COLLABORATION MECHANISMS FOR UNIVERSITY-INDUSTRY PROJECTS

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ABSTRACT
This paper outlines strategies for the effective implementation and support of university-industry projects. Sourcing projects from industry facilitates access to real-world problems, skill development and project management experience, and has become an increasingly popular feature of design engineering degrees. Despite this, there are many challenges in their implementation. The range of stakeholders can lead to differences in objectives and expectations; teams can struggle to manage and maintain effective progress; and it can be difficult to apply a generic academic format and deliverables when each project has its own unique challenges. This paper outlines current thinking in relation to Project Based Learning (PBL) and the issues with its effective implementation. It then reviews the approach at the University of Strathclyde, where an industrial projects scheme has been embedded in the curriculum for more than fifteen years. Specific strategies to the construction, timing and format of project milestones are outlined in relation to three 'learning loops' that support project teams without being overly-prescriptive. It is hoped that these will be of interest to other institutions currently running or thinking of implementing similar schemes.

Keywords: University-industry collaboration, product development, student projects, course design

1 INTRODUCTION

This paper addresses the dichotomies that emerge in university-industry projects and presents a series of strategies, focusing on effective supervision and client engagement mechanisms, that can help ensure projects run satisfactorily. Project work is increasingly used to help students integrate, apply and expand on knowledge gained from theoretical classes in their curriculum [1]. This approach has been formalised in educational literature as project-based learning: working in teams, students explore problems, develop solutions and create presentations to share what they have learned. According to Curtis [2], compared with traditional teaching methods this has many benefits including: deeper knowledge of subject matter, increased self-direction and motivation, and improved research and problem-solving skills.

Project-based learning is similar, but not identical, to problem-based learning [3]. They share more than the same abbreviation: they are both instructional strategies that are intended to engage students in 'real world' tasks to enhance learning; they are both student-centred approaches; and both include a facilitator or coach [4]. They do, however, differ in that project-based learning typically begins with an end product in mind and asks students to research, plan and design to reach this goal, while problem-based learning uses an inquiry model where students are presented with a problem, gather information and summarise their new knowledge- there may or may not be an end product [3]. Both are authentic, constructivist approaches to learning, but in the context of product development, project-based learning (referred to as PBL from here on) and its focus on the content, knowledge and skills acquired during the production process is the more appropriate method.

In setting project topics, particularly in a vocational field such as product development, the benefits of university-industry projects, such as Stanford's popular ME310 course [5], are well documented [6-8]. From an institutional perspective, benefits include access to real-world problems, exposure to current industry and enhanced standing in the community [9-11]. For senior undergraduate students, this can be an excellent vehicle to test their skills before entering the workplace. For companies, it can afford access to fresh ideas and university resources otherwise beyond their means. Despite the clear benefits associated with university-industry collaboration, there are a number of challenges in the set-up and execution of such schemes. This paper will therefore review current thinking on organizing projects, present the example of a scheme at the authors' host institution, and present strategies and guidelines for other institutions considering the implementation or revision of such collaborations.

2 IMPLEMENTING UNIVERSITY-INDUSTRY PROJECTS

One of the major advantages of PBL is the scope for learning team working skills within the project context. When coupled with the effect of introducing an external client with expectations beyond the usual academic criteria, this can lead to a very positive learning experience [9]. There can, however, be issues in aligning real project requirements to a course syllabus [12] and it is often desirable to provide clear signposts to ensure uniformity across a year group [13]. An overly prescriptive approach detracts, however, from the open-ended format that is integral to PBL and allows students to develop problem-solving strategies and conduct critical thinking. We therefore address the learning mechanisms of PBL and recognised approaches to delivery below.

2.1 Learning mechanisms

In engineering design, there has been a shift from strongly theoretical towards more learner-centred approaches which take account of human and social factors in the design activity [14]. This is in line with the general educational trend where social interaction (in this case in the design studio) is thought to be fundamental in developing internal knowledge [15-17]. While still assuming there is a process of assimilation from the supervisor, this recognises a "joint enterprise" [18] in learning. Previous frameworks [19] have illustrated how design knowledge is created and shared during the interactions between a design team, coaches, instructors and the product development activity. In the industrial project context, there are additional considerations: there is input from the client as well as normal teaching, and project management and project activity can be considered as distinct, with the management skills supporting and facilitating effective project activity.

2.2 Structuring projects

University-industry projects generally have a structure that will guide students through a development process during an academic year. Prior to this, however, it is necessary to source appropriate companies and topics. Massay et al [7] describe a 'Preparation, Identification, Action' cycle that means students actually research and identify the project requirements, and specify exactly what type of action team should be formed to fulfil the project. While this kind of activity is useful in assuring buy-in from all stakeholders, it is often impractical to devote such a significant portion of time to project preparation. Moving teams through a development process during an academic year is challenging, especially as students have limited experience in managing work of this magnitude. Structuring projects in a manageable way can include dividing work into a series of "mini projects" that address a series of pre-defined tasks appropriate for student skills [20]. A similar approach is a requirement for written and verbal progress reports upon completion of project "modules", to help guide students in a "timely progression towards the final project goal" [21]. Whatever the precise mechanisms employed, qualitative assessment can be challenging, and a range of formative tools and feedback mechanisms are required to reinforce objectives and expectations [13].

2.3 Challenges

Undertaking university-industry projects often involves a degree of compromise – student projects cannot run subject to the same conditions as normal industry projects and the different motivations of the various stakeholders can lead to compromises on goals, management and delivery of output [22, 23]. Students are still engaged in skill development, have limited industry experience, and over the course of a full academic year can become easily disheartened during the inevitable ups and downs of real-life projects.

It is therefore necessary to ensure there are robust mechanisms for communication between stakeholders and to support team progress without being overly prescriptive – each project is inevitably different. It is our position that key to achieving this balance is through careful consideration of project milestones and feedback mechanisms. In the rest of this paper, we will outline Strathclyde's approach to industry projects, and how milestones have been formatted to encourage a productive collaboration.

3 INDUSTRIAL PROJECTS AT STRATHCLYDE

At the authors' host institution, an industrial projects scheme that encompasses over thirty projects per year from a range of disciplines (including design, manufacturing and management) that relate to product development has been in operation for more than fifteen years. Projects run for the majority of one academic year (September - May). Briefs are developed during the summer months: once a brief has been finalised between the client company through preliminary discussions, the project is allocated to a discipline-specific team. Companies range from multinationals, SMEs and start-ups: several of these clients have been involved consistently but new clients are involved each year. Client relations are critical: significant emphasis is placed on project management, and the team is expected to take a best practice approach to documentation and coordination of all project activities. A company representative is appointed to liaise with the team and they are allocated an academic supervisor who provides support and guidance throughout the project, meeting teams once per week in the department studio space to discuss progress. In product development, the application of knowledge to creative thoughts and ideas allows the designer to develop innovative solutions, and it is therefore important to foster a creative studio environment to allow teams to share information and ideas in an informal atmosphere.

3.1 Project stages

There are four stages to each project (Figure 1) with associated milestones. At each milestone a meeting takes place, and formal feedback is required of the client company. This engages both the student teams and clients in presentations or meetings to reach shared decisions. This is not the only class students undertake: it is worth 20 credits and they are awarded 120 credits for the year. As a consequence, effort can vary significantly during the year due to exam and holiday constraints. General levels of effort based on observations over a number of years are indicated by the dotted line.

3.1.1 Milestone 0

Review and agree project brief with client, including objectives, deliverables and identification of any specialist resource, computing or facilities that may be required. In addition, the team should identify, create and begin utilising the project management tools (including Gantt charts, meeting minutes, task allocation, online shared working etc.) to allow effective working during the course of the project. IP is discussed at this time if appropriate, and the general agreement is that it resides with the client.

3.1.2 Milestone 1

A thorough investigation is carried out to define the parameters and criteria to take the project forward. This may be presented as a design specification, layout schematic, gap analysis, or other appropriate format. In addition, the team should have developed an in-depth awareness of the projects risks and mitigating strategies and developed a detailed client communication strategy plan – teams are required to submit a report dealing with these two aspects.

3.1.3 Milestone 2

The team typically develops a range of concepts and solutions to the particular problem, identifying avenues for development as the project progresses. For example, rendered CAD models may be generated, evaluated and presented to the client. A key outcome of this stage is clarity on final project deliverables, including a report on the innovation, commercialization and business impact elements of project.

3.1.4 Milestone 3

The final project solution typically includes a report which should be of strategic benefit to the client organisation, accompanied by supporting models or drawings as appropriate. Teams also submit a reflective report on the approach and mechanisms for project documentation, project planning and control, mechanisms for information management and key learning outcomes based on the project context. An industry presentation day, where all teams present, provides the opportunity to disseminate the work in a conference-type format.

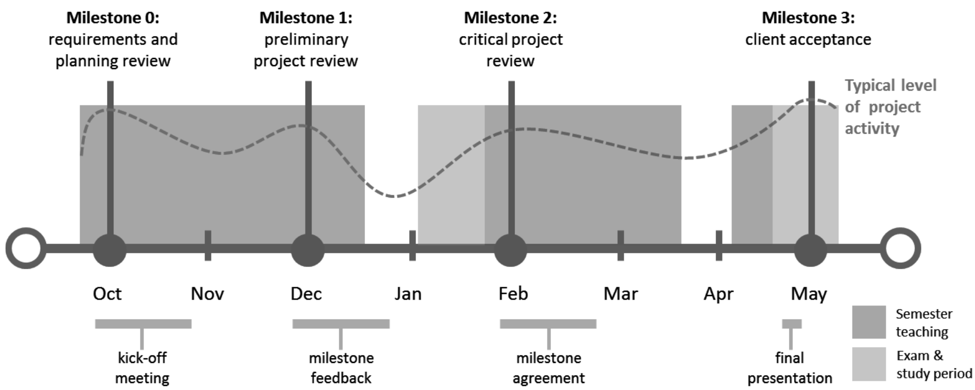

Figure 1. Overall project timeline, with milestones and typical effort

4 DISCUSSION

The overview of current literature and experiences at Strathclyde illustrate that PBL is well suited to the product development context. It demands the autonomy and initiative on the part of the learner that are necessary to become a successful designer or engineer, and its open-ended nature is reflective of the design process where there is no single 'right' answer. While all institutions experience structural issues in maintaining steady progress and effort through the design process, tangible milestones with clear deliverables can be applied at appropriate levels for the student cohort and problems set. The project topics however, are significantly enhanced by the utilisation of industry partners, which brings an authenticity and sense of responsibility that is difficult to recreate from purely academic requirements.

We therefore firmly believe that University-industry projects enhance the learning experience, but that the biggest challenge in the structuring of university-industry projects is to manage the different stakeholders involved. This centres on the team activity, supported by the client, supervisor and lecturer (Figure 2). In this section, we therefore review strategies for maintaining effective communication channels and how the teams' activities can be best supported. The aim of introducing the milestones was to formalize key mechanisms relevant to project management and to ensure progress throughout the year and to incorporate reflective thinking on team performance and approach. The milestones act as a conduit for several 'learning loops' relating to context, progress and assessment, and we address each of these in turn.

4.1 Loop 1 – Context

Loop 1 is concerned with setting an appropriate project context. A clear pathway for collaboration is critical in industry partner uptake and active participation during the university-industry project cycle. Projects are initiated through discussions between the lecturer and client organization. The balance between academic learning objectives and industrial outcomes is agreed at this point, as well as logistical issues such as time and financial commitments. IP and confidentiality issues are also addressed if appropriate. It is here that the philosophy of a joint enterprise is established, and the client should be made aware of the benefits as well as the responsibilities of involvement. The team reviews, refines and agrees with the client the precise scope and deliverables as the project progresses. Working on "real world" problems requires students to absorb new information and understand project parameters, a fundamental aspect of PBL.

4.2 Loop 2 – Progress

Loop 2 focuses on the mechanisms for ensuring the project is progressing as planned. The supervisor is pivotal in ensuring the team adopts and utilises the management techniques identified for Milestone 0 and 1. The guidance provided by supervisors at weekly team meetings is fundamental to establishing a consistent pattern of work during the year. Additionally, they are the mediator between the university and the client organization for the duration of the project. In attending the milestone meetings, they are able to retrieve feedback on client satisfaction, and to use this in team supervision. The learning comes from the application of management techniques, team-working, and use of discipline-specific tools and techniques.

4.3 Loop 3 – Assessment

Loop 3 is closely related to the formal assessment elements of student performance. Attendance and contribution at weekly meetings is recorded and considered at the end of the year as part of a peer weighting exercise. Learning comes from formal feedback on the milestone submissions. There are also a number of lectures delivered on topics such as risk management, client relations, innovation, and commercialization that students are expected to absorb and apply in their particular project contexts. Finally, the focus on solution delivery is a strong motivator and important experience – the open format of the final presentations and large audience acts as a motivator for students to perform at a high standard.

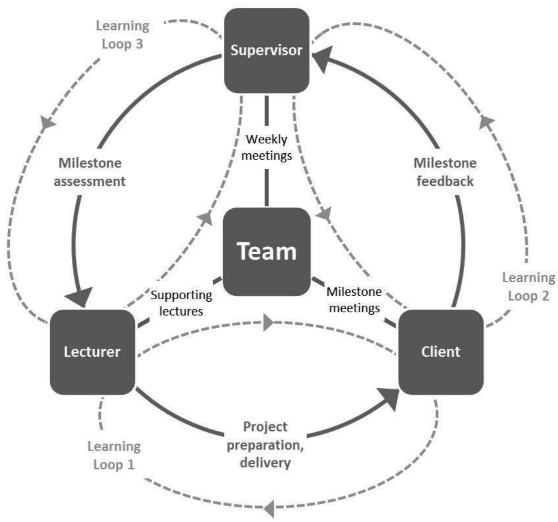

Figure 2. Stakeholders and their interaction during university-industry projects

5 CONCLUSIONS

University-industry projects provide a learning experience different from the other classes and projects that students typically undertake. The PBL experience, in terms of access to real-world problems, skill development, initiative, team working and project management, makes it a valuable addition to the curriculum. There remain, however, challenges in managing the different stakeholders involved and providing a robust academic framework for a range of unique projects. This paper has outlined the approach at the University of Strathclyde, developed through many years of running an industrial projects scheme. By identifying clear milestones, with mechanisms for feedback by all the stakeholders involved, and requesting specific reflective reports at appropriate points in the development process, it is possible to provide a structure that supports teams without inhibiting their opportunities to undertake innovative work. It is hoped, nevertheless, that the initial strategies outlined in this paper will be of use to other institutions running, or considering, similar university-industry projects.

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