CHALLENGES AND BENEFITS TO SOFTWARE ENGINEERING GROUP PROJECT CONTEXTS

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Abstract

A significant final year project is a component of many degree programmes, particularly in computing related degree courses. The project provides a final opportunity in a Software Engineering degree programme for students to demonstrate rigorous software engineering skills in the design, development, and testing of a solution to a specific problem. However, there is a significant challenge for the project teaching team to provide project contexts in which students can develop the additional skills of team-working and working with an external customer. These skills are highlighted by employers in the Software Engineering industry as essential and are identified as core skills in Software Engineering curricula guidelines and reviews. Team-working skills can be developed effectively by providing group projects and guiding the team's organisation around communication, task co-ordination and broader project management processes. However, providing projects which will develop the skills of students around working with a customer is more challenging. Traditionally academic staff propose projects in their specific area of research interest and provide regular supervision by "acting" as the customer or client along with academic guidance. Alternative approaches have been used to provide a more realistic experience of working with a customer by sourcing and providing projects from industry partners, cross-university collaborations, and community-based organisations. In this paper, we discuss the relative benefits of the different projects' contexts from the perspective of the students carrying out the projects, their project mentors or supervisors and the module assessors. we reflect on and present the challenges of providing, supporting, and assessing projects from a variety of contexts and lessons learned after two iterations of a final year software engineering project module.

Keywords: software engineering education, collaborative learning, project-based learning, capstone course, community engagement, industry partnership.

1 INTRODUCTION

Final year projects in Software Engineering (SE) degree programmes provide an opportunity for students to develop and demonstrate the learning, acquisition and demonstration of key skills needed to enter the SE workplace. Research has identified gaps between the skillset held by SE graduates and the needs of the industry [1]. The ACM/IEEE joint task force established recommendations for curriculum design and delivery aimed at maximising the necessary skill coverage within SE2014 [2], the curriculum guidelines for software engineering undergraduate degree programmes. In SE2014 the inclusion of a significant final year or capstone project in an SE programme "is regarded as being an essential element of a software engineering degree" programme. Additional key characteristics from SE2014 are that the project should span the entire final year, involve some implementation and significant evaluation, and be delivered through groupwork, if possible. Furthermore, the task force recommended the project "should have a 'customer' other than the supervisor so that the student gains fuller experience with product development life-cycle activities".

While SE degree programmes vary in emphasis and content, most programmes now include a significant project in the final year with many of these being undertaken as a group project. However, the contexts of final year projects vary considerably, from the traditional project proposed by an academic within their field of research and interest, to "live" or real-world SE problems. Projects that can offer the opportunity for students to engage with some form of customer has led to an increase in efforts to source projects externally to the main academic supervisor. These projects may be proposed or provided by industry, be developed through multi-disciplinary collaborations between academics across the university or proposed from community-engagement collaborations with the private, public and third sectors. All these project contexts provide an opportunity to meet the SE2014 recommended customer-engagement aspect of the student experience, which a project proposed and supervised by a single academic is unlikely to.

This study follows a previous investigation in which the research question: “What is the most effective software engineering project context?” from the perspective of a student. [3]. The results of this study indicated that students felt confident that all the projects, irrelevant of context, had provided them with sufficient opportunity to develop skills needed for the SE industry. However, it was noted that the projects with external involvement resulted in higher levels of satisfaction, particularly when they were sourced from community engagement. Feedback from the students along with the recommendations from SE2014 make a significant case for providing group-based projects with some aspect of externality within all projects. However, many academics in this area will attest anecdotally to the challenge of providing such projects, particularly for programmes with large class sizes. In this study we focus on the teaching and support team perspective across the different project contexts. Our research question is:

RQ: What are the challenges and benefits to different software engineering project contexts from the teaching team perspective?

1.1 Background

The SE Project at Queen’s University Belfast is a double weighted, two-semester final year module which is a requirement for the award of the degree of BEng in Software Engineering. The module is designed and managed by a module convenor and the teaching team, who currently source all the projects from contacts within industry or through collaboration with colleagues within the university, including external-facing initiatives. In addition, the module convenor provides the list of projects, allocates the projects, and provides general guidance, supplementary lectures, mentoring and additional supervision for many of the projects.

Our study focusses on two iterations of the module running in academic year 2020-21 and 2021-22. In 2020-21 there were 72 students enrolled in the module, most of whom were returning to the university from a year of placement in industry. Students took a range of projects with the majority completing group projects. Those students completing projects individually were granted this exceptionally and because of the impact of the COVID-19 pandemic. In 2021-22 groupwork was compulsory from the outset for all 50 students enrolled on the module. Project contexts across both year groups ranged from academic-proposed projects, projects born out of collaborations with academics or researchers in other schools, industry-provided projects and projects negotiated through the university’s community-engagement initiative, the Science Shop at Queen’s University [4]. A project list was provided at the start of each academic year with students bidding for projects. Project allocation by the module convenor was made largely based on the students’ choices.

While the module is managed by the module convenor there are several staff from across the University supporting the SE projects. All members of this team play an important role in negotiating a project proposal with colleagues in other disciplines, industry or third sector (non-governmental and non-profit-making organisations or associations). In this study we aim to capture the staff perspective of SE project contexts.

2 METHODOLOGY

The paper aims to investigate and reveal insights into the challenges and the benefits across different project contexts as experienced by the wider teaching and support staff of the SE projects. It provides a follow-up to a previous study on the student perspective carried out with the student cohort in the academic year 2020-21. The data collection occurred after the completion of the second iteration of the SE project module (in 2022) and as part of a module reflection and review.

2.1 Data Collection

As there was a small number of participants eligible for this study, a qualitative approach was used. Members of the SE project module team representing different roles and perspectives of the project provision, support, assessment, and delivery of the SE projects during the two academic years were invited to take part in a guided discussion, unrecorded, but with notes taken. The three participants (P1, P2, and P3) and their roles within the context of the project module are as follows.

Table 1. Focus Group Participants and Roles

	Role within Module	*Project Context*
P1.	Project Proposer and Supervisor	Cross-University
P2.	Project Proposer, Supervisor and Assessor	Community-based; Industry-supported; Cross-University
P3.	Project Negotiator, Proposer	Community-based

A set of questions was devised to investigate the challenges and benefits of the different project contexts. The following are these "guiding" questions which were used to inform the discussion but were not exclusive or rigid.

Table 2. Guiding Questions for Focus Group.

Number	*Question*
1.	How difficult is it to establish a scope for the specific project? How much effort is required to do this?
2.	Are there specific areas/times of high levels of supervision or input? Does this vary with context?
3.	Do you feel that the students got the opportunity to develop the skills required for the SE industry in the context of the projects you were involved in?
4.	Were you happy with your understanding of the project and module aims? Do you feel there is alignment/mismatch with the module convenor and/or the customer/collaborator? Are there challenges around this?
5.	Were you happy with the work the students completed? Is there room for improvement in how the project(s) worked out?
6.	Did the customer/collaborator get what they wanted from the project?
7.	How could the project be improved or provide more/better opportunity for students to develop the required skills?

A copy of these were sent to the participants before the meeting to give them the opportunity to reflect on their experience with the module. The module coordinator and author of this paper led the discussion recording notes from the discussions.

2.2 Data Analysis

An approach inspired by reflexive thematic analysis by Braun and Clarke [5] was used to highlight key aspects from the discussions and to draw out themes from the data. Braun and Clarke developed a systematic and rigorous approach to qualitative analysis using the approach of coding and theme development. A description thematic analysis approach was used due to the limited amount of data which aims at identifying features, patterns and finally themes within the data. The six phases approach proposed by Braun and Clarke was followed. Thematic analysis requires a high level of familiarity with the data, maintained by active curiosity and an awareness of bias influencing judgement. Furthermore, the recommended approach is work iteratively, looping back over the phases with a fresh view and increasing awareness of subjectivity. Each step may be completed several times before clear codes are established and themes begin to emerge.

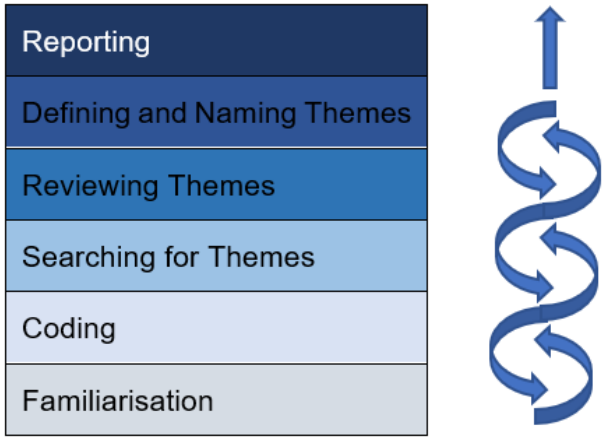

Figure 1. Six phases of Thematic Analysis by Braun and Clarke.

In this study, the notes from the focus group were read and re-read several times to development depth of familiarisation and engagement in the responses from the teaching team. The systematic approach of coding was then applied to the data, identifying and labelling features relevant to the study. This process resulted in the rejection of some of the data which was deemed irrelevant to the research question. All features were labelled and extracted. In the third step, codes were brought together, and overall themes began to emerge. This step was followed by several reviews of the themes. These two steps (searching for themes and reviewing themes) were carried out repeatedly and iteratively maintaining a curious and questioning approach until stable and consistent themes emerged.

2.3 Limitations and Threat to Validity

The investigator of this study was a member of the teaching team of the module and therefore could be considered as entering the study with a potential bias based on their own experience with the module. The participants responses were taken in note form rather than recorded which, additionally has the potential to influence the data captured. However, by providing the set of questions up front the discussion was very focused which maintained a high level of relevant data, reducing the amount of data recorded and likelihood that the investigator may self-select comments from the participants. The investigator recorded the data in note form as the participants responded to each question, sharing the notes with the respondents post-meeting for verification that the notes were an accurate reflection of the discussion. The thematic analysis proposed by Braun and Clarke is normally applied to transcriptions from recorded interviews, resulting in a highly complex coding process and high levels of data rejection. The approach used here is taken from the idea of thematic analysis but is not a true application of the process. However, the approach provided a systematic method to analyse the data. Furthermore, to mitigate against any internal bias, the investigator approached the analysis phase with a sense of curiosity and conscious awareness of possible internal bias, repeating the phases with a new approach each time before establishing any interim results from the analysis phases.

3 RESULTS

Four overarching themes emerged from the data, and these were Agreement of Expectations, Technical Constraints, Research and Scope, and Exchange of Information. Agreement of Expectations emerged as an overarching theme with the other themes directly relating to this central organising theme.

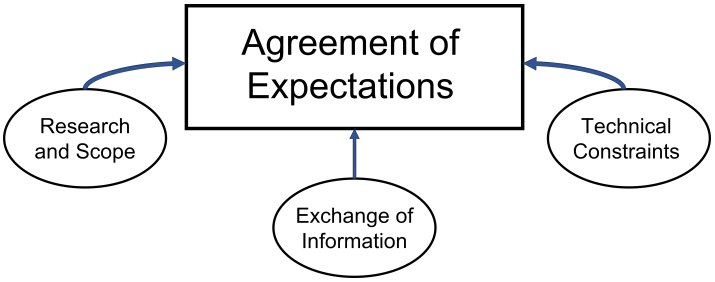

Figure 2. Thematic map of the study

While there is significant interconnectivity between all these themes, the codes largely fell into one of each theme, with all themes connecting to the overarching theme. Examples of some of the codes with their corresponding themes are shown below in Table 3.

Table 3. Example Codes and Emergent Themes.

Theme	***Data Excerpts***
Agreement of Expectations	*For projects which have an external source and particularly when they are proposed from a non-technical perspective there needs to be time invested up front.*
	The proposers […] may not have a clear or realistic perspective.
	Even academic partners from other areas have a good understanding of the academic requirements.
	[…] ensuring that the students wrap up their project to complete the module but also manage stakeholders' expectations
	[…] easier to manage collaboration within the University than with external partners.
Research and Scope	*[…] the ideation period takes most input as the students develop an understanding of the problem. Staff input is required to narrow down the problem.*
	The ability to research and problem solve were critical.
Exchange of Information	*The proposers don't speak the same language*
	[…] requests or information from clients need to be managed so that the project does not go out of scope
	[…] projects which have a multidisciplinary approach, the students are required to present to the client in another school
	[…] there is a significant growth of skills evidenced by the improvement in presentation and communication skills
Technical Constraints	*[…] takes a lot of time is setting up the technology but because the projects are very varied most academics are unable to support this*
	Students are keen to use current and new technologies, but these cannot always be supported in the University
	Currently there is limited support for students to develop systems outside of the school infrastructure which makes it a challenge to handover

Exchange of Information was a theme which was noted at various points throughout the SE lifecycle, but primarily within the initial negotiation and scoping of a project stage. Those projects proposed by academics or developed through established academic relationships were agreed to be the least challenging as both parties "spoke the same language" and expectations were largely aligned. Projects which required the students to discuss, negotiate, present, and respond to an external project proposer were noted as having developed their communication skills significantly during these processes. While much of this activity occurs during the "understanding the problem" and requirements elicitation phases, the project proposers were provided feedback and direction throughout the lifecycle to updates from the students on their progress. At times, it was noted, that some project proposers would ask for requirements to be added to the project late into the project lifecycle. This created a challenge to the project scope. The participants reported having to support students to push-back on such late requirement requests.

Regardless of the project context, the ideation phase of the project requires most support from the teaching team as reported by the participants. It was also noted that the development of research skills in students during the earlier years of study or on placement were beneficial to the **Research and Scope** phase.

From the analysis, **Technical Constraints** provided some of the greatest challenge as reported by the participants. This theme had several strands. Firstly, the participants reported that the diversity of the projects and the range of possible technological solutions meant that they found it challenging to both scope the initial project proposal and support the students in the technology set-up. This varied across the participants depending on their individual experience of the specific technologies identified for individual projects. It was also noted that students were keen to use technologies that they were either interested in learning for their future career opportunities or because they had had access to these technologies in their year of industrial placement. These were not always available to them within the University context. Restrictions were placed on the students due to the IT infrastructure provided by the

school or the University, and while some commercial solutions offered “free” solutions or tiers there was always a risk of the project inadvertently moving into a costing scheme.

There was significant overlap across the themes and interconnectivity between them, but all the other themes fed into the overarching theme of **Agreement of Expectations**. Agreement between academics, whether within the school or on a cross-university basis was most easily achieved with all parties clear that the module requirements (learning outcomes and assessment processes) where the central platform from which the project is established. As the externality increased, agreement of expectations became increasingly challenging, with a project proposed by a community or voluntary group with little technical expertise proving to be the most challenging. Moreover, there was an agreement that these projects should be handed over to their external stakeholders but that this was not always completed adequately. It was noted that in the final stages of the project, when focus for both students and staff are redirected more fully on the final assessment component of the module, this process was not always completed to the satisfaction of the stakeholder. This poses a substantial risk that project proposers may lose interest in collaborating with the team on future projects or express their disappointment to other potential project providers. Supporting staff also noted that they would have preferred to have more oversight of the assessors’ formative and summative feedback during the 2021-22 iteration in which the assessment was centralised to the immediate module teaching team. This was seen to be an opportunity to improve understanding and agreement around the project assessment expectations.

4 DISCUSSION AND CONCLUSION

This study has provided an opportunity to build on previous work which focussed on the students’ experience of Software Engineering project contexts [3]. Students had indicated a high level of enjoyment in projects that were provided by external sources rather than the traditional project proposal by an internal academic within that study. While they found it challenging to engage with “real” clients on projects, particularly those from a non-technical background, they also reported a strong sense of satisfaction of their experience of projects with an external context. In this follow-up study the spotlight was turned to the teaching staff and their experiences of the different project contexts. The participants included project negotiators, proposers, supervisors, and assessors. They were invited to take part in a guided discussion on their perspective of the different projects. Analysis, inspired by Thematic Analysis from Braun and Clarke [5], was carried out with themes emerging from the participant discussion. The overarching theme which became the central challenge from the staff perspective, was Agreement of Expectations. Projects conceived by an academic required least effort requiring only agreement between the academic, the module convenor and the student team. Projects developed through collaboration between academics in different schools proved to be only marginally more challenging in the initial task of defining scope. It was noted that academics, regardless of area field of research or teaching, usually have a common understanding of module requirements and have similar expectations about what a student project can be expected to deliver. Even though the discipline areas may be significantly different, academics will tend to “speak the same language” and have a common understanding of academic requirements. Projects, however, which are proposed from outside sources, require considerably more effort up front to establish a shared understanding around a project to set up agreement around expectations and requirements. Some of this effort is focussed on the development of a clear understanding of the problem underlining the project idea and then further refined into a realistic scope for a student project. This is particularly noted for project proposers from community-initiatives who may not have the required technical knowledge to understand the complexity of possible approaches to solving a problem. Managing and negotiating this kind of project can be time-consuming and complex but was stated as critical for the satisfaction and/or success of the project for both students and stakeholders.

Once a project has been scoped out and very high-level requirements agreed the project is made available to students. Final year capstone projects are often provided as a problem to be solved with minimal indication of the possible solution. It is part of the students’ requirements to carry out an initial domain analysis and requirements elicitation and to fully define and agree with the client the requirements which the student team will attempt to meet. Prior to the final year project students may not have been provided with a high-level problem to be solved that does not include a well-defined specification. Projects with only vision statements or aspirational concept will require the students to develop and apply research as well as problem solving skills. Teaching teams are often required to assist with ensuring that the scope of the project is feasible within the timeframe and with the technologies proposed.

The participants in the study agreed that working with a client can greatly enhance the students' communication and presentation skills. Throughout the duration on the project students will be expected to present their progress to the client and seek feedback. It was noted that these skills become greatly enhanced as the students progress through their project. However, one challenge that occasionally presents itself is that the external client will occasionally request additional functionality or features as they begin to see the solution take form. Teaching team members may be required to step in to assist students to manage these additional requests as they arise.

From the staff perspective, one of the most challenging areas is managing the technical aspects of the projects. Students are often keen to use technologies that either they have experience of from their year in industry or are actively targeting specific skill acquisition to enhance their curriculum vitae and opportunities in the job market post graduation. These technologies are often commercial products and may not be provided or supported within the school infrastructure or be available as a free tier for student project development. Furthermore, unless the academic has had exposure to the specific technology it can be difficult for teaching staff to provide useful guidance on the suitability of the project technical set-up. Project handover was flagged as a significant issue for projects with external sponsors due in part to the availability and access to the technologies used to develop the project. Additionally, students returned their attention to the assessment of their project in the closing weeks and did not always close and handover their project to their clients/project sponsor. In order to maintain the opportunity to work working with external collaborators, it is important that, were possible, projects are successfully handed over to their proposer.

One area of further study is to identify the range of technologies and platforms the students are choosing to develop their projects and to identify trends and suitable in-house solutions to support these choices. This makes the process of a handover to an external project proposer difficult or even impossible unless the proposer can provide support for the suggested platforms and technologies.

While project contexts that involve some form customer or client experience generates a significant challenge in terms of sourcing, agreeing, managing expectations, and supporting, the study participants agreed that the development of the students' skillsets was enhanced by the experience of working within a more realistic scenario. The greatest challenge of all might be in creating a sustainable pipeline of projects year on year.

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