DEVELOPING INNOVATIVE GRADUATION PROJECTS BASED ON CDIO APPROACH

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ABSTRACT

Innovation is surely amongst the most frequently used words in business today, not least because excelling in these areas is widely acknowledged to be associated with business success. Innovation is also integrated into CDIO syllabus (4.7.8, 4.8.6).

In this paper, the author would like to deal with this issue for graduation projects, developed at Faculty of Mechanical Engineering, Ho Chi Minh City University of Technology. The process of implementing the innovative graduation project has four phases, twelve steps with learning outcomes in which students are expected to be able to: create and manage effectively a project; recognize Voice of the Customer, understand needs and set goals; use practical and theoretical methodologies to communicate and evaluate ideas; apply innovative processes and an effectively-managed team approach for solving complex technology innovation and/ or product development tasks; experience the process of Conceive – Design – Implement – Operate; create, test and evaluate products; demonstrate experience of working with industry partners.

A case study illustrates the process, in which some machines of a rice milling plant are redesigned, manufactured and operated automatically with better productivity and quality. Results are developed widespread in Southern Vietnam. Six patents are issued.

KEYWORDS

Innovative graduation projects, root cause analysis, CDIO syllabus.

INTRODUCTION

One of new manufacturing trends for the next decade is that innovative companies and countries will win the market. Innovative companies may take more the market share of non-innovators. Key to continued innovation is investment in university research in science and technology and ready access to a skilled workforce. Nevertheless the current situation in Viet nam and in Vietnamese manufacturing companies is to be concerned. According to Global Competitiveness Report 2012 – 2013, published by World Economic Forum in September 2012 [1], Overall Global Competitiveness Index 2012–2013 of Vietnam is ranked at 75/ 144, Availability of latest technologies:137/ 144, and Firm-level technology absorption: 126/ 144.

This situation requires Vietnam and Vietnamese companies have to make strong progress in technology innovation, and have to consider that “to innovate or to die”. Innovation needs innovators and universities play an important role in integrating innovation into curriculum and subjects. Among them, graduation project is a comprehensive and big task, which requires students know to apply knowledge, skills and experiences to solve engineering problems that have a wide and practical solution environment. It is better that the project assignments are generated and defined by industrial companies and are therefore relevant problems associated with real products.

Hence, developing innovative graduation projects based on CDIO approach [2] in which engineering problems to be solved and linked up with production practices is crucial. In this paper, the author would like to address innovative graduation projects developed at Faculty of Mechanical Engineering in the academic year 2011-2012 at Ho Chi Minh City University of Technology.

INNOVATIVE GRADUATION PROJECT

Objective and learning outcomes

Objective of the graduation project is to provide possibilities for the students to participate in industry related technology innovation and/ or product development projects with a range of complex, multi-disciplinary problems, expose them to team-based problem solving in a realistic business, societal, and environmental context, help students understand market and business needs, encourage students to set realistic goals, apply sound project and team management procedures and create innovative solution concepts on the basis of their fundamental technical engineering knowledge.

The projects are usually tasks formulated in collaboration between the university and industrial companies in order to solve problems relating to technology innovation and/ or product development.

Upon completion of the project students are expected to be able to:

- Create and manage effectively a project,
- Recognize Voice of the Customer, understand needs and set goals,
- Use practical and theoretical methodologies to communicate and evaluate ideas,
- Apply innovative processes and a an effectively-managed team approach for solving complex technology innovation and/ or product development tasks,
- Experience the process of Conceive – Design – Implement - Operate.
- Create, test and evaluate products,
- Demonstrate experience of working with industry partners.

The process

The process of implementing the innovative graduation projects is designed in close reference with CDIO syllabus [3] and the model framework for CDIO implementation in Vietnam [4].

Phase 1: CONCEIVE

Step 1: Select a topic

Lecturers help students identify topics for project work. List of topics include manufacturing and processing industries such as textile and garment, footwear, mechanical, agriculture, food, plastics, mechatronics, etc.

The topics should be suitable for students to apply knowledge learned from the curriculum as much as possible, give students opportunities to experience the process of Conceive – Design – Implement – Operate and linked with technology innovation projects from above – mentioned industries.

Step 2: Contact the partner company

There are memorandums of collaboration between Faculty of Mechanical Engineering (HCM UT) and industrial companies. The lecturer arranges a meeting between students with the partner company. The company provides students with relevant information (Voice of Customer) to identify the needs of technology innovation and set goals.

Students form team; create, plan and schedule the project; identify risks and changes.

Step 3: Identify the problems to be solved.

Start by inquiry, listening and dialog, students identify the problems to be solved. Problem may be: operational parameters are not yet optimized, reliability of some components, mechanisms are low, productivity or product quality is not as expected, etc.

Step 4: Apply root cause analysis to determine root causes of each problem.

By applying system thinking and root cause analysis (RCA), students determine root causes of each problem. To be effective, RCA must be performed systematically, usually as part of an investigation, with conclusions and root causes that are identified backed up by documented evidence. There is a RCA diagram for each problem. There may be more than one root cause for a problem, the difficult part is demonstrating the persistence and sustaining the effort required to determine them.

Step 5: Propose solutions for each root cause.

Through critical thinking, creative thinking, brainstorming and six thinking hats method, students propose solutions for each root cause. Each solution must be concrete and feasible. There may be a certain solution which can solve not only one but also more root causes.

Step 6: Conceive innovative ideas and create solutions

By comparing, analyzing, synthesizing and benchmarking, applying practical and theoretical methodologies, students conceive innovative ideas, define and create new solutions to overcome most or all root causes. There may be some communicating possibilities, negotiation, compromise and conflict resolution with company staff and the customer.

Phase 2: DESIGN

Step 7: Design or redesign the machine (mechanism, device, component)

Because solutions may be diverse and relate to some different areas such as mechanical engineering, mechatronics and automation, information technology, industrial engineering, etc. then they require technical and multidisciplinary teaming. During the process of designing or redesigning the machine (mechanism, device, component), students need to present the ability of time and resource management, of electronic/ multimedia/ graphical communication; the knowledge in design process, design for manufacturing, assembly and disassembly, maintainability and reliability, sustainability, safety, aesthetics, operability and other objectives. Innovation spirit must exist everywhere and every time.

Mechanism, device, component are modeled and designed by using tools such as ProEngineer, Inventor, SolidWorks, Cimatron, Ansys, Abacus, Mathlab, DFMA and cost analyses methods.

Phase 3: IMPLEMENT

Step 8: Manufacture and assemble products

Students join with company staff to design a sustainable implementation process; to implement hardware manufacturing process, software implementing process, hardware software integration; to monitor the whole process of manufacturing and assembling new products (machines) at company plants. By this way, students have opportunities to practice professional behavior, to work in industrial companies and different enterprise cultures.

Step 9: Test products

Students participate in the process of testing new products (machines) to assure required functions, specifications.

Phase 4: OPERATE

Step 10: Install

Students participate in the process of installing machines at an industrial plant.

Step 11: Operate

Students join with company staff to design and optimize sustainable and safe operations, to train operators in the plant.

Step 12: Record results and write a report

Students record results before and after improvement/ innovation.

All above – mentioned steps have been continuously reported to the supervisor during the project. Students write a final report and give a final presentation of the results.

CASE STUDY

Case study is implemented in the Long An Manufacturing Company. Company's main activities comprise manufacturing machines and related services for rice milling plants.

Phase 1: CONCEIVE

Step 1: Select a topic

Selected topics relate to agricultural and food processing machines. Enhancing the added value of agricultural products through improving and innovating technology and machines is a mian national strategy.

Step 2: Contact the partner company

There is memorandum of collaboration between Faculty of Mechanical Engineering (HCM UT) and Long An Manufacturing Company since 2007. The lecturer arranges a meeting between students with the company. The company provides students with information on the current state of products (machines), customer comments and the needs of technology innovation and set goals.

Step 3: Identify the problems to be solved.

Start by inquiry, listening and dialog, students identify the problems to be solved.
The rice milling line is composed of dozens of machines (Fig. 1), manufactured by Long An Manufacturing Company. Six main machines are: husker, husk separator, destoner, whitener, polisher and fine paddy separator.

The context is that in the current rice milling lines, operator adjusts manually each machine based on quality of the output rice. If quality criteria are not good, operator readjusts the machine. Hence, there is loss in quality between adjustments.

In the other hand, because of manual adjustment, there are differences in productivity between different operations or machines. So, there is loss in productivity between adjustments and unbalance.

The company has requirements to improve the above mentioned disadvantages.

According to some surveys and customer's comments, each machine has its own problems. In this case study, we focus on husking machine (husker). There are three following problems:

- Low and unstable productivity (Problem 1): productivity of the husker is the amount of the paddy entering the machine in a unit time (tons/ h). This current productivity is low and unstable.

Fig.1: The rice milling line, made by Long An Manufacturing Company.

- Low and unstable percentage of husked paddy (Problem 2): percentage of husked paddy is the ratio of the amount of husked paddy to the amount of the paddy entering the machine. This current percentage is low and unstable.
- High percentage of broken rice (Problem 3): percentage of broken rice is the ratio of the amount of broken rice to the amount of entire rice. This current percentage is still high.

Step 4: Apply Root Cause Analysis to determine root causes of each problem.

By applying system thinking and root cause analysis (RCA), students can determine root causes of each problem as following (Tab. 1):

- Root cause of Problem 1 is the operator adjust manually and usually the feeding hopper.
- Root cause of Problem 2 is two rubber shafts are worn during husking process.
- Root causes of Problem 3 are two rubber shafts are worn during husking process and position between the feeding screen and two rubber shafts changes.

Step 5: Propose solutions for each root cause.

Through critical thinking, creative thinking, brainstorming and six thinking hats method, students propose solutions for each root cause (Tab. 1).

- The solution for Root cause of Problem 1 is to monitor and control automatically the feeding hopper.
- Three solutions for Root cause of Problem 2 are to measure and monitor automatically the wear degree of two rubber shafts, to control automatically the speed of two rubber shafts in order to maintain the desired velocities and to control the pressing force on the rubber shafts.
- The solution for Root causes of Problem 3 are to control automatically position between the feeding screen and two rubber.

Step 6: Conceive innovative ideas and create solutions

By comparing, analyzing, synthesizing, benchmarking and discussing with company staff and the customer, students create new solutions for the machine as following:

- Automatic feeding system (Fig. 2).
- Automatic device for measuring and monitoring the wear degree of two rubber shafts (Fig. 3).
- Automatic device for control the speed of two rubber shafts (Fig. 4).
- Automatic device for controlling pressing force (Fig. 5)
- Automatic device for controlling the position between the feeding screen and two rubber shafts (Fig. 6).

Table 1: Analysis of problems, root causes and solutions for improving/ innovating husker

Problem	**Root cause**	**Solution**	**Device, system to be improved/ innovated**
1. Low and unstable productivity	The operator adjust manually and usually the feeding hopper	To monitor and control automatically the feeding hopper	Automatic feeding system (Fig. 2)
2. Low and unstable percentage of husked paddy	Two rubber shafts are worn during husking process	To measure and monitor automatically the wear degree of two rubber shafts.	Automatic device for measuring and monitoring the wear degree of two rubber shafts (Fig. 3)
		To control automatically the speed of two rubber shafts	Automatic device for control the speed of two rubber shafts (Fig. 4)
		To control the pressing force on the rubber shafts	Automatic device for controlling pressing force (Fig. 5)
. 3. High percentage of broken rice	Two rubber shafts are worn during husking process	Above - mentioned	Above - mentioned
	Position between the feeding screen and two rubber shafts changes	To control automatically position between the feeding screen and two rubber shafts	Automatic device for controlling the position between the feeding screen and two rubber shafts (Fig. 6)

Phase 2: DESIGN

Step 7: Design or redesign the machine

By using Inventor and DFMA, students design the above mentioned system/ devices.

Phase 3: IMPLEMENT

Step 8: Manufacture and assemble products

Students participate in the process of manufacturing and assembling the improved machine in company workshops.


Fig. 2: Automatic feeding system.


Fig. 3: Automatic device for measuring and monitoring the wear degree of two rubber shafts.

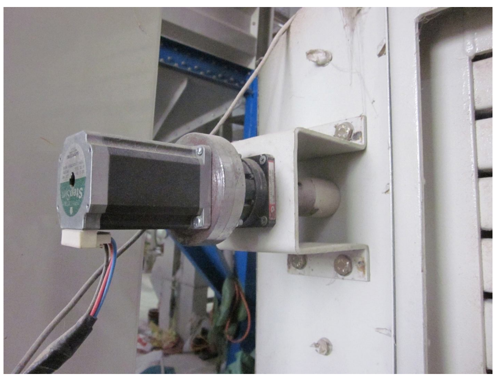
Fig. 4: Automatic device for control the speed of two rubber shafts.


Fig 5: Automatic device for controlling pressing force.

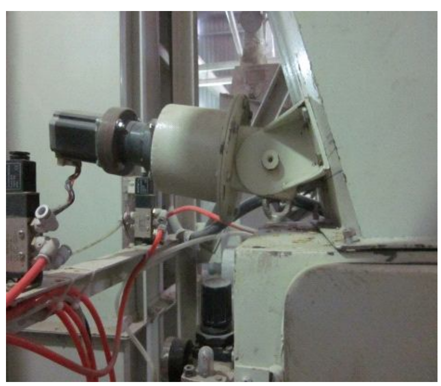
Fig 6: Automatic device for monitoring and controlling the position between the feeding screen and two rubber shafts.

Step 9: Test products

Students participate in the process of testing the improved machine.

Phase 4: OPERATE

Step 10: Install

Students participate in the process of installing the improved machine at a rice milling plant.

Step 11: Operate

Students participate in the process of operating the machine at the rice milling plant.

Step 12: Record results

Students record results before and after improvement and innovation.

For husker: productivity increases 14,3%, percentage of husked paddy increases 11,2%, percentage of broken rice decreases 1,1%, specific energy consuming decreases 16,7%.

The same process for other machines.

The company and our staff, students have received six patents: Automatic rice husker, Husk separator with automatically adjusted separating vanes, Automatic destoner using image processing technology, Automatic whitener, Automatic whitener, Automatic polisher, Fine paddy separator.

EVALUATION

The project is evaluated in cooperation between the examiner, the supervisor, company representative and a group of three - five students. The evaluation is based on two meetings and an evaluation form to be completed by all students.

The students are happy with these innovative graduation projects, in which they experience innovative thinking and process – the Conception, Design and Introduction of New Goods. They find projects interesting, motivating and useful not only for them as future engineer but also for industry. Projects bring realistic world to the education.

CONCLUSIONS

The objective and stated learning outcomes are fulfilled. Students experience CDIO phases in innovative graduation projects, understand deeply roles and responsibility of an engineer, are more self confident and available to be a future engineering leader with innovation spirit.

Projects are implemented in close collaboration with the industry. The industry is pleased with the projects, the solutions, the knowledge, the skills and behaviors that the students have gained. The industry understands more the importance of innovation and collaboration with the universities.

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BIOGRAPHICAL INFORMATION

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