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Uncanned learning through an Industry based final year project – Food for thought

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BACKGROUND

The Metropolitan Group (Metro Group) of Institutes of Technology and Polytechnics (ITPs), New Zealand, developed the Bachelor of Engineering Technology (BEng Tech) level 7 programme for first delivery in 2010. The industry based final year project, (45 credit) is considered the capstone of the BEng Tech program requiring the student to demonstrate the skills of an independent learner in a professional real life scenario. This course was a new mode of teaching in the New Zealand Engineering ITP arena and although it is not new in University engineering programmes, it has a more industry focus. In 2011 Waikato Institute of Technology (Wintec) was the only Metro ITP offering this final year project.

PURPOSE

Students are prepared for their final year project in their first and second years of study, and as an analogy can be compared to the chef collecting ingredients to prepare the evening meal. The same ingredients can be used to make many dishes, but if the final dish is not what the diner or client ordered, the meal is not a success.

This then lead to the question 'What are the main ingredients required to ensure student success in a client directed final year project?' where the 2011 projects at Wintec were used as a case study.

DESIGN/METHOD

The study identified these main ingredients and the impact they have on the success of the student to collate previous learning into a coherent independent learning experience.

RESULTS

In addition to adequate specialized technical knowledge, 'professional skills' such as professional communication with the client and supervisor, writing and presenting skills, responsible project management and independent study skills / cohesive critical analysis developed through project based learning proved to be core ingredients to ensure a successful outcome for both the student and client.

CONCLUSIONS

The success in an industry based final year project requires a high level of critical independent learning founded on specialized technical knowledge, supplemented by 'professional skills'. The learning from an industry or 'uncanned' project extends the student learning into a cohesive whole.

KEYWORDS

Industry based project,Project Based Learning,Final year project

Introduction

Final year projects are an integral part of engineering education (Blicblau and Richards, 2010; Johns-Boast and Patch, 2010). Projects can be either 'Canned', which are "*simple or even complicated academic exercises*", Chamillard (2002), as referenced in Johns-Boast and Patch (2010) or 'Uncanned', an industry based project, requiring the student to interact with a client in a professional real life scenario.

IPENZ define three routes to registration as an engineering professional in New Zealand. They are as an Engineering Technician, Engineering Technologist and as a Professional Engineer (IPENZ, 2012a), and are aligned with the Dublin, Sydney and Washington accords respectively. Professional Engineers, as defined by The Institution of Professional Engineers New Zealand Inc (IPENZ, 2012a) are capable of dealing with complex engineering problems and activities and their exemplifying qualification is the four year Bachelor of Engineering (BE) degree, level 8. Engineering Technicians are capable of dealing with well-defined engineering problems and activities and their exemplifying qualification is the two year Diploma, level 6. In New Zealand, both the BE degree and the Diploma have been long been recognised by industry as defining engineering qualifications, while the qualification and role of the Engineering Technologist is relatively new. This study is focused on the Bachelor of Engineering Technology (BEng Tech) degree qualification as teaching and assessment methods are still being tested and refined.

Engineering Technologists, are capable of dealing with broadly defined engineering problems and activities, and their qualification, the three year BEng Tech degree, level 7, is considered more applied and industry focused (Metropolitan Group of Institutes of Technology and Polytechnics (Metro Group), 2009a) than BE degrees. Metro Group approval document indicates that

> *the programme will include learning activities developing applied knowledge of engineering technology, …. by the use of . . . projects and assignments requiring research and interaction with industries employing engineering technologists*

and

> *Students also gain first-hand experience through: Development Projects that are acquired from industry.*

The BEng Tech degree is therefore an industry focused education.

The Metro Group in New Zealand developed the BEng Tech degree programme for first delivery in 2010. The final year project, course MG7001 Engineering Development Project, a level 7, 45 credit course (qualification total: 360 credits) is considered the capstone of the BEngTech programme. According to the Course Descriptor (Metro Group, 2009b), the PURPOSE/AIM of the course is

> *To provide the student with a significant amount of time in which to investigate an engineering problem; to propose, specify, design and develop a solution and where feasible, to construct and test a prototype.*

Purpose

The final year project was a new mode of teaching in the School of Engineering, Science and Primary Industries at Wintec. This lead to the question, 'What are the main ingredients required to ensure student success in a client directed final year project?' where the 2011 projects at Wintec were used as a case study. This study aimed to identify these main ingredients and the impact they had on the success of students to collate previous learning into a coherent independent learning experience.

The findings of this research will inform Wintec academic staff on best practise in delivering level 7 projects. This research will be shared with other ITPs offering the Metro BEng Tech

as well as the Wintec Bachelor of Technology (Science) degree, which offers a similar level 7 project.

This research is based on the first cohort of Wintec final year students, of which there were only 13. The small sample size may limit the validity of this study.

Final year engineering projects

The concept of a final year project in engineering education is not new. Blicblau and Richards (2010) state "*It is common for all engineering courses in Australia to include a final year project in the curriculum*…", while Johns-Boast and Patch (2010) support this opinion with their statement "*many tertiary institutions use group project courses as capstones for their engineering… degree programs*". Chung (2010) detailed a similar final year project at Nanyang Polytechnic's School of Engineering. Mills and Treagust (2003) define professional problem-solving skills required in engineering as

> *the ability to reach a solution using data that is usually incomplete, whilst attempting to satisfy demands from clients, government and the general public that will usually be in conflict, minimising the impacts of any solution on the social and physical environment and doing all this for the least cost possible*.

Projects such as these require a high level of critical independent learning founded on specialized technical knowledge and supplemented by 'soft skills' or '*professional skills'* as defined by Shuman, Besterfield-Sacre and McGourty (2005).The professional skills required to complete an engineering problem such as this would typically include time, task and resource management; communication with clients, other professionals and the community; and the ability to carry out a total project. Sohel, Thorne, Jagathesan, Sergeev and Bennamoun (2011) state that engineering students are graduating with good knowledge of fundamental science and computer literacy but don't know how to apply the theory in practice. Project work in the final year of engineering study is one way of developing these professional skills. The importance of engineering students learning from project work is well documented in the literature, (Chung, 2010; John-Boast and Patch, 2010; Mills and Treagust, 2003) and include the development of work-ready skills.

Mills (2007) reviewed McKenzie et al's (2004) survey that indicated oral presentations and a final written report were the assessments adopted by over 90% of US engineering capstone projects. An increasing number also used intermediate written reports while a small number (less than 15%) used a range of assessments which included logbooks and self-reflection journals.

Blicblau and Richards (2010) detailed the role of research project work in undergraduate study. They indicated that generally students only undertake research in their final year project, with little done to encourage research in previous years. They looked at courses in the first year of their institution and found that only one course out of four in each semester of the first year had a major project or research component. They are currently investigating whether success in the first year courses is an indicator of success in the final year project.

Nepal and Jenkins (2011) reported on their study to determine student's preferences on the range of strategies that help develop a blended learning experience in an engineering design course. They questioned their students on nine strategies which included, among others, (i) degree of freedom when setting the direction, scope and timing of activities, (ii) provision of learning resources and materials, (iii) activities that help manage the project. They found, it was important to involve both students and teaching staff in setting the direction, scope and timing of activities; the provision of sufficient background information leading to the project based learning course was important as was providing a variety of strategies to monitor the progress of the project.

Mills (2007) reported on a significant improvement made to their design project by the provision of a dedicated learning space for the final year students. This Project-Based

Learning (PBL) space consisted of a large, flexible teaching space (movable small group tables and chairs), where guest lectures, class meetings and student presentations were held and where students could work together informally in small groups or as a class. Mills states

> *The importance of dedicated project space and "living" space for the students involved in the project cannot be underestimated….. its success has now been recognised and the university is moving to develop other such spaces in other schools.*

Chung (2010), detailed the Accumulated Experience Sharing (AES$^{(R)}$) established at Nanyang Polytechnic, Singapore. The AES$^{(R)}$ is an electronic Knowledge Management System, the purpose of which is to formalize learning from accumulated project experience. It acts as a repository of prior knowledge and widens students' exposure to project work. The sharing of this body of knowledge aligns with IPENZs' fifth fundamental ethical value, "*Sustaining engineering knowledge".* IPENZ (2012b).

Final year project at Wintec

In 2011, Wintec offered the final year project of the new Metro BEng Tech for the first time. Wintec was the only Metro ITP offering the year 3 courses in 2011, and in particular the project. Students completing the final year had all previously obtained a Diploma or similar qualification allowing them to stair-case in the BEng Tech. (Stair-casing from the Diploma to the BEng Tech enabled the students to cross credit up to 50% of the 24 courses and complete their BEng Tech qualification in 18 months.) As part of the Metro qualification, the Learning Outcomes for the Engineering Development Project is fixed as specified by the Metro Group and is detailed below (Metro Group, 2009b):

> *LEARNING OUTCOMES*
>
> *On the successful completion of this course, the student will be able to:*
>
> 1. *Synthesise a solution for an engineering problem.*
> 2. *Complete a project to a specified standard.*
> 3. *Design, construct and test a product.*
> 4. *Use software application packages as an engineering tool.*
> 5. *Communicate effectively with customers, peers, technicians and engineers.*

The course descriptor does not prescribe whether the projects should be industry based or not. To align with the Metro approval document, as detailed previously,

> *Students also gain first-hand experience through . . Development Projects that are acquired from industry,*

the decision was made at Wintec that all final year projects would be industry based.

According to Blicblau and Richards (2010), engineering final year projects usually comprise between 10 and 25% of the final year of study. In the Metro BEng Tech, it comprises 37.5% of the 120 credits of the final year of study, (or 25 and 50% of the course allocation in the first and second semesters respectively). This seems to be significantly higher than other institutes when compared to Blicblau and Richards (2010), although Mills (2007) reports that at her institution project work forms 50% of the final year of study.

Assessment is specified as three main activities: product (50%), reports (35%) and presentations (15%). At Wintec, six assessments were scheduled, which included Project proposal report (10%); Project proposal presentation (5%); Technical project report (60%); Project presentation (10%); Project management (10%) and Reflection journal (5%). By including a reflection journal and project management (which includes a project journal) as assessments, based on McKenzie et al's (2004) survey, as referenced in Mills (2007), Wintec appears to be on the less travelled road. Mills also states that the assessment of a

project should focus on the full range of skills being developed during the project, namely the professional skills as well as technical skills. The Wintec assessments therefore reflect best practice as suggested by Mills.

The project required the student to select a topic and an industry supervisor (with the assistance of Wintec staff), and to work with their industry supervisor to complete the project to the client's requirements. Planning and update meetings took place with both the academic and industry supervisors. The role of the academic supervisor was as a facilitator to monitor the progress of the project, to give guidance on quality expectations (standards of behaviour with clients, documentation standards, etc.) and to advise on project issues as the project developed, so as to assist the students to obtain their goal. Their role was not to play policeman or actively engage in the detailed development of the project content, nor to solve any problems that arose. This is supported by Nepal and Jenkins (2011), who state that in modern teaching methods such as PBL, students take charge of their own studies without relying 100% on their lecturers, thereby developing their own independence.

Similar to Blicblau and Richards (2010), Wintec student's only complete one communication-research based course in each semester of their first year of the BEng Tech. In the first semester of the first year they study MG5003 Engineering Communication and in the second semester they complete a course entitled MG5031 Professional Engineering Development. The aim of this MG5031 course is (Metro Group, 2009b)

> *To develop broad knowledge and understanding of professional engineering roles and activities and their interactions with society and the environment*.

This course lends itself to critical evaluation of the subject matter leading into communication (report writing & informative presentations in class), thereby developing the students' research and communication skills. It builds on the abilities developed in the MG5003 course of the previous semester. Knowing the requirements for the final year project, the assessments of this course are designed as a threshold concept (Male and Baillie, 2011), to underpin some of the requirements of the project. This study looked at the success of students in this MG5031 course as an indicator of success in the final year project, similar to the on-going research of Blicblau and Richards (2010).

Currently, in the second year of study at Wintec, courses are more traditional, with smaller individual projects which may but not necessarily require some research and oral presentations. In 2012 Wintec embraced the principle of PBL as opposed to traditional lecture- tutorial learning methods for all courses, leading to changes in future teaching styles. According to Jowitt (2009)

> *PBL is becoming widely accepted as a means of adding value to the learning experience in tertiary teaching institutions, and to producing 'industry ready' graduates.*

Further research is planned to record this development at Wintec and the impact this change in teaching pedagogue has on the success of students in their final year project.

The project management required for this course entailed recording regular meetings with supervisors who act as clients, the formation of a suitable Gantt chart detailing milestones, regular monitoring of progress against the Gantt chart, updating the Gantt chart where necessary, formal minutes of meetings with supervisors and the development of a project journal recording all decisions taken in the form of a daily diary and/or notes of any major technical decisions. This level of project management is in line with industry expectations.

The purpose of reflection is to improve our professional practice. The reflection journal thus presented evidence of abilities to use reflective practice to critically evaluate and review documentation and presentations against project performance indicators. At the end of the year, the students were required to present a reflective journal containing evidence of 'what went well, what went wrong, what has been learnt, what would be done differently if it was done again' for five project based entries.

Case study

This case study attempts to answer the question 'What are the main ingredients required to ensure student success in a client directed final year project?' The hypothesis was that the following skills are the main ingredients:

- communication skills – both verbal and written
- project management
- critical analysis / independent thought
- working with a client or supervisor and
- reflection on and learning from own performance over the duration of the project.

Thirteen students undertook the engineering development project at Wintec in 2011. Seven were in electrical specialization (power) and six were in civil. The students all completed individual industry based projects.

All of these students were exempted from the year one course MG5003 Engineering Communication as a result of their prior qualification but all students completed the MG5031 Professional Engineering Development course. The possibility of using the students' success in this MG5031 course as an indicator of likely success in the final year project was investigated. The correlation between the student's successes in the professional skill components of the project, (reflective journal, project management, project proposal development and presentation skills) with their technical content mark was analysed. Correlation was determined using a best fit linear regression line.

Similar to the work of Nepal and Jenkins (2011), these 2011 Wintec students were surveyed using an anonymous on-line survey tool, on a number of topics to determine their perceptions on the main ingredients required to ensure student success in the project. The questionnaire consists of 16 questions in total, consisting of forced choice multi-choice questions. The questionnaire was an online quiz, and no questions are open ended. Topics relevant to this research paper included (i) preferred learning style: project-based compared with traditional lecture-tutorial learning, (ii) degree of freedom to select the project scope, (iii) timing of activities, (iv) foundation knowledge preparedness covering technical and 'professional' skills, (v) preferred project management activities, (vi) their perception on the main factors that contributed to the success of their project (technical knowledge, critical analysis skills, independent study skills, project management skills, communication skills – writing, presenting or communicating with supervisors/team members and holistic approach to the project).

Results

Of the thirteen enrolled students, ten successfully completed their project, five electrical and five civil students.

Comparing the final marks in the year one course MG5031 as a possible indicator of likely success in the project revealed a poor correlation R^2 of 0.406. Conversely, all the students who passed the project had all performed well or very well in MG5031

The analysis of the student's successes in the professional skill components of the project, (reflective journal (5%), project management (10%), project proposal development (10%) and presentation skills (15%)) with their technical content mark (50%) again revealed a poor correlation. The highest correlation was with the project management component, R^2 of 0.725. This is reflected in the fact that those students who managed their project well all passed the technical content part of the project. The other components had a R^2 of less than 0.45. The three students who failed the project overall failed their technical content aspect of the project, but not necessarily the professional skill components. This indicates that while

professional skills enhance the learning from a project such as this, without adequate underpinning specialized technical knowledge, a successful outcome cannot be assured.

Only 6 out of 13 students responded to the questionnaire. A summary of the analyses of the survey indicated;

(i) preferred learning style: project-based compared with traditional lecture-tutorial learning,

All students preferred project based learning but half also enjoyed a combination of project based learning and traditional lecture-tutorial learning.

(ii) degree of freedom to select the project scope and timing of activities,

83% of the students preferred shared responsibility between the supervisor and the student. Half of the students preferred an industry based project while 33% considered an industry based or academic developed project as acceptable.

(iii) foundation knowledge preparedness covering technical and professional skills,

Technical preparedness: diverse response, ranged from definitely to not at all.
Professional skill preparedness: 67% responded definitely or moderately.

(iv) preferred project management activities,

All students indicated their preferred management strategy was regular meetings with their supervisors, while half considered regular formative and summative assessments were helpful. However, half of the students also considered themselves able to manage the project without externally set milestones.

(v) the student's perception of the main ingredient(s) that contributed to the success of their project, in order of preference:

Professional communication with supervisors: 83%

Communication skills – writing, presenting: 67%

Independent study skills: 67%

Critical analysis skills: 50%

Project management skills: 50%

Technical knowledge: 33%

Holistic approach to the project: 0%

The result of this student survey clearly indicates that in the students' opinion:

- Professional communication with the client and supervisor was the main ingredient that contributed to the success of their project. This is supported by their preference for a shared responsibility in selecting the project scope and timing of activities and for an industry based project as compared to a purely academic project.
- The students' preferred learning style is PBL. PBL requires the student to undertake critical analysis and independent learning processes. Half of the students indicated it was an important skill required to successfully complete the project. However, currently most of the year one and two courses in the Wintec BEng Tech programme are traditional lecture-tutorial learning.
- Enhancement of personal project management skills may play a role in ensuring success in the project. While half of the students considered this a necessary skill for passing the project, only half of the students considered themselves able to manage the project without externally set milestones,
- The students indicated that their underpinning technical knowledge did not prepare them for the final year project. However, in contradiction, they also recorded it as having a low level of impact on their successful outcome. On the other hand, they indicated they were prepared in the professional skills such as communication,

suggesting the use of the course MG5031 as a threshold concept was an effective educational tool.

Findings

This research has indicated that the main ingredients required to ensure student success in a client directed final year project are:

- Professional communication: successful guidance and support from supervisors who played the role of a client.
- Communication skills – (writing and presenting) which are developed in the year one courses MG5003 and MG5031.
- Personal project management skills may play a significant role in ensuring success in the project.
- PBL requires the student to undertake critical analysis and independent learning processes and was the students' preferred learning style. Wintec's embracement of the principle of PBL as opposed to traditional methods of learning should prepare the students better for their final year project in the future. Future research is required to monitor the effects of this change on the success of students in their final year project.
- There was no immediate correlation between the reflection journal marks and the overall performance of the students. This may have been as a result of the assessment requirement that the reflection journal only be submitted at the end of the year. It is hoped this aspect of the assessment may endear a lifelong habit of reflection in the workplace, and that a positive result will be demonstrated in the future.
- The students indicated that their underpinning technical knowledge did not prepare them for the final year project. In addition, they also recorded it as having a low level of impact on their successful outcome. However, all students who failed the technical content aspect of the project also failed the course.

This last point validates the hypothesis that in addition to adequate technical knowledge, professional skills such as professional communication with the client and supervisor, writing and presenting skills, responsible project management and independent study skills / cohesive critical analysis developed through PBL, are the necessary ingredients required to ensure success in a client directed final year project. Reflection was not found to be a main ingredient.

The establishment of a dedicated learning space as described by Mills (2007) and an electronic Knowledge Management System such as the Accumulated Experience Sharing (AES$^{(R)}$) of Chung (2010) at Wintec could also significantly enhance the learning experience and outcome of these final year projects.

Like a good chef preparing the evening meal for a diner, tertiary institutions offering engineering education need to ensure their graduates are what their client, the engineering profession, requires. The BEng Tech final year project at Wintec attempts to provide an applied and industry focused qualification, with adequate 'professional skills'.

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