). The aim of the third year student group project (and associated support process) is to help the students to put into practice the theory they have been taught in all of the programme elements in a relatively benign setting. This group project is considered a major part of the programme as it accounts for a quarter of the students' efforts during their third academic year. They do complete other group projects during the programme (which may eventually also benefit from the output of this research), but none of these other projects contribute so much to the final degree classification.

When the students graduate it is likely that they will be working in multi-discipline teams. The authors of this paper have been investigating the best ways of providing students with a relatively safe environment to experience the benefits and challenges of multi-discipline teams. This goes beyond the SE programme alone and is also of importance to students on other degree programmes within the department. For the SE students, working with other related disciplines exposes them to working with other experts who have particular points of view and needs and requirements when working on a project. For the electrical engineering (EE) students, working with SE students allows them to experience and appreciate things from a more holistic point of view. Together, their experience will be more applicable to the real world.

The main focus of this paper is on the evolution of support and delivery of third year group projects. However, it is worth noting the importance of previous stages of the students' education in preparation for such an environment. Some students adapt quickly, but many struggle with the format, despite earlier preparation. The ones who adapt quickly tend to be those returning from industry (a number take a year in industry between their second and third years), although that correlation has not been proven (and is not part of this work).

The role of student group projects in an undergraduate programme

Undergraduate student group projects are not an easy option for either staff or students. Graham and Crawley (2010) provide an overview of engineering project based learning in the UK and highlight some challenges and best practice. The issue of demands on time and resources is recognised. The involvement of industrial partners in providing a more "real" experience has been positive. Not all students will enjoy or be suited to working in teams but they do, however, see the value of student group projects and the challenges pursuant to giving them an engineering experience that is closer to the "real world" (Aman et al., 2007). Students experience problems such as 'clients not communicating, team members underperforming and the consequences of not directly managing risks for which you are not directly responsible' (Lindsay et al., 2008) - real life issues regularly faced by engineers in the workplace. Dealing with these difficulties provides valuable experience and insight into the problems encountered in real world projects and students can reflect and report on these without the level of consequence that would otherwise be at stake. Perhaps the biggest challenge for staff is the setting of learning objectives and provision of appropriate assessment which accurately considers individual involvement in the student group project. The potential of computers and other new technological developments to enable and support collaborative learning is recognised (Rick and Guzdial, 2006).

The delivery of the student group project module is a form of problem based learning (PBL), with the control of the process being in the hands of the learner(s). (Following recent changes to the student group project this control has increased, as outlined later in this paper.) PBL offers a way to support students' development of both subject specific and softer skills in a stimulating learning environment. Benjamin and Keenan (2006) note that allowing students freedom in the application of 'creativity and collaboration to resolve the uncertainty and complexity of problems [they] have identified themselves' goes a long way to increasing enthusiasm, something which the authors have witnessed throughout the course. It is useful in challenging the students' quest for the right answer, something which is not always available, achievable or even desirable when learning about engineering (Daniels et al., 2010). Creativity is a very important skill for a student engineer to develop; how to incorporate this into learning objectives and assessment methods is another challenge for staff. Open ended project modules allow for flexibility whilst ensuring that necessary learning takes place and enabling evolution of the modules. For such modules to be successful, it is important that staff are supportive and that there is buy-in from students.

Loughborough University has an impressive record in graduate employment. In the current economic climate, finding employment following graduation is becoming increasingly difficult and it is recognised that the development of professional attributes is not easy to incorporate into the curriculum (Daniels et al., 2010). With that in mind, it is all the more important that students are encouraged to 'engage with the processes of professional engineering practice' (Lindsay et al., 2008), making the distinction between engineering students and student engineers. It is believed that the holistic development of lifelong learning skills and development of a more professional approach throughout the major student group project will contribute to this. 'The development of […] 'soft' skills is crucial for the new engineers and their employers, and for stakeholder perceptions of the value and relevance of engineering education' (Daniels et al., 2010). In essence, the major student group project provides some of the less tangible skills that graduate engineers need (Waks and Frank, 2000). Tomkinson et al., (2007) note that positive outcomes of such work (from the student's point of view) include 'multi-disciplinary teams, working in groups, relevant, real life problems, independent learning/ learning from others'. Encouraging students to understand, identify and record competencies, both tangible and less so, within their work is

the focus of a separate project which is being funded by the HEA Engineering Subject Centre (see http://www.engsc.ac.uk/mini-projects/encouraging-undergraduate-students-to-identify-and-maintain-competency-records for more information).

The student group project

The student group project is taken in the third year of a MEng programme, prior to which students have had considerable exposure to group work. It runs over a whole academic year and accounts for a quarter of each student's study load during that time.

A key goal of the group project is to provide students with the opportunity to participate in a project dealing with a complex problem which is set in a real environment. The aim is not necessarily for the students to solve the problem presented to them, but rather to experience the various challenges presented, both technical and personal.

Students taking part in the multi-disciplinary group project may be on one of four programmes: systems engineering; electronic and electrical engineering; electronic and computer systems; or electrical and renewable energy systems. They work together in groups of between five and eight, tackling a problem designed to provide a challenge similar to one an engineering graduate might face. Typical project topics have included design and development of:

- autonomous underwater vehicle for aircraft black box location or to gather data on marine life
- sports pitch line marking system
- autonomous vehicle and hovercrafts for various bomb disposal applications.

Assessment takes place at three main stages:

- *scoping assessment at the start of the project* (report based)
- *interim design review at the end of semester 1* (document/artefact review and viva based)
- *final assessment at the end of semester 2/ end of the project* (including assessment of reports and final system demonstration).

The student group project final presentation/ demonstration day is a key showcase for the department, attracting many visitors from a range of industrial sectors. The output of the event reflects on the students and academic staff involved in the student group projects and is very important in maintaining academic-industrial relations. An overall supervisor assessment evaluates individual contribution within the groups during the year.

Issues addressed by the research project

The module has evolved over time and it was important that it was reviewed in the light of educational theory to ensure continued effectiveness of teaching.

From the 2008/09 academic year, a number of changes have taken place concerning how the student group projects in the third year of an undergraduate MEng course are organised and delivered:

- From 2008/09 the student group projects are assessed at a more advanced level (level 7) which means that the students are expected to take responsibility for control of the student group project, including the production of the deliverables and the use of supervision. Part of the challenge is to allow students the freedom to exercise this independence whilst still keeping in place an acceptable level of monitoring and support.
- The 2009/10 academic year saw the introduction of a multi-disciplinary aspect to the student group projects. It is recognised that the disciplines involved are separate yet cognate. Students on the different programmes develop very different competencies and approaches. The plan was to combine the student group projects across the department instead of running separate student group projects for the various degree programmes, thereby avoiding a concomitant variability in student experience and expectation. This combined student group project was initially offered as an option for third year students from 2009/10. If proven beneficial to student development, the multi-disciplinary major student group project may be the only option given to students.

These changes had an impact on the way in which the student group projects were supported: a research project was undertaken to investigate the potential implications, investigating effective practice in running

student group projects within academia and industry. The changes in the group project followed on the heels of previous changes in the final year individual projects, where students from all programmes were placed on the same module and followed the same project structure and the same intended learning objectives (ILOs). Due to the collaborative nature of the group projects, it was determined that a wider review would be required.

Research project outline

The aim of the research project was to identify the requirements for a more efficient and effective support system for undergraduate student group projects in the School of Electronic, Electrical and Systems Engineering at Loughborough University. Examples of similar endeavours include the wiki-based CoWeb (Rick and Guzdial, 2006). Facilities for production of such wikis are provided by Loughborough University's virtual learning environment (VLE), although the CoWeb support system aims to meet a wider remit.

The objectives of the research project were:

- to determine the purpose of the student group project (partly to identify what students should be capable of at the end of their third year and how the project contributes to this). It was thought that if the purpose could be defined more coherently then appropriate support could be developed.
- to identify all stakeholders' support requirements, especially students and academic support staff. By starting here, it would be possible to develop a support system that is *needed*, rather than a system that tutors want to provide. This was achieved through stakeholder engagement alongside investigation into other student group projects.
- to investigate how support was provided for other similar student projects across Loughborough University. This was carried out both internally and externally with a view to identifying and implementing best practice.
- to investigate what technological solutions are available. Work began to identify ways in which the support system requirements could be implemented, beyond staff support and staff time. This involved investigation into purpose-built software, consultation with experts and determination of the current state of the art from the relevant literature. It is work on this objective which gave rise to the follow-on research project, detailed in the *Future work* section later in this paper.

Methodology

Following identification of relevant theories to support module change, an iterative, action based methodology, similar to an OODA loop (observe, orient, decide, act), was adopted. This has allowed small steps to be taken and has minimised disruption to student learning during the process. Another reason for small iterations of change is to support both staff and students through *cultural* change. The iterative loop of action research is likely to continue and will help implement and develop the support system whilst group projects are delivered. Naturally arising actions feed through to updates for the module (and elsewhere in the courses/programmes where applicable). Based on the iterative nature of the research, the support system has been developed (to version 1). The development has not been straightforward and challenges have been faced. Some elements are still under development.

Reported observations stem largely from the supervisors closely following the progress of the groups, including formal meetings and informal discussions. Formal project and course evaluations have also formed part of the work. The project support team held regular meetings to discuss planned and implemented actions to ensure continued support of ILOs.

This research seeks to investigate the potential in a range of media to support student learning and development. In a similar way to Rick and Guzdial (2006), this project adopted a scholarship of application in a design based research approach. The development of the support system aids the students in their projects and helps researchers to better understand the application and use of a mixed media environment. The research does not necessarily aim to abstract new knowledge, but rather to better understand the situation and identify how support may be designed and provided in a more efficient way for staff and a more effective way for students. It is recognised that different students are likely to favour different media and so an element of flexibility within the design is important.

Tackling the research project objectives

In addition to those explicitly stated in the module specification (which focuses on the design lifecycle experience and development of competence in controlling a project), the research project identified some wider purposes of the student group project. These additional purposes, not identified or explicitly stated previously, are:

- to enlighten students on the diversity of SE research
- to foster good staff/student working relationships
- to develop potential ideas for final year individual projects
- to enhance relationships with industry for Loughborough University and with potential employers for students.

Many other transferable skills are developed and identified within the module specification.

Data was collected in the form of questionnaires and interviews (semi- and unstructured) with the aim of identifying support requirements from key stakeholders, including students, supervisors and examiners. Students reported that the existing support was adequate and effective but that it could be enhanced to reflect the changes in the way that student group projects are organised and managed. Such enhancement will improve student experience and feedback and reduce staff workload. Students want flexibility in the way in which they access support and an electronic system offers this.

Suggestions from stakeholders included the increased exploitation of existing online tools. Many tools are already available within, for example, the Loughborough University VLE. Use of such tools should also help to improve communication of information between all of the stakeholders involved, including signposting the use of learning from all student projects that are part of the course. Amongst the elements that require new solutions to be developed is the need for an inventory to highlight the resources available for student project use (e.g. equipment, laboratory space, workshop time).

Rick and Guzdial (2006) note the 'challenge of seeking help', where students are reluctant to ask staff for help for fear of how this may be perceived. The introduction of a support system including (but not limited to) staff support may help those students by providing other routes to help.

Tomkinson et al. (2007) also recognise the fact that the multi-disciplinary nature of both project teams and support staff can be positive and that including disciplines from outside engineering could be a good way to further improve support. This is another area to be considered in future work.

Research project outcomes and findings

The following factors are identified as problems/challenges to be addressed during the realisation of a support system:

- the students are on different programmes
- the students take a variety of optional modules during the year and will thus develop different competencies
- there are unequal motivations among students
- it is important to understand individual contributions within the groups
- different students will have different perceptions of the module and these may not be compatible with staff perceptions.

These factors all influence both the demand for and the design of the support system.

The main research project outcome was the identification of an initial set of requirements of an interactive, integrated support system. The system will be developed and run through a VLE, with tutors and supervisors managing some of the interaction through an online record system and bespoke database. Use of a common infrastructure should allow easier access for both students to use and staff to develop the system. Loughborough University's VLE is called LEARN and is a Moodle based system. A number of necessary features have been identified; some integrating existing tools and some requiring bespoke development:

- *An online self and peer assessment system.* WebPA was designed to help students assess their own and their team's performance in group work and related activities and can support a consistent self and peer assessment method for the group projects whilst also encouraging reflective practice by the students (Loddington et al.,

2009). More information about WebPA can be found at http://www.webpaproject.com.
- *An online record system to help staff keep track of student performance.* Co-Tutor provides this facility. The use of Co-Tutor is recommended to help the supervisors monitor and manage the group-supervisor relationship. This mechanism also assists technical supervisors in providing evidence to support assessment of individuals within the group and also the group as a whole at the end of the project. More information about Co-Tutor can be found at http://co-tutor.lboro.ac.uk/about.php.
- *An online system to allocate project topics to groups and supervisors.* ProjectList is a bespoke database originally designed for final year individual student projects for tracking student projects, the students assigned to them and the staff supervising them. This tool will help to manage the allocation process and make it more transparent, thus encouraging the groups' understanding and buy-in. More information about ProjectList can be found at http://projectlist.lboro.ac.uk/info.
- *An online meeting allocation system.* A feature of Loughborough University's VLE has been adapted to enable this. The system allows groups to make appointments for support sessions with tutors within a pre-allocated time period. This was previously managed through emails, which was very confusing. Automating the process has already reduced the administrative load and increased efficiency.
- *An online resource database.* Although requiring further development and integration into the VLE, this will allow students to make better use of the items that are acquired each year (such as computer and test equipment), along with workshop time and laboratory space. This is especially important as the budget for these projects has been significantly reduced for the 2010/11 academic year and faces a further reduction for 2011/12.

Further required features include a 'frequently asked questions' (FAQs) section for students, with answers provided by supervisors, support tutors and students who have completed the student group project in previous years. A separate section of the FAQs will be available for staff, especially those new to supervising this type of project.

Along with this support system, the support lectures that accompany the student group projects have been redeveloped to provide the necessary support and information at an appropriate time, as indicated by this research. Previously the topics were general, industry based and required a certain amount of extrapolation by the students to identify the usefulness and application to their projects. New topics are specific to the project and are process based (taking students through the design process and project lifecycle). It is expected that students will gain the necessary technical knowledge in other modules.

It should be noted that the intention is not to *replace* the staff-student contact (nor any of the other support) but rather to augment it.

In their feedback on the module, students have highlighted the positive influence of the work, especially in development of creativity and other soft skills. They have commented that the project gives them valuable experiences to draw on, especially in job interviews. They also note that, whilst control of the project is initially difficult to grasp, they value the opportunity for reflection at the end. They do need more guidance to use the support available effectively throughout the project and it is hoped that the new support system will act as a portal for this.

Findings also highlighted some inconsistencies in weighting of marks (for example, where interim assessments carried a higher weighting than similar elements in the final assessment). This has now been addressed. Clearer feedback is needed, an issue which will be addressed in line with the new assessment plan.

A number of deliverables were produced:

- *Roadmap for better support.* An initial draft has been developed and will be augmented in future work. As a result of this research project, elements of the support are also being implemented in other student group projects across the school.
- *Guidelines for technical supervisors.* An initial draft has been developed and is being tested. This provides a coherent and consistent guide for the different supervisors involved with the various student group projects.
- *Various internal and external dissemination methods of the case study and outputs.* Presentations and seminars have been

held internally. The work has also been presented to the various funding bodies at dissemination events. The project was presented at an international conference and has been discussed with a view to furthering the work and implementing it at other HEIs across the UK.

Benefits of the research project

The benefits of this research will be reaped by both students and staff who are involved in this type of project across the whole of Loughborough University. The main advantage is more consistent support for the third year major student group project which will be more accurately aligned with student requirements and expectations. The extent of this benefit is subject to ongoing evaluation as further development and phased implementation of the new support system takes place.

The School of Electronic, Electrical and Systems Engineering at Loughborough University is striving to provide more timely, useful and consistent feedback to students throughout their degree courses. More effective and efficient support for the major student projects as a result of this research will help staff to ensure that students receive more appropriate feedback on their work at the relevant stages.

It is hoped that the work of this project (and other supporting research) will make development and adaptation of similar systems and system elements for project support easier to adapt in the future.

Future work

Work is ongoing in this area with input from colleagues across Loughborough University who are also interested in investigating multi-discipline undergraduate projects and how they are designed and run.

Funding has been obtained through the National HE STEM Large Scale Curriculum Development call which will enable the development, realisation and implementation of the support system. This also supplies a much wider base for testing and dissemination and provides a unique opportunity to work with a number of HEIs from across the UK to identify further requirements.

From the point of view of the student, there has been some success in integrating the different facets of a project (technical, systems, management) (Lindsay et al., 2008). Further research needs to be conducted to ensure that the introduction of different cohorts does not widen the perceived separation (by students) of these facets. Closer alignment and transparency of assessment should help this.

Consideration will also be given to how this research could be applied to the support of other student projects, such as:

- collaborative individual student projects
- distance learning projects (where providing a cohesive environment is essential (Endean et al., 2008))
- student projects that span departments and faculties.

In the future it is hoped that students will be encouraged to be more independent and reflective and become deeper learners as a result.

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