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MANAGING INDUSTRY COLLABORATION: PROVIDING AN EDUCATIONAL MODEL IN A CLIENT-LED PROJECT

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ABSTRACT
Collaborative projects with industry partners are critical to the relevance and success of the Swinburne University of Technology Product Design Engineering course. Such projects permit student access to critical 'in-house' industry experience and provide critical analysis and feedback from a commercial, not just educational, perspective.
This paper examines the final year 'professional project' where students choose a project direction through the identification of a strong social need, then collaborate with industry partners(s) to realise a successful product outcome. Partners offer technical and manufacturing knowledge or an understanding of the market and user needs. Final outcomes are expected to be creative in design and innovative in the application of engineering theory, whilst meeting market needs and manufacturing objectives. The project is documented by a 16,000 word technical report containing the full rigour of academic research, design and engineering analysis.
Issues arise when student objectives and educational requirements conflict with the commercial constraints of the industry partner. The student's learning experience and creativity may be restrained by economic or manufacturing restrictions imposed by their project partner. The project intent must be carefully aligned with the expectations of all involved parties especially the technical partners who provide expertise and resources with the expectation of free research and development. Does the project result in design for production, or is it purely educational, albeit with a more informed commentary?

Keywords: industry-education interface, industry collaboration, project based learning

1 INTRODUCTION
Product Design Engineering (PDE) is an interdisciplinary course, a combination of two traditionally disparate disciplines: industrial design and mechanical engineering. This results in a graduate with diverse skills; the human centred design approach and scientific methodology of engineering. At Swinburne University of Technology, PDE is offered through collaboration between two faculties; the Faculty of Design and the Faculty of Engineering and Industrial Sciences across two campuses. The course aims to develop engineering graduates who are socially responsible, human-centred, creative and innovative, sustainable and relevant to industry.
The fourth year 'professional project' is self initiated and directed; students undertake research to determine a potential product with a strong social need, and then collaborate closely with industry partners whilst developing their designs. The project requires that design outcomes are critically analysed including design for assembly/disassembly, life

cycle analysis, finite element analysis and failure mode effects analysis. Projects must address humanitarian, environmental, medical and/or sustainable needs. It is expected that final outcomes are products without precedent, which represent sustainable practice, innovative human centred design and creative engineering.

This paper examines the task of facilitating the students' educational needs and the development of the design, assisting the collaboration process and managing the expectations of all parties; industry, student and university.

2 PROJECT OVERVIEW

2.1 Project Proposal:

Student projects are self-initiated and usually transpire in one of three ways:

(a) The student conceives the project, then seeks suitable industry and technical partners for support with technology, project definition, and user needs.

(b) Lecturers introduce students to appropriate companies who suggest a research project, usually one that applies their emerging technology to a specific need.

(c) Final year students are returning to study after a year of industry based learning gaining experience in their chosen fields. During their placement, students identify a project of mutual interest, ensuring a continuing relationship.

2.2 Project Approval

Projects are presented to a review panel consisting of design and engineering lecturers early in the first semester for approval and project guidance. This process ensures that the proposal meets the project requirements, is supported by informed industry partners and is of sufficient academic and design rigour to sustain the student for two semesters of activity. Students must have research findings that define and justify the project.

2.3 Industry partners

Students must develop effective relationships with industry partners. These partnerships facilitate technology information exchange, access to marketing and user demographics, manufacturing knowledge and support, and commercialisation opportunities. Initially the student requires market and technology information to define the product, later it is imperative that partners provide critical analysis of designs proposals, assist technology implementation and ideally, commit to product development after project completion.

2.4 Project outcomes

The project culminates in a 16,000-word technical report, a professional document of design, engineering and academic rigour. A model (or prototype) and a design folio containing development drawings and production documentation support the submission. At the end of the second semester design outcomes are presented to a review panel comprising design and engineering academics and representatives from industry. Student presentations outline the product need, the research and development process and must validate the final design

2.5 Research process

The research component of the project must include:

- project planning (Gantt charts)
- literature review
- IP /patents and standards
- ergonomics and human factors
- market analysis
- competitor product benchmarking
- user demographics and needs
- SWOT and PEST analysis

This extensive process is conducted throughout semester one, prior to conceptualisation. Students' research findings form the basis of their written thesis, and inform the product design specification, which describes project intent and product functionality. An interim 8000-word technical report is submitted at the end of semester one.

2.6 Design process

Concepts responding to the design specification are generated, presented and evaluated prior to the end of semester one. Concepts are then subjected to rigorous scrutiny and analysed against defined researched customer needs and proposed product metrics, before a concept direction is chosen for development. The design and development utilises the development methodology described by Ulrich and Eppinger. [1]

2.7 Design outcomes

As part of the product development process, designs must be critically analysed against established criteria including:

- design for assembly and disassembly (DfA)
- design for the environment (DfE) - including life cycle analysis (LCA)
- finite element analysis (FEA) for strength and deformation
- failure mode effects analysis (FMEA)

These analyses form the second half of the technical report. Manufacturing costs must be calculated (including tooling amortisation), and designs validated against identified market needs and the product design specification (resulting from the research phase).

2.8 Engineering outcomes

Full and appropriate engineering must support all student designs. As the course is multidisciplinary, aptitude in both design and engineering must be reflected in the final project outcome. The application of engineering theory must be documented through research, calculations, formulae and analysis whilst designs must use appropriate technology, materials and manufacturing processes and be resolved to prototype stage.

3 PROJECT ISSUES

3.1 Managing expectations

Of ongoing concern are the issues of balancing industry partner expectations against educational needs. It is essential that students, their technical partners and teaching staff achieve the correct balance between facilitating full student creativity and achieving a realistic and viable product outcome. The project should have commercial product potential but must offer the full scope of academic, engineering and design challenges.

Issues may arise when the objectives of the student and the educational requirements of the project clash with the commercial realities of the industry partner. Lecturers must ensure that industry partners are cognisant with project scale and understand their participatory role is more mentor than client. The learning experience may be limited by technical or manufacturing restrictions imposed by the industry partner. Students may need to extend the parameters of their project to express their potential and achieve an appropriate learning and product outcome. It is important for the industry partner to acknowledge that this is fundamentally a university project, not a commercial research and development program, and set their expectations accordingly. Involvement with the project is not a no-cost alternative to employing the services of a professional. [2] Whilst many of the student outcomes have excellent commercial potential, the designs will require significant development before the product is 'market-ready'.

3.2 Managing the collaboration

The issue central to effective industry collaboration is communication. Developing and maintaining collaboration with appropriate industry partners is essential to consistent project progress. Students often lack courage when approaching industry or maintaining effective liaison, particularly if they perceive their career prospects are under scrutiny. However, once contact has been made, it is often the industry partners who are difficult to contact or engage in the development process. It has been observed that students will forge ahead with the product development process without industry consultation for fear that engagement may lead to design revisions and an increased workload. In this case the direction of the project and the intent of the product is lost, adversely affecting the final outcome. Teaching staff must monitor the student-industry relationship carefully to ensure that effective communication is ongoing, the industry partner's feedback is informative and that appropriate levels of technical support are forthcoming. Students are required to document this process by maintaining a contact log of their consultations with industry support partners, in order to provide evidence of successful collaboration

3.3 Maintaining a realistic and achievable outcome

Projects must be carefully mapped to ensure that the intent is achievable in the time frame and with the available resources. Students must balance the expectations of others against their own abilities, their workload in other areas of study and the academic requirements of the subject. It has been our experience that project proposals require 'downsizing' to a more achievable level; e.g. a project starting as a vehicle interior targeting an aging population, may become an investigation of vehicular ingress/egress systems with the resultant design being a rotating-track seat mounting.

3.4 Ensuring manageable student workloads

Whilst this project is run over two subjects, it represents only a one fourth of the student's academic requirements in their final year, yet it consumes their workload and quickly becomes their focus. As it is the last major design project, students are determined to make it their major academic achievement and view the final outcome as essential to their career in product development. This can be to the detriment of their other areas of study and teaching staff must carefully monitor workloads to ensure that the project intent is achievable within the scope of the project and the student's abilities. Lecturer input during planning and implementation is crucial to ensure the project is manageable and achievable within the constraints of time and the student's ability

3.5 Effective Teaching Methods – digital learning

With thirty or more students engaged in product development, it can be difficult (with limited consultation time) to quickly evaluate a students progress and for the students to effectively communicate the details of their design. In recent years this project has been included in a Digital Learning Initiative, with students issued with a laptop, loaded with design, communication and project management software. Resultantly, students can utilise class time more productively to further their designs, communicate their project progress effectively and seek peer review and assistance. 3D-CAD, Internet research and data sharing are now part of the studio environment, greatly assisting teaching and teaching. Students are benefiting from improved communication and lecturers are more closely involved in the design development process.

3.6 Student Feedback

As found by Walsh and Murray [3], end of semester evaluations frequently do not reflect the student energy and enthusiasm experienced during semester. Feedback through on-line surveys often reflects student frustration with their project progress, workload pressure and timeline management issues. This is indicative of a student cohort that has, to a certain extent, been micro-managed throughout their course. Students in this self-directed project often struggle with project planning and direction. At this stage of their career they are not used to controlling the agenda and often expect lecturers to provide more direction and support that is appropriate. They are not always comfortable with lecturers taking redefined roles as facilitators and mentors, rather than traditional teaching approaches. However, it is critical that students 'own' the project and take full responsibility for the project outcome if the desired gradate attributes (entrepreneurial and professional) are to be achieved. Indeed, Palmer indicated that student dissatisfaction can be indicative that significant education has occurred. [4]

3.7 Intellectual Property

University policy allows students' full ownership of their design outcomes within their projects, students are also free to negotiate with industry partners to realise the product commercially. Teaching staff are often drawn into this process, helping both student and company define their respective contribution to the final outcome. Early in the project, a patent attorney provides lectures on intellectual property rights, to facilitate royalty agreements. Staff are often required to sign non-disclosure agreements with emerging technology partners, and specific details of a student's design are often precluded from display at the graduate exhibition because of the sensitive nature of either technology or application. Whilst these issues can be problematic and intimidating for students, they indicate that a commercial partner recognises the potential of the proposal and wishes to formalise the relationship. Well-articulated agreements can lead to successful outcomes for the student, including employment post-project and future royalties. A 2007 project (a medical diagnostic device) has progressed and a design consultancy been engaged by the industry partner to finalise development and oversee production. The graduate has been placed into the consultancy to project manage the development of her design.

4 PROJECT ACHIEVEMENTS

4.1 Designs into production

Whilst commercialisation is a desirable outcome, it is not intended that this project result in the manufacture of student designs. Students are often reluctant to engage any further in the development process having completed the academic requirements of the project. Students will utilise their project research and design documentation to prove their credentials for employment and after course completion, see the project as having achieved its purpose. In other cases, partner companies lack the funding or commitment to invest in prototyping, field-testing and pre-production development.

Despite this, many projects have proceeded further. It is anticipated that more than 40% of 2007 projects have industry partners keen to continue development to production. These products include revolutionary quarter-saw timber milling equipment, a foetal heart monitor, an innovative truck ingress/egress system, a molecular diagnostics device utilising microfluidics, a miniature MRI, and energy saving in air conditioning. Whilst it is rewarding to see student designs become commercialised, it is important for students and industry to understand that the learning outcome is more important in design education, than the project outcome.

4.2 Learning outcomes

The professional project succeeds as a showcase of student skills and abilities and provides industry relevant and commercially realistic outcomes. Students are able to demonstrate a wide range of design, engineering, liaison and project management skills that lead to increased employment opportunities. The project requires students to demonstrate initiative, develop entrepreneurial skills, and collaborate with industry partners and research organisations to develop an innovative product. Students are provided an opportunity to integrate knowledge and skills acquired during the course, in a design solution that includes mechanical engineering theory in a product context.

5 CONCLUSION

Working closely with industry partners develops real world methods and provides a validity and relevance to student outcomes. Students have the opportunity to benchmark themselves against industry standards in product design and development. The resultant designs incorporate emerging technology, new materials and sustainable manufacturing. Industry involvement in student projects has led to improved strategic relationships for the program, and provided new employment pathways for the student and their peers. The students' benefit from the relationship by being better prepared for the *practice of engineering*, through the opportunity to balance theory with real world practice. [5]

This experiential learning project allows analytical knowledge to be applied in a commercially realistic application with full industry analysis and thorough validation resulting highly desirable graduate attributes and employability. As found by Dutson *et al.* [5], the success of capstone projects such as this can be measured through the interest expressed by industry in graduates who have experienced such a rigorous process. The professional attributes developed through this project facilitate employment in higher-level positions, and more rapid career progression into management.

The professional project outcomes express all the attributes we expect of future engineering designers; a human centred approach, ethical and sustainable practice, creative design and innovative engineering and relevance to industry. It allows the 'client' to lead the product agenda within a carefully controlled learning environment whilst imbuing the student with responsibility, independence and management skills.

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