



THE APPLICATION OF DESIGN METHODS IN PROJECTS TO ENHANCE STUDENT ENGAGEMENT

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CONTEXT

The value of application of design methods in creating new product/service concepts by students has been examined and presented in this paper. Tertiary undergraduate students, who have worked in teams of three or four on design projects where they were to develop innovative new concepts, were selected for this study. Responses from 22 students at Auckland University of Technology and 40 students from the School of Engineering and Advanced Technology, Massey University were gathered from first year engineering project courses run in 2013 and 2014.

PURPOSE OR GOAL

This study examined the value of teaching design thinking methods that were utilised by students in creating innovative concepts for their target markets. The study highlights the key benefits of better student engagement when participatory design methods are used in designing new products. It shows how these methods were applied and also how they made a difference to the final project outcomes. The teaching approach encourages developing the student's own problem solving skills, design thinking and practices. The focus of the study was on the application of the design thinking approach and methods which helped enhance student engagement in the courses.

APPROACH

The key aims of the project were to gather evidence of student learning and engagement from the application of design thinking methods and the engineering design process. Staff in both design courses prepared the project brief and material for tertiary students to apply design-thinking methods in order to create new solution concepts for their respective users. The design approach and methods that were taught allowed for users and stakeholders to be closely involved in the projects. The data for this study included information from two projects that involved a total of 62 tertiary students across two academic institutions. Analyses included an examination of the progress in the project through observations, staff and student feedback, the project logbook (which included reflections on learning) and the project outcomes. Student surveys, student class attendance and their pass rates were monitored and compared to previous years.

ACTUAL OR ANTICIPATED OUTCOMES

The study showed the evidence of successful application of participatory design methods (such as role playing and storyboarding) by students in the creation of innovative concepts. Prototypes were generated and evaluated by involving users in the design process. The study showed that the level of interest and engagement from students was high, as evidenced by their reflections on the project-work and the project outputs.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This paper has provided evidence of the importance of the design process and methods in order to better engage students in their learning. The paper demonstrates to educators the value of teaching design methods through projects to young tertiary students as early as in their first year of engineering. It highlights the emerging trend towards preparing students for real-world practice, with examples of how it was done.

KEYWORDS

Design methods, Student engagement, Project-based activities, Stakeholder engagement

Introduction

In recent years, academic institutes and professional bodies have recognized the importance of educating students in problem solving, design and communication skills (Scott et al., 2003). Design is seen as one of the fundamental activities in engineering practice (Bernabei & Power, 2012; Scott, Hadgraft, & Vojislav, 2003). Design has been practiced in engineering and has similarities with project-based learning (Scott et al., 2003), which has in the past been carried out in the final year of study. Research has shown that project-based learning is an approach that provides learners with higher order cognitive processes of creating, analyzing and evaluating (Hung, Hwang, & Huang, 2011).

The key aim of this study was to examine the influence of design activities on student engagement in their first year of study. This was done by collecting and analysing information from two project courses in the first year of study, across two tertiary institutions.

Student Learning through Projects

Researchers have tried to develop various systems or guiding strategies to assist students in improving their learning performance and engagement (Hsieh, Jang, Hwang, & Chen, 2011; Hung et al., 2011; Lisson, Garaniya, Chin, & Slater, 2013; Panjaburee, Hwang, Triampo, & Shih, 2010). Project Based Learning (PBL) is an approach to learning that teaches a multitude of skills critical for success in the twenty-first century. Students drive their own learning through inquiry, as well as working collaboratively to research and create products together (Bell, 2010). PBL enhances collaboration, communication, negotiation and engagement skills among students (Bell, 2010). Research has shown that project based learning fosters authentic learning, motivation, creativity and engagement among students (Bell, 2010; Hung et al., 2011).

Stakeholder Engagement in Projects

It is important to involve stakeholders during the design process in order to better align the new product's features to their needs. (Bernabei & Power 2012; Booth, Schofield, & Tiffen 2012). The design process and thinking can be understood as an exploratory, iterative process in which problems and solutions co-evolve (Booth, Schofield, & Tiffen, 2012; Cross, 2001). The value design brings is a different way of thinking, doing things and tackling problems (Lisson et al., 2013). Far more than principles, rules and procedures, it is a process most effective when imbued with attitudes and ways of thinking that have evolved over generations within the community of those who routinely practice creative invention and synthesis. Significant among these are ways of thinking from the design fields appropriately referred to as "design thinking" (Sudjic, 2008). Design thinking integrates solutions and finds ways to incorporate stakeholder needs into suitable offerings.

The design process starts from developing a thorough understanding of stakeholder needs and combining customer knowledge with the designer's creative ideas (Wattanasupachoke, 2012). The design thinking approach has stimulated innovation in many areas by making new products and services more appropriate, and therefore more desirable to consumers.

Current Research

The literature summarized above provided the basis for this research to look into the influence of design activities on student engagement and project outputs. Various design methods (such as role play, lotus blossom and personas) were taught to students in order to

create an appropriate solution. Staff supervised the students through the problem-solving process by asking questions, without giving away the actual solutions. The project-based design activities and techniques were useful for gathering stakeholder information, recognizing patterns in data, generating ideas that have emotional meaning as well as being functional, and constructing prototypes. The following two projects discuss courses where design thinking methods have been applied by students to create novel solutions which were customized for specific user groups and their contexts.

Project One

An experiential learning course titled 'Engineering Practice: Global Perspectives' is taught to all first year engineering and food technology students at Massey University. Engineers Without Borders (EWB) in conjunction with a local community organisation provides the design briefs, which outline the issues found in the target community selected for the year, such as villages in Vietnam, East Timor or Nepal. The students work in teams of 4 or 5 in their first semester, and apply their design and engineering problem solving skills to create solutions to a selected brief.

Examples of project design briefs were to construct a roof with innovative use of local materials for houses, or to provide adequate sanitation or clean drinking water. Staff from the School of Engineering and Advanced Technology supervised the project teams. The solutions ranged from solar-powered cookers to water filtration systems to novel roofing materials and structures. The EWB criteria to judge project outcomes required a consideration of social, environmental, economic, cultural, and ethical aspects of a project, which are as important, as the technical aspects. The students were taught the main stages of a design process, which one of the authors refers to as the four Cs - comprehend, create, critique and communicate.

Comprehend - In this stage, teams of student's researched and summarised information about the context, users and their needs. They were taught how to research and gather contextual data on the weather, population and any other relevant information that may impact on their design decisions. They learned to reach out to stakeholders through the EWB website forums, where they could post questions, and/or through social media, and also by interacting with people of the community who are currently at the University.

Create – Students were taught several idea generation and creativity techniques which they apply to their project in order to generate a number of potential solutions. They were taught basic visualisation skills in order to represent their concepts such as drawing, Photoshop and computer-aided design. The method of 'personas' was extended in a novel way to include a description and a visual of a typical person as well as the product context. Figure 1a, represents an example visual showing a typical villager, as well as the context of the product (cooking area in a village hut). Role-playing by taking on the role of a typical villager and squatting down to cook in a traditional cook-stove, gave students a real sense of the smoke levels involved while cooking, and the required dimensions of a new smoke-hood to be built. Figure 1b shows a small-scale clay-hood prototype with side air vents, being tested to check that smoke is directed out of the chimney.



Figure 1a. Villager cooking in a traditional stove



Figure1b. Clay-hood prototype testing

Critique – During this phase students assessed and selected the best concepts to prototype, based on important criteria provided by EWB. They used selection matrices to do this and develop design specifications. Then they build their prototype, and finally test and evaluate their prototype. Figures 2 and 3 show prototyping examples from one of the team projects. They made functional prototypes that were tested for performance.



Figure 2. Prototyping a small-scale bamboo roof



Figure 3. Final small-scale prototype roof

Communicate – a comprehensive report was written that included their design process, solution details, and implementation plans. This included visual instructions for assembly and maintenance of the roofing product by the local community. The students also had the opportunity to present their solutions at an end-of-semester exhibition to external judges from industry. Students are required to record their progress during the project in the form of a logbook to keep notes of their ideas, a record of team meetings and reflections on their own contributions to the project, the team effort and their learning.

Project Two

The course called ‘Experience Design’ was a ten-week project at Auckland University of Technology (AUT) undertaken by 22 students at the beginning of semester two in 2013. The key aim of the project was to introduce some of the fundamental concepts of design and management of the design process. It also assisted students to engage with broader contextual and social issues in creating innovative concepts. Given the short period and the complexity of the projects, students were provided with a structured design process and a set of design methods. During the course, students were required to identify and explore the needs of elderly users, and understand their strengths and limitations in using the intended products. The project was divided into five key phases: 1. Ideate 2. Define 3. Prototype 4. Evaluate 5. Results.

Ideate

Ideation is the most crucial step in the design thinking process. The goal for students was to develop background knowledge and then generate ideas. Students were required to

understand and empathize with users and their behaviors in relation to the needs and wants of the users. Students used design-thinking methods for idea generation such as observations, role-play, interviews, six thinking hats, lotus blossom and personas. Lotus blossom was used to generate multiple ideas and organize thinking around themes. It helped to explore a number of alternative possibilities and ideas (Figure 4a and b). Personas were created after in-depth observation of users. The personas assumed the attributes of the user groups, their culture, background, needs, desires, habits and social environments.

EXPERIENCE PROCESS: IDEA GENERATION

LOTUS BRAINSTORM: ISSUES WITH OLD AGE

DEBT	SECURITY		PHYSICAL ABILITY	ORGAN HEALTH	MOOD			
MEDICAL FEES	ECONOMIC	SAVINGS	MEDICAL FEES	PHYSICAL HEALTH	MOVEMENT			
AGING POPULATION	FREEDOM	ASSETS	AESTHETICS	MORE PRONE TO SICKNESS	AGILE			
RELIGION	COMMUNITY	FAMILY	ECONOMIC	PHYSICAL HEALTH		MEDICAL FEES	HOBBIES	
INVOLVEMENT	SOCIAL	FRIENDS	SOCIAL	OLD AGE	SELF	ACCEPTANCE	SELF	SELF-ESTEEM
AGING POPULATION ON "AGING"	SOCIAL VIEWS	SOCIAL SUPPORT	MENTAL HEALTH		LAW	MORALS & VALUES	MOOD	SELF-SATISFACTION
			MEMORY LOSS	COGNITIVE ABILITY	EXPOSURE TO NEW STIMULI	SECURITY	LEGAL FEES	FAIRNESS & TREATMENT
			MEDICAL FEES	MENTAL HEALTH	MOOD	MEDICAL	LAW	SUPER-ANNUATION
				MORE PRONE TO SYNDROMES			ENTITLEMENTS	

Figure 4a: Example of Ideation Process application

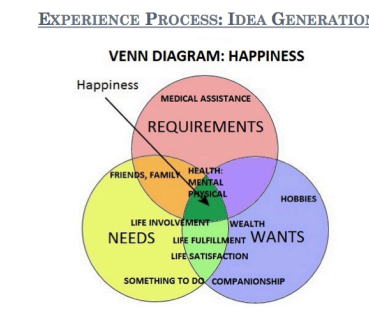


Figure 4b. Example of Ideation Process application

Define

The Define stage is a filter where ideas are reviewed, selected or discarded based on stakeholder requirements. Students were taught to analyze and refine the ideas from the ideation stage. Students were encouraged to keep an open mind in order to identify and develop innovative concepts. They were encouraged to think laterally about the problem in order to create a number of concepts. Students evaluated the results by presenting them to small groups of users. From these results, students were able to select a particular new concept to explore further. A number of methods such as mind mapping; strengths, weaknesses, opportunities and threats (SWOT) analysis; ranking ladder and systems diagrams were used to refine the ideas and understand the advantages and disadvantages of selected concepts.

Prototype

A prototype can be a sketch, model, storyboard, or cardboard mock-ups that demonstrates an idea. Students were encouraged to produce prototypes that are quick and simple to create. It was more about building the concept visually and building it with users in mind. Students used various media for creating prototypes (See examples in Figure 4a and b, 5 and 6). Another example of a design thinking method taught to students was to map the experience of the product/service to identify the touch points which can be visualized as needs, which in turn can be expressed as concept models and values of a total system.

A number of prototype examples that addressed different user requirements developed by student teams in Project 2 are discussed below.

Bommerland: This prototype enabled a platform that provides more possibilities for senior internet social networking. The concept site included a system for the elderly to connect to friends according to their interests and hobbies. The system has facilities such as a web-cam, simultaneous translation into various languages and an emergency calling system.

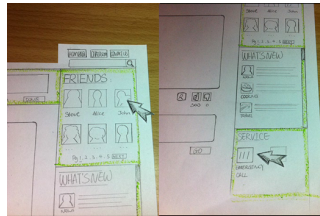


Figure 5. Storyboard of Social Networking system for Seniors

Virtual Reality Experience: This prototype solution used virtual reality technologies to provide an experience of outdoor adventures that the elderly miss out on due to their physical or medical conditions. The concept provided the elderly with a chance to experience the outdoors and adventures that they are specifically interested in.



Figure 6. Virtual Reality Experience visual board

'Quick Look App' was a prototype mobile phone 'application' for elderly users. One can access the information in many languages and has immediate translation facilities. The app (shown in Figure 7) provides information quickly on transportation, entertainment, shopping, health, restaurants and various places of interest specifically for the elderly.

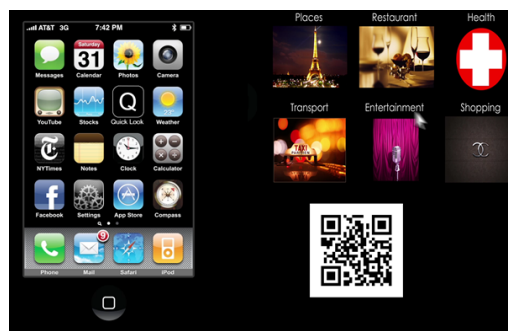


Figure 7. Quick Look App visual

Evaluate

After the prototypes were generated, they were taken back to users to gather feedback and to evaluate the solutions. The goal of the evaluation phase was to get honest feedback, even if it was negative. Students were encouraged not to invest too much time on perfecting the prototypes before getting feedback. The main point of re-engaging with the users was to

improve the solutions and not to prove that their prototype is perfect. The evaluation was intended to answer questions that help bring the prototypes closer to the final solution. It was an opportunity for students to learn about their users' reactions to their prototype solution. This was a valuable way to make students rethink and redesign their final solution from a users' perspective. Students engaged in various methods such as in-depth interviews, expert interviews, heuristic analysis, in-context immersion, and questionnaires to get feedback from users, stakeholders and experts.

Discussion and Analyses

Student Attendance and Performance:

The following tables show that the attendance in class as well as the pass rates has improved since introducing design-based courses at both institutions. These are measures along with all the other indicators that were examined as evidence of better student engagement in the new courses.

Table 1. Student Numbers and Grades in Project One for the Past Four years
(Albany campus).

Project One	2011	%	2012	%	2013	%	2014	%
			Design-based Course (Engineering only)					
Grade: A's	9	14	3	5	4	7	8	14
Grade: B's	18	29	22	33	22	39	24	41
Grade: C's	15	24	35	52	28	49	26	45
Fail	20	32	7	10	3	5	nil	0
Total Enrolled	62		67		57		58	

In Table 1 it can be seen that the number of failures in the new course has come down significantly since 2011.

Table 2. Student Numbers and Grades in Project Two for the Past Three Years.

Project Two	2011	%	2012	%	2013	%
Grade: A's	2	13	22	79	28	67
Grade: B's	14	87	4	14	10	24
Grade: C's	Nil	-	2	7	2	4.5
Fail	Nil	-	Nil		2	4.5
Total Enrolled	16	-	28	-	42	-

Student numbers have increased considerably since 2011, and so have the 'A' grades. There was an increased level of students' participation and attendance in the class.

Students' Reflections

The study showed that the application of user-design methods in both projects motivated students to build empathy and understand users' needs. The project outputs and student feedback confirmed that project-based learning can engage learners and help them improve their problem solving behaviour, as confirmed by earlier researchers such as (Johnson & Johnson, 1999; Krajcik, Czerniak, Czerniak, & Berger, 2003) Students also evaluated their own projects, their team effort, motivation and creativity levels. Students became critical friends by giving constructive feedback to each other during the design process, which helped them to identify their own strengths and improve their interactions with each other.

Team reflections, and the team 'contract' and agreements among team members to cooperate in the project helped with better attendance in the class. At the start of the course, team members agreed to abide by the team rules which included attendance at team meetings which were held during the course. It was also noted in their project logbooks that at times they helped their peers to complete a task, which helped to keep up the motivation and engagement by all members of the team.

The project outputs and logbooks showed that the process of collecting, abstracting and organizing data was an effective way of engaging students in deeper thinking and fostering problem solving capabilities. The outputs were appropriate for the purpose, context and users. The project outputs were novel (as shown in Figures 1-7) and their development and progress was shown in their logbooks. This provided clear proof that the students collaborated with each other and built on initial ideas. It was also evidence of original work that has not been plagiarised, as the project brief is changed every year.

Reflections on learning were collected from students from both projects 1 and 2. Selected quotes have been included here from their project logbooks.

Stakeholder input:

We learnt about natural materials like bamboo, coconut fibre and charcoal from the EWB staff and from the forum.

Never had a clue what elders go through emotionally in our society. They are sometimes treated as not wanted in today's fast paced life.

Use of Design Methods:

The persona we created was really useful, as it reminded us of the real need and urgency to solve the problem of smoke in the hut.

The Lotus blossom method helped us to organise our ideas into a structured format. It helped us to generate multiple ideas from different themes.

Staff observed the students' enjoyment and sense of achievement particularly when testing their prototypes and the prototypes worked as intended. Staff confirmed that the need to think and make decisions throughout the projects, engaged the students actively in the hands-on projects. Students also interacted more with their peers in their teams and with other teams. They also learned from other teams and from the range of prototypes and solutions produced by classmates. Staff observed that students were excited to show off their prototypes and what they had achieved during the course. All the students passed the courses, confirming that they had met the expectations of the course and the staff.

Formal Feedback: 81.8% of students who answered the online course survey in Project 1 were satisfied with the quality of the learning experience, 80% agreed that the course helped develop their thinking skills (such as problem solving, creativity, critical analysis etc.).

Some student comments included:

Good tools for ideation.

I did like the introduction of new and effective problem solving techniques, often I wish I had been introduced to them earlier in the process.

Responses to the statement: The aspects of the paper that most helped my learning were:

*Practical work on project helped experience real world applications of engineering.
The practical learning aspect, and real-world situation, where we work for an actual client, in a team.
The practical applications of the things we had learned during lectures.*

Staff from Massey's Centre for Teaching and Learning carried out a 'Teaching Evaluation through Student Dialogue (TESD) session with students in Project 1. To the question - *What helps your learning in the Global Perspectives course?*, students replied as follows:

- Group work
- Practical nature of course work
- Real world/applied projects
- Exemplars
- Creativity exercises

Most but not all students appreciated the value of the logbooks. Many were very positive about the logbook's worth as a resource, and see them as a record of their learning, and evidence of their design process. However, there were a few who would prefer to see them made voluntary. Given that the practice of keeping logbooks is an important habit to develop, it may help in the future to allow flexibility in the actual form of project note keeping such as digital logbooks or social media logs or website-based project records. Also, there is a need to consider new ways of making their use more attractive to student in future projects.

Conclusions

The results of this study provide evidence of student engagement and successful application of design methods. It has provided evidence of the importance of stakeholder involvement taught to students when they create new products in their early years of tertiary study. The projects encouraged students to engage with users from a market segment other than their own. This can sometimes be challenging for young students, but when given methods and instructions on how they can go about it, they learn to value the information. They see first-hand the benefits of the design methods in planning and providing a structure to finding several potential solutions and then selecting the most appropriate solution. This paper presented the view that the application of design methods by students in creating solutions motivates them. Staff supervisors of these projects confirmed that students' engagement and confidence increased when they created concepts and got feedback from their peers and users on their prototype solutions. The paper highlights the emerging trend towards preparing young undergraduate students to practice innovative thinking and behaviour, with examples of how it was done.

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