Case Study

AN ASSESSMENT OF LEARNING OPPORTUNITIES CREATED BY A MULTIDISCIPLINARY STUDENT PROJECT USING THE MODEL OF KNOWLEDGE CREATION.

Richard Humphrey, Peter Harris, Matthew King and Jennifer Rodgers

ABSTRACT

The paper presents the facilitators' reflections on the benefits and challenges of developing and facilitating project-based learning for students from different disciplines. It reflects on the staff initial project collaboration, development and conclusion of a multidisciplinary student project between Bachelor of Applied Science (BappSci) Physical Activity, Health and Wellness students (n=3) and students studying for their Bachelor of Engineering Technology (n= 7). This paper assesses the opportunities for multidisciplinary knowledge creation using the conceptual model of knowledge creation disseminated by Fong (2003). It goes on to present the collective reflections of staff involved and lessons for future project collaborations.

INTRODUCTION

In this ever-changing world the importance of knowledge has been postulated as being a primary resource or asset for income creation (Fong, 2003). Knowledge and intellectual-based assets are distinctly different from tangible assets, such as land, machinery and materials. For graduates to be successful in this knowledge intensive, post-industrial era, they have to be capable of acquiring, processing and utilising new knowledge (Nonaka, Toyama & Nagata, 2000). Businesses and organisations seek ways to train their staff to be constantly innovative but face endless challenges in this pursuit (Fong, 2003). Knowledge-creating skills are of particular importance in ensuring businesses maintain commercial credibility and in turn the employment of the graduates they recruit (Leonard-barton, 1995).

Researchers have explored the benefits of multidisciplinary teams as an essential means for new knowledge creation and innovation (Nonaka & Takeuchi, 1995; Fong 2003). As a result of Fong's (2003) research, the model of knowledge creation was proposed to understand the processes within multidisciplinary project teams. It was conceived that applying this model within the education setting might enable educators to more effectively facilitate project-based learning activities.

Project–based learning is a term used to describe a broad range of approaches with a variety of practices and outcomes (Palmer & Hall, 2011; Helle et al, 2006). There is a wealth of literature espousing the benefits of project-based learning as a means of developing student-centred learning and highly desirable professional competencies (Palmer & Hall, 2011; Loureiro, Sherriff & Davies, 2009). Acknowledged benefits include the development of teamwork (both internally and externally), improved self-directed learning, ownership of the project, commitment, competence and comprehension of the commercial world beyond the classroom (Palmer & Hall, 2011; Zhou, 2012); all benefits highly desirable to businesses and organisations seeking to create new knowledge and foster innovation (Fong, 2003). The essential pedagogical move from teaching to facilitation fosters a more reflective and iterative learning environment, ideal for creative endeavours (Zhou, 2012).

Palmer and Hall (2011) state that there is general consensus that project-based learning includes: finding the solution to a problem or completion of a task that requires students to complete a number of activities; students typically work in teams; the project itself is meaningful, often multidisciplinary, requiring work over an extended period; the project involves the development of an artefact (product, design, model, computer simulation etc); the completion of the project requires a written report or oral presentation; and teaching staff take a hands off advisory role, facilitating rather than leading.

Fong's (2003) model of knowledge creation is a five-process model. The first process, "boundary crossing", refers to the boundaries routinely observed between team members, often with different skills and experience, and externally between the team and client or consultant. The second process is knowledge sharing, which occurs between the various group members. In this process there is believed to be an advantage in having greater diversity within the team, which enables broader discussion. The third process is knowledge generation; new learning or knowledge develops through the group discussion and collaboration.

The fourth process in Fong's (2003) model is knowledge integration; the consolidation of knowledge within the team and the piecing together of the constituent parts to create the project's solution. The fifth process is the collective team learning gained by the team's involvement in the project. Failure is a key driver for innovation in this process and support is essential for the teams problem-solving processes.

The project described in this paper set out to provide learning opportunities for students from engineering and health disciplines. The host institution's guiding principles include sustainability, which was an additional area intended for staff research using the product or solution of the project.

THE PROJECT

The student project was initiated by a group of three BappSci Physical Activity, Health and Wellness students undertaking their third year research project at Otago Polytechnic. They proposed a Public Health study to objectively assess the volume of alcohol consumed by students at social events and house parties. Inspired by the "Fun Theory" Bottle Bank Arcade (http://www.thefuntheory.com/bottle-bank-arcade-machine), which was created to encourage bottle recycling. The students proposed taking this idea a step further with the construction of an interactive bottle bin, which would capture data from the bottles deposited. This would enable the Health and Wellness students to calculate the volume of alcohol consumed from the bottles deposited in the bin.

It was planned that any students hosting an event could book the completed bin. The bin would be delivered to the venue (student house or flat), students would deposit their bottles in the bin, which would reduce the broken glass in the vicinity and resultant injuries. When bottles were inserted into the bin, the mechanism inside sorts the glass by colour and takes a 360 degree photograph of the bottle and its label, enabling the students to calculate the volume of alcohol from the bottles deposited. When the bin was collected the party organiser would be required to provide an indication of the number of people attending the event so that an average units of alcohol consumed per person could be calculated. In addition, it was hoped that the reduced glass debris in the local environment would aid neighbourly relations and social sustainability.

The Health and Wellness student's research project supervisor carried out initial scoping with colleagues from the School of Engineering, to gauge interest and feasibility of the project. Once interest had been established, further conversations were completed, in order to identify the appropriate staff and Engineering students to be involved in the project. The Health and Wellness students liaised with their research project supervisor and the Engineering lecturer in order to create a working brief for the Engineering students to draw upon in order to initiate their elements of the project.

Whilst the initial scoping with the Engineering school was being conducted, the Health and Wellness students also engaged in meetings with a representative from the local city council. This potential stakeholder was the council official responsible for glass recycling. They were contacted and invited to consider the students' proposal. During these meetings the students gained knowledge of the needs of the council, potential sources of funding and glass recycling infrastructure that could be used to further the projects aims. This knowledge was also incorporated into the working brief for the Engineering Design students.

Having received the working brief, the Engineering students set about researching and designing concepts that could satisfy the brief. The design course for the Engineering students focused on Customer Centred Design theory with targeted outputs including reflective design development and a testable functioning prototype. Students worked in independent groups and were assessed on their progress toward the prototype development and completion with 3D computer models, control programmes and fabrication of prototype components.

Contact was made with suppliers of materials and existing bottle waste management businesses. With the information gleaned, the Engineering students designed and presented their concepts, which included estimates for construction. Feedback was provided to the Engineering students from supervisors and the Health and Wellness students. Several projects were shortlisted and developed further before a final presentation where the decision was made as to the most suitable concept.

Following the decision being made, funding was sought to fund the purchase of materials and construction of the bottle bin. Having secured the funds the materials were purchased and construction proceeded.

INTERRELATIONSHIPS BETWEEN THE FIVE PROCESSES OF KNOWLEDGE CREATION AND THE STUDENT PROJECT

As previously explained, Fong's (2003) model of knowledge creation is a five-process model. To assess the opportunities created by the student project staff reflected upon the processes outlined within the model.

The first process, boundary crossing, occurred on a variety of levels. The disciplinary boundaries between Engineering and Health and Wellness were traversed, with the further potential addition of discipline of sustainability. There were crossovers by both staff and students, which increased with the diversity of experiences shared within the multidisciplinary team. Further boundary crossing occurred between the students and council glass-recycling official, who might conceivably be considered the client.

The most interesting instances of boundary crossing occurred between the students from Engineering and Health and Wellness. The Engineering students had limited experience with the student drinking culture, which lead to a number of early proposals including seemingly impractical components (for example the use of QR codes or Bluetooth pairing).

The second process, sharing of knowledge, occurred both within and between the disciplinary teams. Within the Engineering team, individual members held specialist knowledge of certain areas essential to the project. Some had knowledge of electronics, others welding and fabrication, others commercial paint and finishing. Sub-groups formed to address elements of the project independently before bringing them back together.

The Health and Wellness students were able to share their research on student drinking culture, technical requirements gained from their meetings with the city council official and feedback on suggested incentives to promote interaction with the bottle bin. While the two groups were not assessed upon their collaborations, the sharing of information in a timely manner was essential for both groups of students gaining a successful outcome in their assessments.

Staff shared their knowledge and experience but were mindful of the need to adopt a hands off, advisory approach, as suggested by Palmer and Hall (2011)and Donnelly and Fitzmaurice (2005); facilitating the project rather than taking the lead. Further, sharing of knowledge also occurred between the council official, material suppliers, the original arcade bin creators, glass/waste disposal companies and the student project team.

The third process, knowledge generation, occurred as a result of the other interacting processes within the model. Not only did the students gain new technical knowledge which helps to keep them up-to-date with current technology in a rapidly changing technological landscape, but also new knowledge and experience around more traditional soft skills such as team working, time pressures, self-directed learning and ownership of the project as suggested by Palmer and Hall (2011) and Zhou (2012).

The final product took elements from a number of the initial proposals and the knowledge gained during the course of the project. The scale of the bin came from one proposal combined with information from the health and wellness research. The mechanism came from another proposal, which was initially informed by the original arcade bin creators. The bin's delivery system was informed by the knowledge shared by glass recycling companies and the council official but added the camera and light sensors, which captured data for the Health and Wellness students while sorting the glass for recycling.

The fourth process in Fong's (2003) model, knowledge integration, saw the respective elements coming together with a cohesive solution to the original working brief. Unfortunately, the time constraints placed on the project meant that the students initially involved did not complete the construction of the bottle bin.

The students' inability to finish the bin's construction meant some of the knowledge consolidation opportunities were missed by those initially involved. However, through logging and status reports, the students who subsequently took over the project gained from these opportunities and could then springboard onto a previously vetted solution.

The final process, collective team learning, occurred throughout the project. All students gained insight and experience in working with clients and consultants. The health and wellness students gained an appreciation of engineering and engineering solutions to real world challenges. The Engineering students gained knowledge of Health and Wellness interventions, soft skills and commercially relevant experience. All team members had to utilise problem-solving processes and develop contingencies to overcome failure. Project team members were encouraged to develop alternate plans to minimise the negative consequences of any elements not meeting the needs of the project.

THE STUDENT EXPERIENCES

All of the students involved managed to contribute to the creation of a viable solution to a real world project. For the Engineering students there was the experience of receiving the brief, researching the topic, designing and constructing a solution. The interactions with the "customers" (Health and Wellness students) offered opportunities to experience feedback and debate the merits and drawbacks of respective proposed solutions as well as experience first-hand the importance of documenting acceptable solutions for defined parameters and the considerations that must be made when expectations change or the design development leads in a new direction.

Similarly, the Health and Wellness students benefitted from the experience of developing the brief and interacting with the Engineering students in order to see the bin come to fruition.

The initial scoping was conducted in plenty of time. However, making contact with the appropriate colleagues and identifying suitable students for the project took several months. This delay impacted on the time available to complete the project. Delay also occurred as a result of the time taken to access funds for the purchase of materials. Initially it was believed that funding would be secured from an external funder. However, during the funding application process, guidance was sought from the funding body and it was made clear that they would only fund research on proven concepts, not pilot studies such as this one. Internal funding was gained but took time to secure.

For the initial cohort of Engineering Design students, these delays and course time constraints meant that, although they were able to engage in all the collective team learning opportunities, the resulting outcome of the course was a minimally functional prototype, which was sufficient to satisfy their assessment needs but not suitable for the Health and Wellness students needs. Having the materials and bottle bin prototype did provide opportunities for subsequent Engineering students, who were able to quickly pick-up where the previous students had left off.

Unfortunately, as with the Engineering students, the initial cohort of Health and Wellness students were not able to make use of the bottle bin in order to collect data for their final year research project. Course completion and time constraints impacted upon the original Health and Wellness students, who initiated the project. They had always had a "fallback" plan prepared as an alternative, which was the collection of data by more traditional survey means (using the AUDIT alcohol consumption survey tool) in order to successfully complete the assessment for their research project. However, a student from the next cohort was able to take advantage of the bottle bin project and picked up the research the next year.

STAFF REFLECTIONS

While staff had experience in project-based learning, their inexperience in multidisciplinary student project design meant that a number of curriculum planning elements were missed. However, it was entirely probably that the project would not have proceeded if greater time had been spent planning, as it was time sensitive, due to the needs of the students involved.

Reflecting on the challenges within the project, staff concluded that it would have been wise to have a number of prioritized stages within the project, which would have enabled the completion of a solution in sequential modules, which could have been further progressed as time allowed, rather than designing and constructing an integrated 'ideal solution'. One opposing challenge to this staged solution approach was the need to secure funding and for all materials for the final product costs to be calculated and included within the funding applications. As a result of reviewing this issue, the supporting institute has proposed to set funds aside to be utilised for cross-disciplinary projects. In addition, support provided for the early scoping and planning (e.g. end of the preceding academic year) of such projects to improve planning and increase the probability of properly scoped projects being completed within the time available.

At times, during the initial design and construction phase of the bottle bin project, it might have been beneficial to appoint a Project Manager or Coordinator to ensure:

- Tasks were completed
- Everyone knew what was happening
- The needs of all disciplines involved were met
- The project was completed on time

It was frustrating for some parties to not see or know if progress was being made. However, as Fong (2003) highlights, failure can be a fundamental component within problem solving, which a Project Manager may struggle to overcome within tight time constraints, such as an academic year.

CONCLUSIONS

It was agreed that the benefits for students working on the multidisciplinary project outweighed the drawbacks, although the impact of drawbacks could be minimised if future projects were staged and well managed. For projects to be feasible, dedicated funding needs to be allocated and managed in a way that fits the projects. Complex and slow funding application processes stifle creativity and innovation, which are fundamental benefits this style of learning sets out to foster (Zhou, 2012).

Paradoxically, the tolerance or accommodation of failure is an anathema to traditional forms of education despite being seen as an essential driver for innovation (Fong, 2003). Ensuring students can meet their learning outcomes despite, or even because of, failure can be challenging and requires a paradigm shift for those traditionally trained educators. Designing curricula and assessments to validate the knowledge gleaned from engaging in project-based learning takes time. The longer the time available for the planning of a project-based learning scheme the better. Using reflective reports, as well as completed project solutions, ensures that students can demonstrate their learning and development even if the project outcome falls below expectations.

Richard Humphrey is Academic Leader for the postgraduate programme in Exercise and Health, and Chair of the Otago Polytechnic Research Ethics Committee. Richard has a Master of Science (Exercise Health and Nutrition) and a Master of Philosophy (Exercise Nutrition and Public Health), both from the University of Bristol.

Peter Harris. Before moving to Queenstown Lakes District Council and Economic Development manager, Peter was Innovation Co-ordinator at Otago Polytechnic.

Associate Professor **Matthew King** is Principal Lecturer on the Bachelor of Engineering Technologies (Civil and Mechanical) programmes at Otago Polytechnic and has over 16 years' experience in forensic accident investigation.

Jennifer Rodgers is the Sustainable Practice Advisor at Otago Polytechnic.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support Otago Polytechnic's Innovation fund (This is an internal, institution fund; no grant number applies)

REFERENCES

Donnelly R and Fitzmaurice M (2005) Collaborative Project-based Learning and Problem-based Learning in Higher Education: a Consideration of Tutor and Student Role in Learner-Focused Strategies. In O'Neill G Moore S and McMullin B (eds) *Emerging Issues in Practice of University Learning and Teaching*, AISHE/HEA, pp87 - 98

Fong P (2003) Knowledge creation in a multidisciplinary project teams: an empirical study of the processes and their dynamic interrelationships, *International Journal of Project Management*, 21: 479 - 486

Helle L Tynjälä P and Olkinuora E (2006) Project-based learning in post-secondary education – theory, practice and rubber sling shots, *Higher Education*, 51 (2): 287 - 314

Leonard-barton D (1995) *Wellsprings of knowledge: building and sustaining the sources of innovation*, Boston MA, Harvard Business School Press

Loureiro I Sherriff N and Davies J (2009) Developing public health competencies through building a problem-based learning project, *Journal of Public Health*, 17: 417-424

Nonaka I and Takeuchi H (1995) *The knowledge-creating company: how Japanese companies create the dynamics of innovation*, Oxford, Oxford University Press

Nonaka I Toyama R and Nagata A (2000) A firm as a knowledge-creating entity: a new perspective on the theory of the firm, *Industrial and Corporate Change*, 9: 1 - 20

Palmer S and Hall W (2011) An evaluation of a project-based learning initiative in engineering education, *European Journal of Engineering Education*, 36, (4): 357 – 365

Zhou C (2012) Integrating creativity training into problem and project-based learning curriculum in engineering education, *European Journal of Engineering Education*, 37, (5): 488 – 499