A CDIO APPROACH TO CREATIVITY, INNOVATION AND ENTERPRISE OPTION MODULES

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ABSTRACT

In 2005, a new Creativity, Innovation and Enterprise (CIE) Option was created for second year students to learn new skill-sets that are geared towards moving up the manufacturing value chain. This curriculum framework aims to infuse a mindset for Creativity, Innovation & Enterprise where students learn foundation product design and development skills in year 2 and apply them in their final year "CIE Option Project" (capstone project). This paper describes the achievements and results of the new option, making references to educational reforms and initiatives from Massachusetts Institute of Technology (MIT), Kanazawa Institute of Technology (KIT) as well as Singapore Polytechnic's best practices.

KEYWORDS

Creativity, Innovation, Enterprise, Engineering Design, Multi-disciplinary, Workspace

INTRODUCTION

Education Transformation

For Singapore to be competitive within the region, she has to move into higher value added manufacturing activities which involve developing Singapore's creative economy i.e. growing the design-driven industries (amongst them is product design and development). The push is to prepare trained workforce to engage in upstream activities and to groom a spirit of experimentation and entrepreneurship for original content creation. This allows Singapore to compete in the upstream position, and reduce the risk of competing via conventional means of cost and efficiency.

To facilitate infusion of design education into curriculum, the new CIE Option was launched for second year students which focus on training students with product design and development skill-sets as well as exposure to business basics. This framework was drafted based on MIT CDIO Standards, KIT Education Reform Initiatives and SP Educational Model.

The curriculum was designed to emphasize the multi-disciplinary nature of design, creativity, engineering, entrepreneurship and at the same time train students to meet industry expectations. It also aims to harness the creative potential of technically competent polytechnic students and inculcates design capability and business practices.

Changes were made in the second year and third year curriculum to include modules that give students foundation design skill-sets in the second year with intensive project based learning in their third year. The integrated curriculum aims to give students:
1. strong technical and foundation skill-sets
2. practical skills through real world learning experiences
3. the opportunity for active applications to facilitate understanding and retention
4. a holistic training that includes personal, interpersonal, social and team building skills.

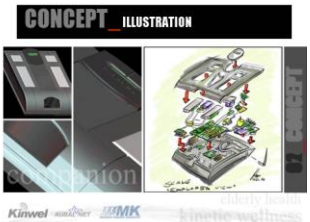
This paper highlighted three modules in the CIE Option, namely:
Second Year
1. Product Design and Development I (PDD1)
2. Product Design and Development II (PDD2)

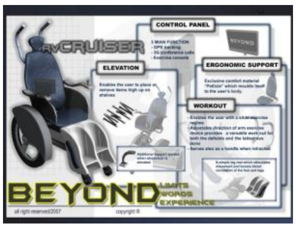
Third Year
1. CIE Option Project (full time final year project)

PRODUCT DESIGN AND DEVELOPMENT 1 & 2 (PDD1 & PDD2)

In semester one of 2005, the first batch of CIE Option students began the new programme. The batch consisted of Mechanical Engineering (MM) and Chemical Engineering (CLS) students. They started with PDD1 foundation skills which include identify users' needs, ideation skills, defining product specifications and creating 3D concept models. PDD1 introduces basic design processes and techniques to students and in PDD2 they are given further in-depth skill-sets which they learn and apply them in their mini projects (CDIO design-build experience – Std 5).

In PDD1, students have to be conversant with product visualisation skills in order to create 3D forms of conceptual products. In PDD2, students venture further to refine their concepts; this time giving more thoughts into the details such as, the core technologies, rapid prototyping, human ergonomics, environmental and sustainable considerations. Below are some of the portfolios and presentations created by student teams. Some of the project poster presentations were sent to Kanazawa Institute of Technology (KIT) and exhibited at their engineering design poster session.






Mini project portfolios and presentation


SP students' posters displayed at Kanazawa Institute of Technology (KIT)

CIE OPTION PROJECT (CAPSTONE PROJECT)

In their 3rd year, the CIE option students follow a different training curriculum compared to mainstream students. They had to complete a one semester (15-weeks) of full time project work according to the CDIO stages and this is a major design-build experience programme for them. Here the project- based-learning, being full time, is more project-focused and intensive, somewhat similar to an industry setting.

To support the learning needs of this programme, the entire Integrated Project Centre (iPC) was renovated to provide the CDIO workspaces (Std 6). Unlike MIT's Guggenheim Aeronautical Laboratory where specific workspaces were designated for C, D, I and O; here, the entire iPC has to cater to the various stages of CDIO; adapting and 'transforming' as the needs changes. In addition, iPC is also used as an exhibition hall during the annual SP Spinnovex Exhibition where shortlisted final year projects are showcased. With these requirements in mind, the workspace was designed to be highly adaptable for the various stages of this programme; from C to D to I to O and to Spinnovex.

WORKSPACE TRANSFORMATION

To create a totally flexible workspace capable of 'transforming' to the needs, a custom built cubicle system was necessary. Each cubicle replicates an "engineering design office" with distinct colour scheme (representing multi-disciplinary collaborations) and an overhead signboard (for team identity). Student teams took to designing their own signboards to reflect their project themes and team identities. Each cubicle is also fully equipped with white board/paper holders for meetings, power sockets for notebooks, storage cabinets for bags and belongings, tables/side tables that can be arranged to suit the team's needs.

Conceive

This stage of the project usually requires teams to engage in ideation, brain storming and discussions with supervisors etc., which are supported by fact finding, research and surveys. Team meetings are carried out within the cubicle, complete with wireless internet access for students to explore options and possibilities.

Design

The teams then move on to this stage where details on developing project tangibles are needed. In the case of a multidisciplinary project like the aroma dispensing exercise game machine, MM students were involved in designing the hardware with CAD/CAID tools whilst the CLS students were identifying aromatic compounds and characterising formulations that will match the game scenarios at CLS labs.

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For product visualisation, the CAD/CAID Lab is located adjacent to the "engineering design office" and is fully equipped with workstations to support product design and development. What is unique about this setup is that all workstations are modular, i.e., each workstation with monitor is individually housed and can be set up at any locations within iPC to meet their learning requirements. Students find this flexibility most useful during the Implement and Operate stages where the availability of CAD tools near their project hardware helps to speed up modifications and design refinements.

“ENGINEERING DESIGN OFFICE” MODE @ iPC

CONCEIVE AND DESIGN

Teams settling in and putting up their signboards

Teams at work in their “Engg. Design Office”

Modular workstations at iPC’s CAD/CAID Lab can be moved from Lab to project site

Implement

As the project gets into this phase, there are more hands-on practical contents where assemblies, interfacing to electrical or chemical sub-systems, testing and troubleshooting are in progress. For larger projects that require more floor space, furniture within the cubicles can be rearranged to accommodate this requirement.

From ‘Office’ → (Conceive, Design)

To ‘Garage’ → (Implement, Operate)

Operate

The final phase is usually the most intensive stage of the project where bulk of the work is on the project hardware. Hence, each cubicle space is used as a “garage” with the tables rearranged. Students typically put in their last ditch effort to get the hardware operating; applying final touches to fine tune, test and enhance the appearance of their deliverables.

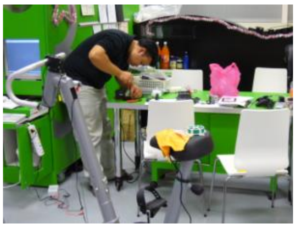
As the project exhibition date approaches, the “engineering design office” mode will now have to make way for the “exhibition” mode to prepare for Spinnovex. Students continue to work on their hardware while conversions of cubicles were carried out concurrently.

To reduce the need for additional storage space to house dismantled cubicle elements, the cubicle columns were reoriented and use as poster display boards. Similarly, the column sideboards were collectively joined to form the central divider with the C-I-E Towers providing the vertical support structure.

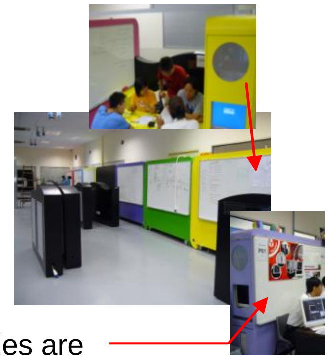
IMPLEMENT AND OPERATE





Workspace is being transformed to “Exhibition” mode

Cubicles are reoriented and used as poster display boards

Central divider is formed by connecting cubicle sideboards (red arrows) to the C-I-E Towers (with green, blue and red display lights)

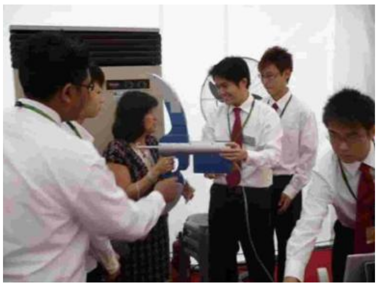
“EXHIBITION” MODE @ iPC during SPINNOVEX



Projects are moved in and setup for Spinnovex

CIE OPTION PROJECTS AT SPINNOVEX

Prof Matsuishi (KIT) on the xD Bike



MM / EEE team (Interactive Game-Bow & Arrow)

MM / CLS team (Physio-Beans)

RM Simulator team was featured in the Channel News Asia-Amazing Asia programme

Guest of Honour-Dr Chew (CEO of Singapore Science Centre) on the “Motion Simulator II”

EDUCATIONAL THEORIES

The CIE Option modules were based on several educational theories, namely Constructivism, Behaviourism and Problem based learning.

In constructivism, learners construct knowledge and meanings for themselves as they take in foundation knowledge (PDD1 and PDD2). They learn through their own experiences, building on their previous knowledge and using acquired experiences to solve new problems. The mini projects introduced in PDD1 and PDD2 gradually builds up their skills level in managing project work; starting with Conceive/Design in PDD1 and then Conceive/Design/Implement in PDD2. Also by increasing students’ awareness of environmental impact and product life cycle considerations, they began to appreciate that product design as an all encompassing activity that needs to address not only functional requirements but also a host of other issues.

Behaviourism or ‘operant conditioning’ charges that all mental activity is a form of behaviour that responses to and interacts with environment stimuli. This led to the creation of a learning environment at iPC that best represents an industry scenario whilst working within the given space constraints. Having a personalised “engineering design office” with their own identity gives each team the added motivation and team spirit to meet their project challenges. By reinforcing what industry practises such as full-time project work, working within time and budget constraint, multi-disciplinary collaborations, self resource-fulness….these inevitably condition students to understand industries’ expectations.

In incorporating Constructivism and Behaviourism into Problem-based-learning and making the process highly systematic (as in the CDIO approach), students are led through an instructional process that better prepares them in dealing with open ended real life problems. The mini projects in second year PDD1 and PDD2 prepares students for the final design-build experience (capstone project) and provides them a process framework for handling project work effectively.

Also the pervasive use of IT support systems at iPC continues to reinforce students' IT skills in leveraging on the latest technologies to enhance their learning. With these tools, students are able to learn both in the physical sense and, of increasingly importance, the virtual sense too.

The "engineering design office" workspace emphasises group learning through team work, social interaction and cross disciplinary learning through collaborations with students across the schools (MM, CLS and EEE). Students are therefore immersed in an environment that promotes collaborative inquiry across disciplines and develops co-operation, effective teamwork and mutual tolerance amongst team members. Such are the demands of the industry and incorporating these elements into their training will better prepare them for their working life.

CONCLUSIONS

From the results achieved by students in the CIE Option programme, it can be seen that building up students' skills in handling projects requires careful planning in the curriculum and syllabi that will not only provide the knowledge but also the "integration" and "use" of such knowledge towards solving real life problems. Using the systematic framework defined in CDIO standards, students are immersed in active learning activities that exposed them to 'design-build' scenarios; starting from mini projects to the eventual final year projects.

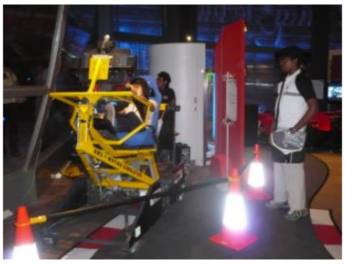
Reinforcement between theory and practice has been the key emphasis in education programmes at the KIT Yumekobo. The provision of facilities, workspaces, human resources to support theory and practice is also equally important and these were planned into the CIE Option right at the beginning.

The CIE Option's full-time intensive project over one semester also provides students a training environment that closely resembles that of the industry. Reporting daily to the Integrated Project Centre with biometric clock-in/out is a way of developing good work habits and attitudes that are vital to team project work. To further enhance team bonding especially when collaborating with students across schools, the programme starts them early in their second year with their PDD1, PDD2 modules and mini projects. The social interactions and team activities helps to build up trust and understanding between members and gave them the confidence in working with 'familiar' team players. For ad-hoc projects (e.g. industry based projects involving EEE students), the EEE students are introduced to the team in semester one i.e. one semester before the actual start of the full time project and this arrangement had shown to be effective.

Students' feedbacks on the CIE Option modules have been encouraging and their learning outcomes have not gone unnoticed. The RM Simulator was loan to the Singapore Science Centre for the "Science of F1 Exhibition"; the Massage Jacket and iExercise Machine generated interest amongst industry partners. A number of project teams also received commendations in gold, silver and bronze certificates for their project achievements.

‘RM SIMULATOR’ EXHIBITED AT THE SINGAPORE SCIENCE CENTRE “THE SCIENCE OF F1” EXHIBITION DURING THE INAUGURAL LAUNCH OF F1 NIGHT RACE IN SINGAPORE LAST SEPTEMBER

Front façade of the Singapore Science Centre with “The Science of F1” Exhibition banner


Students “Operate” on site during setup


Poster boards on the RM Simulator

The CIE Option programme has come a long way since it took in the first batch of students in 2005 and the building blocks that make it work….CDIO Standards, KIT Initiatives and SP Educational Model with integrated curriculum, adaptable workspaces, team building…all adds up to the goal of providing a sound education and skills training that aim to meet the needs of industries.

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MM/CLS Class of ’07-’08

MM/CLS Class of ’08-’09

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