THE USE OF DESIGN THINKING IN C-D-I-O PROJECTS

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ABSTRACT

For students taking the "Design and Innovation Project" module at the Singapore Polytechnic, it has been observed that the most difficult step in the C-D-I-O process is the first step - "conceive". The "Design Thinking" method emphasizes "deep user understanding" through detailed survey / observation of the end users, and subsequent analysis of the data collected. Can the Design Thinking method help students in the "conceive" step? This paper describes a "pilot/trial run" to use the Design Thinking method in conceiving project ideas. It also outlines the limitations / constraints of the method.

KEYWORDS

Design thinking, empathy, ideation.

AN OVERVIEW

Ever since the C-D-I-O approach has been adopted as the teaching methodology, students of the second year "Design and Innovation Project" module at the Singapore Polytechnic, School of EEE, have been able to conceive, design and implement a wide variety of project ideas, based on a micro-controller.

It has been observed that the most "painful" step in the C-D-I-O process is the first step – "conceive". Amongst the problems faced by students during the "conceive" phase were: 1. Time constraint. 2. Lack of a structured approach to idea generation and selection. 3. Lack of life experience to make judgment on the usefulness of an idea.

The Design Thinking method emphasizes "deep user understanding", through detailed survey/observation of users and subsequent analysis of the data collected. Can the Design Thinking method be used in the "conceive" step?

A multi-disciplinary group of students went through a "pilot run" to use the Design Thinking method to understand end users' needs, to generate and select project ideas. As students could see the relevance of their projects, the projects were continued as their final year projects.

This paper describes how Design Thinking can be used to help students develop good user understanding, so that good project ideas can be conceived. It also highlights some of the constraints in the use of Design Thinking in C-D-I-O projects.

HOW IS THE "DESIGN AND INNOVATION PROJECT" MODULE TAUGHT AT SINGAPORE POLY?

The module "Design and Innovation Project" is taught to second year students in three diploma courses (Diploma in Electrical & Electronic Engineering, Diploma in Computer Engineering and Diploma in Electronic & Communication Engineering) in Singapore Polytechnic. [1]

The students are given 30 hours over 15 weeks to work on a C-D-I-O project, with the requirement that the project must be a microcontroller application. Each class of (approximately 20) students will first be divided into teams of 4 or 5 students.

The students will next identify their areas of interest e.g. helping the elderly or handicapped or solar energy applications. The lecturer will then explain the importance of doing a survey to find out what the user needs, instead of simply assuming. The students will also be taught some techniques to carry out a survey e.g. interview in pairs (one asking questions, the other taking notes), questions should be open ended (not yes/no answer) etc.

The actual act of carrying out the survey will be left to the students. In other words, the project team will have to arrange a time outside the curriculum hours to interview a target user group to find out what they need.

The students will also be asked to research the "product landscape" – what products or services are already in the market to serve the needs identified in the survey? How can "blue ocean strategy" be used to outdo the competitors?

With some knowledge of both the demand and supply sides, the students will next brainstorm to come up with a viable project idea, before presenting to the lecturer and fellow classmates. The idea will often be presented with a "concept sketch" (see Figure 1) to illustrate how it will look like at the end. The students will also present a "user journey" to show how a typical user will use the end product.

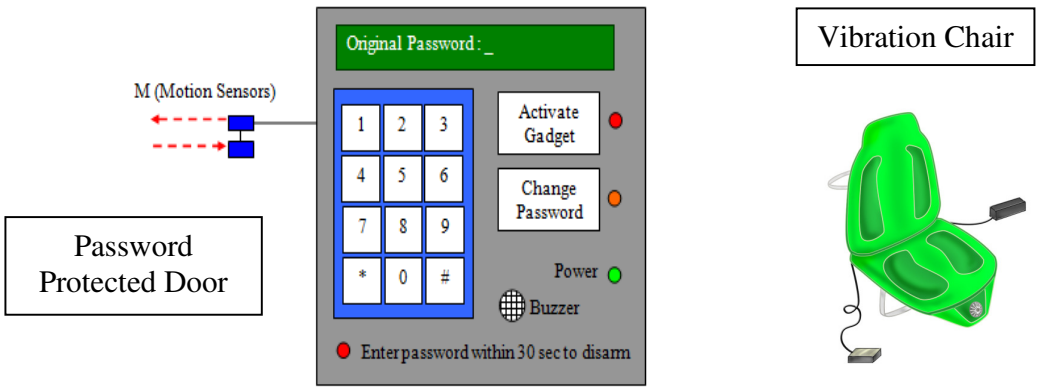


Figure 1. Concept sketches

After this “C” (“conceive”) stage, students will move on to the “D” (“design”) stage, where engineering students will be back to their “comfort zone”, drawing block diagram and circuit diagrams for their hardware design and flowchart for their software design. At this point, they will also be asked to work out an “implementation plan”, so that a simple, working prototype can be created over the next 5 or 6 weeks, during the “I” (“implement”) stage.

Within the limited time available for this project, a typical class of 5 teams may produce these:

- A “password protected door” – a correct password must be keyed in via the keypad for the solenoid (which “locks” the door) to be de-energised.
- An “alarm clock” – when the alarm buzzes, four LED’s will light up in a random sequence, and the sleepy fellow must press four buttons in the same sequence to switch the alarm off.
- A “toilet cubicle occupancy indicator” – red LED means a cubicle is occupied, green LED means vacant, and the total number of available cubicles is indicated outside the washroom for the convenience of the users.
- A “blind man stick” – an obstacle detection / warning gadget for the visually handicapped.
- A “vibration chair” – when seated on for some time, will shake to remind the user not to be desk-bound for too long.

DIFFICULTY IN “C” (CONCEIVING)

It has been observed that the most “painful” step in the C-D-I-O process is the first step – “conceive”. Just how do 18/19 years old students, with limited life experiences, come up with ideas that are technically feasible and yet, are “wanted” or “needed” by others? It is not easy to make judgment on the usefulness of an idea. Amongst the other problems faced by students during the “conceive” phase are: time constraint and the lack of a structured approach to idea generation and selection.

The time constraint comes about because there are only a total of 30 hours over 15 weeks to work on the C-D-I-O project, with a large portion (20+ hours) needed for “I” (Implementation). Implementation involves hardware fabrication, microcontroller programming, interfacing and troubleshooting. That leaves very little time for “C” (Conceive) and “D” (Design).

It is also not easy to guide a few groups of students in a class through user study, idea generation and selection mainly because the students have very different areas of interest – a group may be interested to help the elderly while another group may be interested to help road users etc. As a result, the act of carrying out the user survey is largely left to the students.

That leads to the question: Can the Design Thinking method be used in the “conceive” step?

WHAT IS DESIGN THINKING?

What actually is “Design Thinking”? If you Google this term, chances are you end up seeing Stanford’s D School or Tim Brown etc.

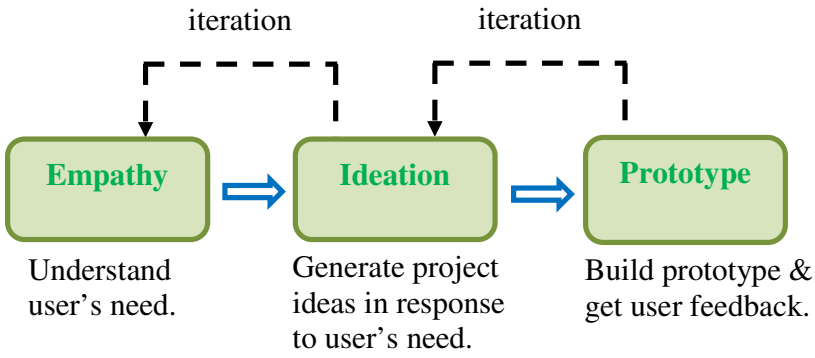
Design Thinking transcends disciplinary boundaries and adopts a fluid process to address a wide range of problems and issues. While there is no single definition for it, a useful starting point is the description below:

"Design thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity." – Tim Brown CEO, IDEO [2]

It is a methodology for practical, creative resolution of problems or issues. It is the essential ability to combine empathy, creativity and rationality to meet user needs.

Design Thinking is a creative process based around the "building up" of ideas. There are no judgments early on in Design Thinking. This encourages maximum input and participation in the ideation and prototype phases. [3], [4], [5]

In Singapore Polytechnic, the (simplified) Design Thinking flow (see Figure 2) has the following key steps: Empathy, Ideation & Prototype. It emphasizes "deep user understanding", through detailed survey/observation of users and subsequent analysis of the data collected.



Simplified Design Thinking flow

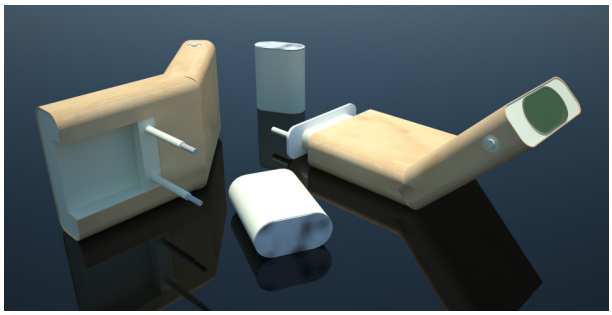
Figure 2. Steps in Design Thinking

In the Empathy step, the team of designers (or engineers) makes an effort to understand the user needs i.e. what kind of product or service the user really requires. This is done through a number of techniques such as survey and observation.

Once the user requirements are well understood, the team moves on to the Ideation step to brainstorm and propose possible solutions that may help to solve the user's problem. Concept sketches can be drawn to capture the ideas.

Often the proposed solutions result in "low resolution prototypes" (so called "quick and dirty prototypes") which are then presented to the users for comments. The quick prototypes (see Figure 3) allow unsuitable ideas to fail early, when the cost of failure is still low.

The prototypes do not have to be functional at this point in time: communicative prototype (such as one that is made of cardboard) that shows how the end product or service is to be used will suffice. It can even be in the form of a video, a skit, a comic strip or simply a good sketch.



"Form prototype" made of plastic – a form prototype gives an idea how the end product will look like, without being functional.

Figure 3. Quick prototype

The user feedback is used to refine the proposed solution. After this, the team moves on to build a functional prototype, before the end users are once again engaged to test-drive the product or service.

The flow is an iterative process. For instance, if (during "Ideation") the team discovers that they do not really have sufficient understanding of the user requirements to propose a good solution, they may have to repeat the "Empathy" studies.

As described above, the simplified Design Thinking flow contributes to the C & D portions of a C-D-I-O project (see Figure 4).

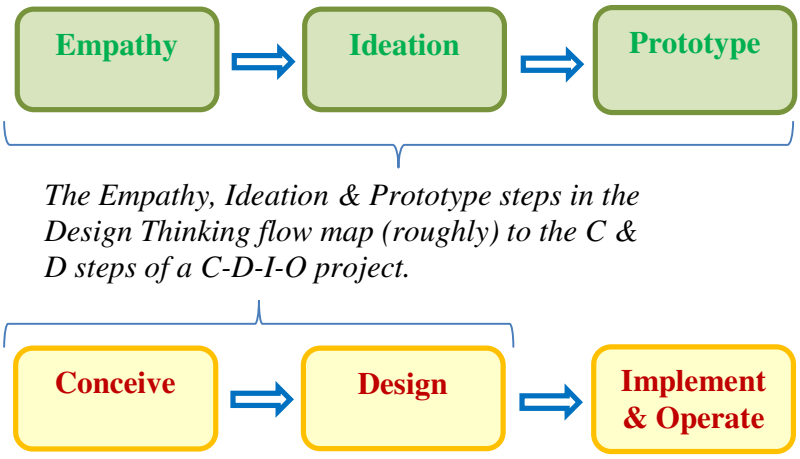


Figure 4. Design Thinking in C-D-I-O

HOW WAS DESIGN THINKING USED TO HELP STUDENTS CONCEIVE GOOD PROJECT IDEAS?

In September 2009, 80 students (and a number of lecturers) from three different schools of Singapore Poly (School of Electrical & Electronic Engineering, School of Mechanical & Aeronautical Engineering and School of Design) came together for a 4-day Design Thinking Workshop. Forty "senior citizens" (aged 50 and above) were also invited as users / co-designers. The theme of the workshop was "Dream Home". The purpose of this workshop was

to allow students from different disciplines to come together and use the "Design Thinking" method to solve real problems.

The 80 students (and 40 senior citizens) formed a total of 20 Multi-disciplinary project teams, each with 4 students (and 2 senior citizens and a lecturer as facilitator).

During the "Empathy" step, the following activities were carried out:

- The end users created "mood boards" (with pictures and words cut out from magazines pasted onto cardboards) to express their ideas of a dream home.
- The project teams went to the homes of the senior citizens to observe their living environment.
- The project teams interviewed other end users e.g. senior citizens at places where old people like to hang out.

After all the "mood boarding", interviews and observation, the project teams started the "Ideation" step. They analysed the data collected (observation, comments, insights etc.) and brainstormed to produce project ideas that could address the issues raised by the senior citizens in search of a "Dream Home". The ideas were captured as concept sketches, comic strips, videos, quick cardboard (i.e. "non-functional") prototypes and presented for critique.

After the 4-day workshop, the students and lecturers from the 3 schools continued to meet for 4 hours every week (over 2 months) to refine the project ideas.

One thing that stood out during the process was: The Design Thinking methodology does not aim for fast convergence – i.e. it does not try to arrive at "the solution" quickly. It encourages taking a step back every now and then, and asking "is that what the user really wants?"

After the 2-months of idea refinement, the students and lecturers from the 2 engineering schools regrouped themselves into 6 project teams to work on functional prototypes of 6 selected ideas over a further 2 months:

1. A horizontal fridge - that allows the elderly to take the stuff in the fridge without bending, as too much bending gives the elderly a back problem.
2. An item finder – that helps the (often forgetful) elderly to locate lost items in the house.
3. A family mirror – which lets the family members leave video messages for others, before leaving home.
4. A hassle free garden – that taps solar power and allows programmed regular watering of the plants.
5. A "dust monster" – that allows users to play a game of PACMAN while mopping the floor. Perhaps this will allow the elderly to pass the daily chore of mopping to his grandchild?
6. A set of "family together mugs" – that light up more LED's when more family members dine together. This serves to subtly remind the family members the importance of having meals together.

As the engineering students could see the relevance of their project ideas, these second year projects were carried on as final (third) year projects.

Back to the question: how was Design Thinking used to help students conceive better project ideas?

The following table summarises the qualitative differences between the projects conceived with and without using Design Thinking:

Table 1
Qualitative differences between projects conceived with and without Design Thinking

Projects conceived by "Multi-disciplinary Project / Design Thinking Workshop" students	**Projects conceived by "Design & Innovation Project" students**
• Show evidence of end user research & data analysis. • A lot of time is spent identifying the problem i.e. the "what". There is no rush to arrive at the solution i.e. the "how". • Details of projects arrived at after a lot of deliberation and iterations, based on the persona of an end user. • Focus is on the end user needs and concerns. • Solution to problem requires domain knowledge from other disciplines e.g. mechanical engineering.	• Evidence of end user research & data analysis often lacking. • Convergence to THE problem happens too quickly. • Details of projects arrived at after a quick "brain storming" session. • Focus is often on what project the students can do in the limited time, with their limited knowledge and skills on micro-controller. • Solution to problem can be provided by electrical & electronic engineering students alone.

The following table summarises the differences between the usual "Design and Innovation Project" module and the pilot run of the "Multi-disciplinary Project / Design Thinking Workshop":

Table 2
"Multi-disciplinary Project / Design Thinking Workshop" vs. "DnI Project" module

	Multi-disciplinary Project / Design Thinking Workshop	**Design and Innovation Project**
Time given for the whole project	4 full days (during the vacation) + 4 hours x 15 weeks + final year project time (9 months duration, approximately 6 hours per week).	30 hours over 15 weeks
Time given to conceive a project idea	4 full days (during the vacation) + 4 hours x 8 weeks.	4 weeks of students' own time (i.e. not time-tabled) - students attend briefing during scheduled lessons but do the work outside classroom hours.
"Theme" for the project?	A theme such as "Dream Home" is given.	Students are free to choose their area(s) of interest.
Guidance / help during the "conceiving" step	Arrangement is made to engage the target end users. Each team has a lecturer as facilitator to provide guidance.	Only briefing given. Students have to plan how their interview / observation etc. is to be carried out.
Nature of project team	Each project team is multidisciplinary in nature, consisting of a few EEE, a few mechanical engineering and a few design students.	Each project team consists of 4 or 5 EEE students.

It can be seen from the table that a lot more time was given to the Multi-disciplinary Project / Design Thinking students to understand the users and their needs.

Arrangements were also made for the students to engage the end users and to make the logistics possible, students were asked to work on a single theme “Dream Home”.

The lecturers (facilitators) worked closely with and guided the students through the interviews / observations and subsequent data analysis.

The fact that each team is multidisciplinary in nature also helped students to “dream big” as technical issues became less of a constraint – if a EEE student cannot fabricate a structure, their team mate from the other school will be able to help.

As a result of these differences (extended empathy study to understand users + facilitation/guidance + multi-disciplinary team), the ideas conceived using Design Thinking better address the end users’ needs, as outlined in Table 1.

SOME CONSTRAINTS, ISSUES AND FINAL THOUGHTS

As is evident from the discussion above, the use of Design Thinking in conceiving good project ideas comes with a set of constraints.

1. Time constraint – It is sometimes possible to persuade students to forfeit a few days of their vacation to come back to school and do “user empathy study” for their projects. These students also spend additional few hours per week over a number of weeks on their C-D-I-O project. Often, additional time must be allocated in the curriculum hours for students to carry out user study.
2. Logistic arrangement required for students/staff from different schools to work together. They must have common time-tabled hours for C-D-I-O project. The lecturers must be time-tabled likewise. There must be a venue large enough to house so many students.
3. Facilitation needed, such as arrangement for students to engage / interview / observe end users. Such arrangement is only possible when students work on the same project “theme”, for instance, “Dream Home for the 50+”.
4. It was also difficult to get the same group of end users (50+) to stay with the student project teams throughout the project. So, the prototypes created could only be shown to other end users for comments and refinement.

The “pilot run” of the Multi-disciplinary Project / Design Thinking Workshop, although a success in terms of learning experience, proved to be very resource-intensive – in terms of time, logistics and facilitation required. It would not be easy to allow a large number of students to go through the same experience.

To allow more students to benefit from Design Thinking in their C-D-I-O projects, Singapore Poly has started developing a comprehensive “Design Thinking Tool Kit” – a collection of common Empathy / Ideation / Prototyping tools that the lecturers will learn and coach the students to use in their projects. Such tools allow more lecturers to become acquainted with Design Thinking methodology quickly, and to facilitate students’ project work in various settings.

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Biographical Information

Chong Siew Ping has been a lecturer with Singapore Polytechnic since 1991. He graduated from National University of Singapore (NUS) with honours degree in Electrical Engineering and later pursued his part-time Master of Science degree (in Electrical Engineering) in the same university. His professional interests are embedded system design, logic circuit design & FPGA (Field Programmable Gate Array)-based design. He was part of a team which developed & pilot ran the module Design & Innovation Project, which allows second year students from the School of EEE (Singapore Poly) to go through the C-D-I-O process.

Patrick Chow is a Senior Lecturer and course manager for the Diploma in Bioelectronics. His main research interest is in the area of digital signal processing and implementation of real-time DSP systems. As course manager, he has initiated various innovative curriculum designs and teaching methods in his course.

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