# A Student Project Development for Multidisciplinary Programs at Otago Polytechnic

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## Structured Abstract

### BACKGROUND

Project based Learning (PBL) emphasises learning activities that are long-term, interdisciplinary and student-centred. Project-based instruction differs from traditional inquiry in its emphasis on students' collaborative or individual artefact construction to represent what is being learned. Industry oriented teaching and learning incorporates an industry perspective, ensuring closer alignment with industry requirements. Otago Polytechnic students are currently developing a project for a sustainable small scale building with solar electricity generation and rain water collection. The project includes students from design, construction and engineering and provides an opportunity for hands on, industry relevant, experiential learning.

### PURPOSE

The aim of the paper is to discuss how a multidisciplinary experiential project can support industry oriented teaching and learning and provide an alternative to a more theoretical, classroom based delivery model.

### DESIGN/METHOD

The project is to build a 10m2 building/studio which will be used by students as a bookable study space. A photovoltaic solar array will provide power for laptops and monitors in the building and rain water collection is included to provide water for the Otago Polytechnic's living campus vegetable gardens. The project is industry oriented and research based involving the collaboration of students across disciplines including; Interiors and Product design, Construction management, Carpentry and Structural engineering, Electrical and Electronic engineering. It provides a showcase to students, staff and the wider community while being a catalyst for deep contextual learning. The impact of this multidisciplinary project on teaching and learning is evaluated through the use of a student survey and the observations of staff.

### RESULTS

At its core the project engages students with stakeholders, as represented by their varied study areas, and builds a dialogue across these disciplines towards a common resolved and constructed outcome. This learning opportunity creates opportunities for students to experience significant connections with the wider industry disciplines. Initial feedback from design and construction management students suggests deep engagement with learning within this multidisciplinary, collaborative and applied environment.

### CONCLUSIONS

The construction of a functional prototype enables students and their supervisors to explore industry specific learning outcomes within a multi-disciplinary research experience. This experience provides opportunities for learners to be engaged in industry oriented research and build skills that respond to unique and innovative new technologies.

### KEYWORDS

Industry Oriented Teaching and Learning, Multidisciplinary programs, Project based Learning, Situated Learning, Communities of Practice

 

## Introduction

Project based learning emphasises learning activities that are long-term, interdisciplinary and student-centred. Project-based instruction differs from traditional inquiry in its emphasis on students' collaborative or individual artefact construction to represent what is being learned. Industry oriented teaching and learning incorporates an industry perspective, ensuring closer alignment with their expectations and requirements. This paper explores how a multidisciplinary project-based approach can support industry oriented teaching and learning and offer an alternative to a subject-based delivery model. This project is ongoing at the time of writing and this paper discusses and evaluates the design and project management planning phases of the project.

## Project brief

The ten square metre (10m²) building project was initially developed for third year interiors and product design students. The concept evolved from a desire to provide an exercise that would give interiors students the opportunity to realise their design concepts in a finished prototype building. In the first semester of 2014, teams comprising Design and Construction Management students worked on the design, costings and project management phases of the project. Carpentry students will start the build phase in semester two, supported by engineering technology students working on electrical and smart control systems.

The limit of 10m² internal floor area meant that the project could proceed, under current New Zealand building legislation, without the need for building consent or the involvement of registered building practitioners. Otago Polytechnic is funding the building which will be constructed on site as a student study space and a showcase for collaborative cross-disciplinary teaching and learning.

## Project conception and design

Project based leaning is not a new concept for design students however the resolved project is typically an amalgam of presentation and developed drawings that respond to a project brief. It is not usually possible to realise the physical design due to scale and cost. The 10m² project follows this same format but with the expectation that the structure would be erected if the design was accepted by Otago Polytechnic's leadership team. During the project development phase the student design team worked closely with the construction management team and carpentry lecturers to add value to their concept. Both teams became part of a wider community of practice within the general fields of construction and architecture which added a new dimension to their learning experience. Wenger (2009) acknowledges communities of practice as fundamental components of social learning systems bound by a collective understanding or sense of joint enterprise. "Communities of practice grow out of a convergent interplay of competence and experience that involves mutual engagement. They offer an opportunity to negotiate competence through an experience of direct participation" (Wenger, 2009, p 229).

A community of practice is a key element in situated learning or 'learning by doing' placing the practice in the context of a shared domain of interest with common goals, shared resources and shared experiences. A community of practice integrates relationships, identities, shared interests and a repertoire of resources and is much more than a grouping of technical knowledge or skills associated with the task (Smith, 2003, 2009). As the 10m² project developed, so did the community of practice - extending beyond the student teams to allied disciplines, trade suppliers and consultants and included significant engagement with the Chief Executive and leadership team of the polytechnic.

As design students participated in the project, there was an observable increase in their sense of worth regarding their skill set, in their project focus and levels of engagement. The excitement and feeling of validation experienced when the team first saw their design appear in the course outline for construction management and again after meeting with the Chief

Executive and getting his approval to commence the project, was very different to previous measures of success. This validation could be viewed as equivalent to a high grade, but the reality was that the high grades awarded for the project were not valued as highly as they might have been when compared with previous projects.

Receiving a 'real' project from the offset was a source of motivation for students and having met the assessed requirements for the course they remain engaged with the project. They demonstrated increased integration and apparent understanding of construction systems that were not included in the formal course content or had been addressed in their study from previous years. Jakovljevic, Buckley and Bushney (2013), maintain that knowledge creation can occur when tacit knowledge is shared and integrated through networks of social interactions that are present in communities of practice. The 10m² project has been an opportunity to create a community of practice around an authentic student learning experience, drawing on skills, experience and expertise across the institution.

## Construction management planning

The managing of an authentic construction project in-house provided all the benefits of real-world learning, while overcoming the typical barriers associated with loss of control over the learning environment when engaged in industry practicums. This part of the paper sets out to explore these benefits.

Traditionally construction management students have worked through three assignments, responding to questions or problems in order to demonstrate understanding of construction management principles. The 10m² project involved a new approach with each student required to compile a portfolio of evidence collected over the four months of learning and submit this as part of their overall assessment. Students worked in teams and sub-teams to perform the tasks with each student submitting an individual portfolio comprising of a Project Charter, Project Management Plan, and Project Close-out Report. This was loosely adapted from a post-graduate Construction Project Management paper completed by the lecturer through Massey University. A similar model was used for a collaborative team assignment with students asked to score each team member's performance using a matrix. In the Project Close-Out Report, students evaluated the project against how well it achieved its goals and objectives, and included a lessons learnt report covering; what went well, what was unexpected and what would you do differently next time?

The Project Management Institute (2013) model applied to this project involves a six-part process for project integration management;

1. Develop Project Charter
2. Develop Project Management Plan (content)
3. Direct and Manage Project Work (changes, performance activities - corrective action - tangible outputs to achieve objectives)
4. Monitor and Control Project Work
5. Perform Integrated Change Control
6. Close Project or Phase

The Project Charter is used to give the project identity and provide the project manager with authority (Vaidyanathan, 2013). Students developed their own project charter assigning one the role of Project Manager. Rather than simply being given information and activities to complete as would have happened in previous years, students worked through problems, asked for information, recorded their own minutes, and organised their own site inspections and meetings. They prepared a project budget in their Cost Planning class run by another lecturer and developed the range of documents which make up the Project Management Plan. The Responsibility Assignment Matrix was used to assign each of the project management documents to teams of three or four, with each team having approximately three plans to prepare. One feature the lecturer observed was that the students allocated the planning documentation based on individual strengths and weaknesses of team members. For example, developing the Method Statement was assigned to students who had extensive building experience. The project manager role was assigned to a student who was currently working part-time, measuring and pricing work for a flooring contractor. This concept had not been taught.

Students then prepared a list of Requests for Information. Construction management students had to interpret the design and analyse it against what was required in order for it to be buildable, identifying any gaps in scope. Indeed, their Risk Register identified a key risk as the amount of undefined scope especially in relation to ordering long-lead items. Windows, doors, and roofing need to be fully detailed in order to have them priced, ordered and delivered, and students learnt that delivery could sometimes take a month or more. It was also identified that the design was outside the Acceptable Solution of NZS 3604 and would require a Specific Engineer's Design. This lead into a discussion about the use of a Producer Statements, and it was established that a Producer Statement-PS1-Design, commonly known as a PS1, would be required. This was provided by a senior lecturer from the Engineering programme.

## Key aspects of the learning experience

As previously stated, the community of practice which developed between students through their independent and interdependent learning, extended across schools and departments. The Construction Management students liaised with the Design and Carpentry lecturers to resolve issues around scope and buildability. They also liaised with other lecturers including their Cost Planning lecturer and lecturers from other departments such as Design and Engineering. Students not only participated in real work-based learning and learnt the individual roles of project participants, they also shared their learning process with other participants.

Project management is by nature, team oriented (Vaidyanathan, 2013). In construction projects, work-packages are usually allocated to teams who take responsibility for carrying them out. Each work-package can be considered a sub-project in its own right. Communication channels are established between teams, such as head contractor, subcontractors, and consultants. The team-based approach created a different experience where students were able to take greater responsibility for their own learning. Zepke, Nugent, & Leach (2013, p124) sum this up in the statement "Let us rethink self-directed learning. Let us include "learning with others" as self-directed learning." Drawing on their experience with the on-line learning environment, they go on to say that educators should "create efficiencies in communication by organising participants into small groups and establishing rapport with each group." (p 147). Project-based learning enables students to learn the skills of project teamwork and managing communication through actually doing it, rather than being taught about it.

By participating in the development and integration of individual project plans, students were subjected to a higher level of learning. Bloom's taxonomy recognises that students achieve a higher level of learning through understanding the relationships between the elements learnt at lower levels (Biggs and Tang, 2007). For example, level 6 diploma learning involves interpretation and application of documentation for problem solving, based on lower level learning where unrelated elements are delivered. This correlates to the integration of individual project plans into a comprehensive project management plan. The team work required for construction project management also develops employment skills and helps facilitate deeper learning through better engagement. Indeed Zepke, Nugent, & Leach (2011) assert "active learning on short or longer- term projects, with students working in groups, develops peer relationships and social skills that are important in engaging learners." (p187)

## Learner engagement and deep learning

Hockings, Cooke, Yamashita, McGinty and Bowl (2008) identified that engaged learners are deep learners and that engagement is more effective when the learning is authentic and project-based. Boss & Krauss (2007) agreed that from a student's perspective, nothing beats the real world to generate interest. Laur (2013) also found that authentic learning experiences, where the students gain their learning through application to real world situations, provide the highest level of engagement. His law students investigated actual legal cases, writing letters to real individuals and getting responses from them. In the same way, construction management students navigated their way through an actual construction project, corresponding with real people and making real decisions. Unlike a class room simulation, the outcomes for each were not pre-determined and the dynamic between lecturer and learners changed. In the same way as Laur (2013), "became the facilitator of my student's learning, while my students became the directors of their own learning experience", the construction management students became the project managers of their learning experience with the lecturer reduced to project sponsor. The inclusion of authentic project work allows students to view their lecturers as collaborators in their learning. This approach is supported by Zepke, Nugent, & Leach (2013, p86) who "advocate much more learner and teacher collaboration in decision making."

From a lecturer's perspective the prospect of facilitating a real construction project with fifteen students without prior experience, would be daunting. However, as Boss & Krauss, (2007) explain;

> "Both lecturer and student had to navigate new ways of working together as the project unfolded, but it didn't hurt that students saw their lecturer trying new approaches and taking risks as a learner."

Project-based learning can be compared to the learning achieved in industry work placements. Howlison and Finger (2010) note that the cooperative educational placement model which combines classroom-based education with practical work experience, is supported by both Kolb's theory of experiential learning and Beckett and Hager's (2002) new paradigm of learning "whereby learning is activity and experienced based." (p2). However Howlison and Finger warn that cooperative educational placements must be well managed in order to embed reflective practice into the students learning. Forsyth (2012) found that "students in construction management often work and study concurrently but this is often undertaken in an ad hoc way that does not derive the benefits of the potential synergy between the two." Hardie (2012) also noted the challenges posed by industry-based learning in construction management programmes. These include the assessment of learning, how students obtain industry placements and the variance between roles and practices across the industry. Solutions such as the use of an online forum can facilitate reflective practice while students are off-site on work placement, however these barriers are more easily overcome where the real project-based learning is conducted within the educational institution. In effect, the lecturer adopts a dual role, both that of project sponsor, and that of educator. In order to derive maximum learning potential from the project-based experience, the lecturer needs to have a sound technical knowledge of construction management as well as an understanding of how to embed reflective practice into the students' learning experience.

Through experiential learning, students use reflective practice to critically review their experience (Zepke, Nugent, & Leach, 2011). During this project students reviewed their work and critically reflected on their experiences at the beginning of each collaborative planning meeting. Being together for this process, allowed students to discuss current issues. Indeed the lecturer encouraged and sometimes facilitated such discussions, for example, when the initial budget prepared and submitted by the students came in unexpectedly high. Students were able to discuss whether they felt under pressure to reduce the budget, knowing that their project may be at risk of early termination. This issue reinforced the need for Quantity Surveyors and Construction Managers to act impartially. Brookfield (1995) explains that reflective activities are often more productive when others are involved with different perspectives adding value to the learning.

As the project developed from conceptual to detailed design and onto construction, students loosely followed Kolb (1984)'s four stage systematic approach.

1) The student had actual experiences. For example, they may have heard debate, pursued documents, and participated in strategic planning. This is referred to as the "concrete experience."
2) Students reviewed their experiences in the first part of their weekly strategic planning meeting. Each team read out what activities they did for the week. They were also encouraged to make reflective entries into a journal, which would form part of their lessons learnt report in their close-out report. Students also discussed issues from what they had been working on with their team mates. This stage is called the "reflective observation."
3) Students drew conclusions from their experiences. They compare their experiences with others they may have had, and identify whether the experiences confirms or changes their set of ideas. This is called the "abstract conceptualisation" phase. In the Close-out Report, the students were asked to reflect on what went well, what didn't go as expected, and what they would do differently next times. It could be said, these questions capture the essence of abstract conceptualisation.
4) The fourth stage involves planning to use or apply the conclusion. Objectives may be set, planning for new experiences, and planning for change. From this the cycles begins again. This is called the "active experimentation." In the one and five-week look-aheads in their weekly collaborative planning meetings, students used the information they had gained from monitoring and reviewing progress, to establish short and medium-term goals and objectives.

The Project Close-out Report (including what went well, what was unexpected, and what would you do differently) is also similar to the method of monitoring progress for reflective practice described by Zepke, Nugent, & Leach (2011); "Diaries and reflective journals are very good. Used regularly they enable you to keep a close check on progress. Just note down details of what you planned, what happened, and what you learnt."

## Results

With the design and construction management planning phases complete, students were asked to reflect on the project using a simple survey tool comprising eight questions including: how the project-based learning differed from their usual learning, whether they gained a better understanding of the professional requirements of their industry and profession and whether they preferred the multi-disciplinary project-based to other delivery models. They were also asked to suggest how the project could be improved.

The opportunity to work with real clients and even a real space was not new for design students however this project introduced two critical elements which transformed their learning experience: collaboration and a buildable outcome.

The formation of the design team comprising three Interiors and one Product Design student was an initial exercise in collaboration as the students had not worked together before. In order to respond to the brief, the team engaged with construction management students and lecturers, the client, a structural design engineer, energy and building consultants and suppliers. This collaboration reinforced the idea that designers do not work alone. The prospect of a built outcome meant students faced the ultimate challenge for a designer – incorporating the client's brief with user needs, within a budget while still retaining a strong creative vision for the project. One student explains this as having to "communicate our ideas more clearly to share our vision, to make real monetary decisions, and to justify our decisions and our design to both ourselves and many others".

This project highlighted the need for a more professional approach to communication with another student commenting that, "working across disciplines teaches the importance of communication, an understanding of professional practice with meetings, documentation, regulations". The reality of a built outcome reinforced the importance of compliance and engendered a new respect for the building code. It forced students to focus not only on the concept but on the "pragmatic realities of construction" such as detailed construction methods and materials. The application and integration of sustainable systems and solutions into the design led to a deeper analysis and understanding of the environmental impact of their choices.

Students discussed how much more engaged they felt during the project and described it as an opportunity to integrate two years of learning with the skills contributed by other disciplines. Finally they expressed a deeper sense of purpose and responsibility to create the best possible outcome and to design something that had a positive effect both on users and the environment.

In contrast to the single design team, students from construction management planning were divided into four teams covering a range of critical areas such as health and safety, quality management, budget, risk management and document control, base programme and method statements and procurement planning.

There were fourteen construction management students involved in the 10m² project and all commented on the benefits of an integrated project based on a real build compared to classroom learning and theoretical assignments. One student commented that despite having covered some of this content in other classes, the project-based approach meant he was able to learn more quickly and easily.  Another student commented that the "practical experience of a physical project with all the associated anomalies gives a better understanding of the constraints". Others felt that they had gained a much more realistic idea of construction processes, project timeframes and the importance of clear documentation and communication.  The teams worked closely with suppliers and subcontractors, emphasising the importance of professional communication.

While students enjoyed working in a team, some commented that they may have missed out on learning about roles and tasks allocated to another team. Some would have like more detailed drawings and specifications from the design team and there were several students who suggested the need for templates to assist with different aspects of the planning.

Overall construction management students said they felt better prepared for working in the industry having been involved in this project and they would like to see more project-based learning opportunities in their programme.

## Conclusions and recommendations

This multidisciplinary project is ongoing and now entering the construction phase where opportunities for further feedback and evaluation will arise.  Through this model students receive the benefits of an industry practicum with lecturers on hand to ensure that content is relevant and that reflective practice approaches are incorporated into the learning experience. They take greater control of their own learning and gain skills in team work and problem solving through application. By collaborating with other project participants they gain a more realistic understanding of project roles and timeframes and standards of professional practice and become more valuable to future employers. Belief and self-confidence are powerful motivators and this learning experience has provided students with the opportunity to integrate their learning within a community of practice. This pilot study has highlighted how managed coordination of the project programme can be dovetailed with learning outcomes across disciplines to provide a platform for a deeper, more authentic learning experience. This model for situated learning has applications for multidisciplinary projects across a wide range of learning disciplines.

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