Full Paper

Introduction

Many academic programs apply Project Based Learning (PBL) principles, and subsequently discover that appropriate student project selection can be a challenge when class sizes are large. (Ivins & Holland, 1999), showed that multidisciplinary project teams provided advantages as a project team by providing for: a project development tool, rapid prototyping, cost reduction, and the design of a more marketable product. Applying such a project team in an educational programme gave advantage in enabling the students to work in such a team. The main challenge for educators is in fact to provide such an experience for their students, an experience that ranges from cultural through logistical to the level of intellectual rigour required.They described the research methodologies and results of an investigation into the operation of a large multidisciplinary team project over a period of two years, with two sets of undergraduates, each consisting of more than 180 full-time students drawn from a number of engineering, design, and design management disciplines. Their findings supported the view that the exercise provided a wide range of tangible and intangible benefits (Ivins & Holland, 1999).

Rullkoetter, Whitman, and DeLyser (2000) introduced a case study where four students worked together in an interdisciplinary team, following a request to design and build an autonomous- vehicle project within specific constraints and requirements. The project development included an autonomous surface vehicle capable of navigation using a Global Positioning Satellite (GPS) navigation system. The test vehicle tagged a series of specific locations and then returned to the original position. The team gained experience in the essential skills of the design process along with engineering project management, including teamwork, scheduling, resource allocation, cost analysis, reporting, and documentation.

Davidson and Hicks (2002) invited thirty-six students to form in nine project teams. The projects required machine design, machine development, design for manufacture, process design and the design, development and implementation of manufacturing software. Each project was multi-disciplinary with each team member engaging in both engineering and management tasks.

Qi and Cannan (2007) designed an industry-oriented and multi-discipline undergraduate degree which including a multi-discipline project at the final year of the degree program. This program enabled multi-discipline projects for the students from automotive engineering, marine technology, building technology and electrical engineering. Hasna (2010) proposed a methodology for Capstone Engineering Design Projects by applying a Social, Economic, Ecological, Technological and Time based (SEET) framework.

Often when a multi-disciplinary project is used for a large size class, the projects are very often small in size but overlapping in the research aims. Many projects were proposed by students and some could be outside of the staff members' expertise area.

Recently, Otago Polytechnic completed an interdisciplinary project (Qi, Terpstra, & Findlay, 2014) for Electric Vehicle research which included students from product design, mechanical engineering, and electrical engineering. Another Otago Polytechnic student project (Finnie, Fersterer, Qi, & Terpstra, 2014), in 2014, involved design students and construction management students in the design and creation of a 10m2 building. This size of building was used because in Otago it does not require compliance approval under a building consent. Using this project as a base, a further proposal has emerged to enable inter-disciplinary student projects from academic programs in the fields of architecture, construction, civil engineering, mechanical engineering, electrical engineering, and sustainable horticulture.

This paper is to discuss that a large-scale project team such as this is able to offer many spaces with a wide range of practical project topics. The on-going multi-disciplinary team will ensure that new team members can reuse the resource, and provide for on-going research.

Overview of the proposed project

The ten square metre building is to be equipped as a sustainable building or eco-building. The building will be fitted out to harvest energy and rain water, and supply and usage information will be collected around the quantity of energy and the volume of water collected. This data will then be matched with usage information so that the energy harvest through solar and wind turbine along with the water harvest can be designed (matched) and optimised for such a sustainable building.

There are two design aims for this building: The first is for a standalone building, which includes smart-grid, electric vehicles, rainwater quality control, wind power, hot water system control, and solar hot water system control. Most of the design and prototyping developments suit the students from undergraduate and trade programs. To enable post-graduate student projects, the research goal is expanded to make use of built-in sensors e.g. temperature sensors, humidity sensors, gas meter sensors, water meter sensors, electric power meter sensors to provide localised information. Information from geographic information system (GIS) and weather forecasting information will also be used in the design of a system control optimizes the uses of the energy sources in different conditions e.g. where, when and cost. The second design goal is to utilise the data collected from the standalone building adapted to a small community housing project. The environmental data is able to be extended and an operational control developed which optimises the energy and water harvests and usage for a small social network which can share the energy and resource. For example, there are 12 buildings in a village. As the buildings are in varying locations, the quantity of solar energy and rainwater harvest are different. The individual buildings have varied demands of energy and water. The social network is able to share the resource.

Otago Polytechnic has built a prototype of ten square metre building. The students will design and optimise the installation of the temperature sensors, humidity sensors, air quality sensors, water meter sensors, and electric power meter sensors in the building. The data will be collected in real-time from these sensors and fed into the processors. The processors are also making use of existing geographical information and will in turn be collecting weather forecasting information.

The final stage will be the development of a mathematical model and algorithm based on the real-time data collection. The control is to activate the solar and wind harvest and rainwater collection in an optimized usage.

The socio-economic objective is to use renewable energy to help build an efficient and sustainable building and society.

Analysis of specializations within the proposed project

This proposed project will be multidisciplinary utilising the knowledge and skills of students and staff from the following disciplines.

Architecture and design – to design and modify the building (building completed but additions to be made to house harvesting tools and data collection)

Mechanical engineering – to design and build the mechanical devices e.g. the built-in PV panels, wind turbines and water tanks.

Electrical engineering – to design and build the electrical cabling and control systems
Horticulture – to design and optimise an environment including local gray waste water treatment.
Above is a primary list of the major tasks of the specializations. However, the reality is that the students from different specializations have to work in a team which is a Multidisciplinary project team.

Academic Programs involved in the proposed project

Otago Polytechnic offers a wide range of programs from trade certificates, diplomas, undergraduate to post-graduate level. All programs selected to this proposed project offer industry oriented project based learning e.g. Master of Design Enterprise, Bachelor of Engineering Technology, Diploma in Architectural Draughting, National Diploma in Construction Management, National Diploma in Quantity Surveying, , and National Certificate in Horticulture Landscape Construction or Sustainable Horticulture.

Master of Design Enterprise

The Master of Design Enterprise (MDE) is an 18 month programme of scholarship and applied research, providing education that supports and implements the integration of design, as a necessary and accepted component of the competitive design-based manufacturing business and the wider value generation process.

This is an ideal opportunity to combine design thinking with engineering technical knowledge to further develop an engineering concept in both a customer focused business oriented manner.

The MDE programme employs a collaborative methodology and approach which values the educational inputs gained from interaction with professionals and practitioners working within all facets of the design, manufacturing and marketing business process.

The MDE programme promotes conscious and strategic design as a powerful creative enabler of innovation in products, services and environments that satisfy people's needs for functionality, aesthetic pleasure and meaning.

The MDE holds 'creativity, innovation and entrepreneurship' as key and essential elements, central to all learning and methodologies used in the programme. Multi-disciplinary design interaction, criticism and debate, is promoted and used as tools to enhance the creative and innovative abilities and perspectives of the design graduate students of the masters programme.

This program consists of a taught course, a 3-month project and a 12-month project. These projects are industry oriented.

Bachelor of Engineering Technology

This is a 3-year engineering degree program, based on the graduate requirements of the Sydney accord of the International Engineering Alliance (IEA) with majors in civil engineering, electrical engineering and mechanical engineering. The graduates are in high market demand around the world for their skills and experience in combining engineering theory with the applied and practical components required in a range of industries. They gain skills in management, economics, communications, problem-solving and critical thinking, while developing a deep understanding of the principles and practical application of modern technology in their area of specialisation, at their final year of study, students have a 0.375 full-time equivalent project within their specializations. The students have the opportunity to participate in a significant industry-based project in order to gain experience within the workplace.

New Zealand Diploma in Engineering (Mechanical Engineering, Electrical engineering and Civil engineering)

The New Zealand Diploma in Engineering (NZDE) is a 2-year engineering program based on the requirements of the Dublin Accord of the International Engineering Alliance. This programme has a 0.125 equivalent Full time Capstone project within the program framework. Project based learning is embedded in the whole program.

Mechanical Engineering involves the design, manufacture and management of engineering projects and equipment maintenance. The industry has experienced substantial growth over recent years due to developments and globalisation of engineering design, research, technology and manufacturing processes. This qualification has been designed to provide specialist technicians and technical engineers in the mechanical engineering industry, and many of our graduates secure employment before they even finish their qualifications.

Electrical engineering graduates undertake a wide variety of work ranging from the design and programming of PLC's in industrial applications to the design and commissioning of complex building services or electrical distribution installations. Roles include project management, maintenance management and contract management as well as general hands-on electrical engineering problem-solving. There is presently a significant shortage of trained engineers and qualified technicians are in high demand for their skills and experience. Use this qualification to gain the necessary expertise and supply the demand; New Zealand-trained engineering graduates have a good reputation worldwide for their work-readiness and high calibre.

Diploma in Architectural Draughting

This is a 3-year program with project based learning. As the population steadily grows, so does the demand for construction and that requires skilled technicians to produce accurate drawings both here and overseas. The graduates can present themselves within construction firms, local authority and government agencies or property development and management companies.

This internationally-recognised qualification focuses on the skills required of an architectural technician such as providing assistance in the process of producing design, presentation and contract drawings, seeking client approval, obtaining building consents and enabling the construction process to progress with ease. The students also complete the National Diploma in Architectural Technology as part of this program.

National Diploma in Construction Management

This is 2-year program with project based learning. As the global population steadily increases, so does the demand for proficient tradespeople to accurately and efficiently complete building projects. The graduates are in high demand within construction firms or property development and management companies. Employment in project management could be another possibility.

Develop a solid technical understanding of construction, site management techniques, measuring, estimation and communication skills, the students gain valuable insight into the profession by working through problems taken from real-life scenarios.

National Certificate in Horticulture, Landscape Construction or Sustainable Horticulture

This is a one-year program with practical skill based training. New Zealand's diverse and robust horticulture and related industries have experienced steady growth over recent years and this looks set to continue well into the future. This means that qualified and experienced horticulturists in any specialist field are in demand across the country and this programme will provide the graduates with an excellent grounding in the principles of horticulture with the flexibility to focus on the areas that interest you the most.

Integrated Project Development

Based on an existing student project of a re-locatable house at Otago Polytechnic, the project development is established as shown in Figure 1.

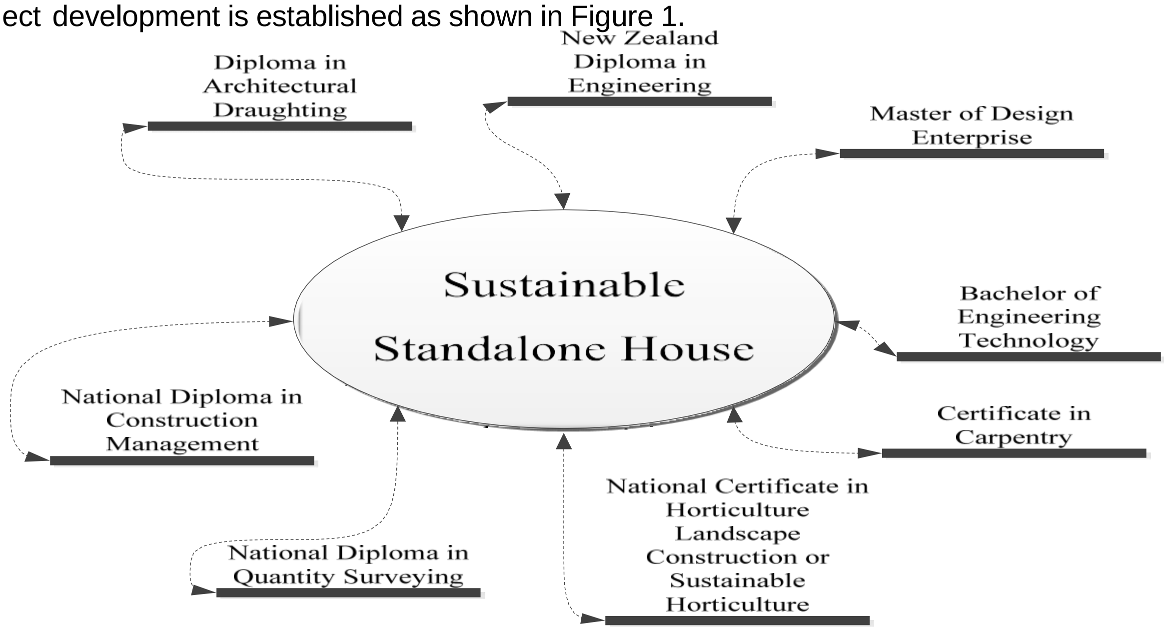

Figure 1: An integrated project developed for multi-program

An existing student project of a re-locatable house at Otago Polytechnic, as shown in Figure 2, for an example, was designed and built by students from Architecture, Carpentry and Construction Management under supervisions. Multi-size of re-locatable houses are now available at the Otago Polytechnic campus.

Figure 2 an example of integrated project at Otago Polytechnic

As showed in Figure 2, the electrical and plumbing systems were designed and installed by students from trade certificate programs. The advanced design and test of the control systems were completed by Bachelor of Engineering Technology students, e.g. the rain water harvest control, wind turbine, solar hot water system, PV panel, battery for smart grid, Vehicles to Grid unit with EV.

Conclusion and Further Development

A student project design of a sustainable standalone house is developed based on Industry Oriented Learning to enable a multi-disciplinary team and work environment. It provides a platform to enable wide range academic programs with the industry oriented project based learning. The further research project is seeking the ethic approval to collect the student feedback, interview the academic and industry staff members, and thus confirm the design of sustainable standalone house to be an on-going commercialised product.

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