A Proposed Closed-Loop CDIO Model to Improve the Startup Ability

Binh D HA, Truong V TRUONG, Bao N LE

Duy Tan University, Da Nang, Vietnam

ABSTRACT

The total population in Vietnam was estimated at 95 million and approximately 40 percent of whom are less than 25 years old. Vietnam is considered as the third largest market in Southeast Asia and startup is being encouraged by the Vietnam government nowadays. The students in the Electrical & Electronic Engineering (EEE) majors have the ability to create some products through CDIO project-based learning for startup. However, they lack continuous innovation ability to achieve startup effectiveness. During implementing the CDIO framework in our university, we have accumulated some experience to solve this problem and obtained some positive results that will be presented in this paper.

The first contribution is a proposal of teaching and learning framework for improving startup ability, namely Closed-Loop CDIO based on the conventional CDIO model. After Operation stage, the students are encouraged and trained to continue to conceive a new idea to improve or to create a new product based on the previous one. The improving issues include functions, specifications, cost, maintenance, etc. The Closed-Loop CDIO framework enables us to improve the continuous innovation ability of EEE Students for enhancing the competitive ability of their products. In this proposed model, we emphasise the nonstop innovation to meet the consumer's requirements.

The second contribution of this paper is the evaluation of this proposed framework based on the accepted products on the market. We statistically investigated after five years of this framework implementation in our faculty from 2013-2014 to 2017-2018 and the results confirmed the effectiveness of this considered model. In order to clarify the efficiency of this framework, we also present one real case, i.e., smart home products. In that case, we describe the detail process of applying of Closed-Loop CDIO framework to enhance startup ability based on smart home products. We will discuss more detail about our works to solve these problems in full paper.

KEYWORDS

CDIO standard No. 5, 8, 10, Closed-Loop CDIO framework, CL CDIO model, startup, innovation, products

INTRODUCTION

With a large population of 95 million and young people occupy the majority, approximately 40 percent of whom are less than 25 years old, Vietnam becomes the third biggest potential market in Southeast Asia. It brings big opportunities for entrepreneurs exploiting this emerging market.

Aware that issue, Vietnam government has been encouraging startup spirit from whole society in recent years (www.startup.gov.vn). Duy Tan University, the cradle of human resources training for startup, has been also deploying to provide the startup knowledge to her students. To start a business, we must not only have knowledge of management, marketing, soft skills but also have certain knowledge about the product or business services. In particular, to increase the competitiveness of young businesses, the owner must have innovative and unique products, (Adam Szirmai, 2011). Constantly innovating ideas is key to innovative products or services (Fei Bian, 2013). However, innovation ability cultivation in the particular field of Electrical & Electronic Engineering (EEE) becomes even worse here due to mass education in Vietnam if we do not have any improving activity on it. There are many works focusing on improving the innovation ability of the student. For example, in "*Innovation Ability Cultivation of Automation Major Students*" (Wang, Yangqin et al., 2013), the author presented the teaching method to enhance the innovation ability of automation major students. By deploying of the innovation education concept, building innovation experiment platform, constructing teaching staff and building innovation team, the students' innovation thinking, innovation spirit and innovation ability was cultivated. In the work of "*Research Experimental Teaching System Based on Innovative Practice Ability*" (Wu, Tong Q. et al, 2013), an experimental teaching system based on innovative practice ability was presented.

Duy Tan University has been deploying startup program from the year 2009 and CDIO framework in EEE education programs from the academy year 2011-2012. At that time, we proposed a new teaching and learning framework for scientific research, namely CDIE (Conceive – Design – Implement – Evaluate) that exists paralleled with CDIO model (Binh Dac HA et al., 2017). The combination of scientific research and CDIO teaching method enables us to improve the innovation ability of EEE Students in our university. In that proposed model, we emphasized the Evaluate phase for all the projects that have new academic results. This work helped students know how to evaluate the new results of their projects. However, at that time the combination startup and CDIO has not been considered as a key to open the door of electrical & electronic product market for EEE students.

Two years later, from the academy year 2013-2014, our faculty has proposed and deployed a novel model, namely Closed-Loop CDIO framework to enhance the innovation and startup ability to our students. EEE Students only focus on their prototype working or not, but they do not consider much about their products for startup. And they do not consider how to continue improving their products to meet the market's requirements. In order to solve these problems, we integrate EEE's major content and business knowledge during implementing CDIO courses.

CLOSED-LOOP CDIO MODEL DESCRIPTIONS

In EEE's education program, there are five CDIO courses, namely CDIO 1 – CDIO 5, for 4 years and a half of training as Table I. Each course has different learning outcomes, detail in Table 1. In CDIO 1, we focus on the activities to cultivate the brainstorming ability for students, so we put the weight for Conceive higher than others. In CDIO 2, we train the students how to design a product and we give the assessment ratio of Design higher than others. Similarly, in CDIO 3 and CDIO 4, we emphasize Implement and Operate abilities, respectively. Finally, in the last CDIO 5, we orient each team to do a project that can evaluate each C-D-I-O at the same level. Each course lasts for 3-4 months.

Table I. List of CDIO courses in EEE education program

No.	CDIO Course Name	Course Learning Outcome	Assessment Ratio
1	CDIO 1	Conceive	C40%+D20%+I20%+O20%
2	CDIO 2	Design	C20%+D40%+I20%+O20%
3	CDIO 3	Implement	C20%+D20%+I40%+O20%
4	CDIO 4	Operate	C20%+D20%+I20%+O40%
5	CDIO 5	Conceive-Design-Implement-Operate	C25%+D25%+I25%+O25%

In order to cultivate the startup ability, we have been implementing the Closed-Loop CDIO framework in Duy Tan University for several years as Figure. 1. The start point of this loop is Conceive, which is the same as the conventional CDIO framework. However, this CDIO framework is tried to apply for 4.5 years with closed loop for selected teams. Specifically, in CDIO classes, we divide it into some groups or teams. We let them decide whether pursuing the startup objective or not. The team, who pursue the startup objective, is assigned running a business project. In this project, they will pursue an idea of EEE's product family that can provide to the market, for example, smart home. In each CDIO course, we flow to the CDIO framework as mentioned above. However, this team does not need to change their product from one course to another course. In other words, they only focus on one kind of product that can be sold on the market. This kind of product will through five courses as follows.

In the course CDIO 1, the students are asked to propose ideas of a product in EEE's field. Ideas can come from field trips at the business, from observations in the daily life of students, or perhaps from practical experiences of faculty in the field of Electrical - Electronics. From these ideas, students begin to learn and research products and markets. Next, they discuss their ideas in their team and decide the final product. Then, they design their idea by drawing and building a simple prototype to convince their potential customers. Finally, they adjust their idea according to the results they got from their survey.

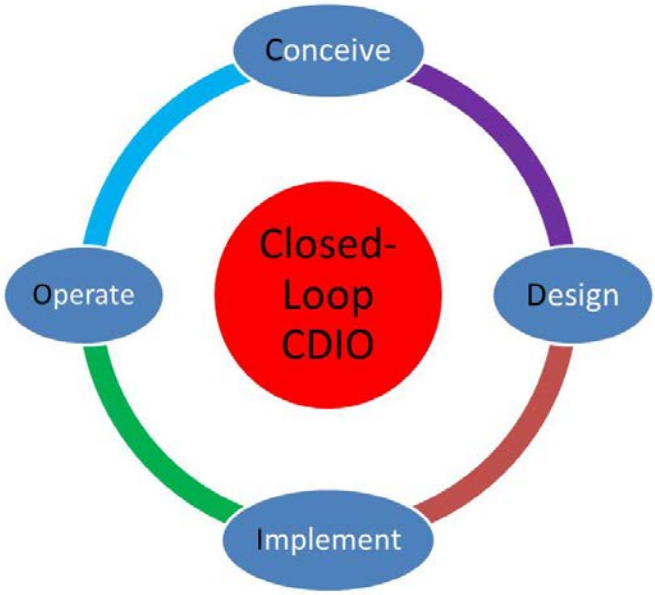

Figure 1. The Model of Closed-Loop Conceive-Design-Implement-Operate (CL CDIO model)

In the course CDIO 2, the selected teams continue their ideas but they should put their concentration on the Design stage. They not only focus on designing for product running but also consider their appearance, cost, convenience and so on to meet the market's requirements. Of course, during this course, they should propose the idea to obtain the best design results. They also are asked to use some software and tools to design and simulate their products. Then, they complete their products by making a 2nd version prototype. Finally, they investigate the customers about this product's design and discuss in their team to optimize their design.

In the course CDIO 3, the selected team seeks for at least one customer to be willing using their product. This product is installed to use in the customer's place. The team will design the manufacturing and installing processes and then implement product installation for its users. In addition to finding test customers, teams can use their products to participate in competitions in the field of Electronics - Electronics. This will help the team to have the first practical experience before deploying to customers. Finally, they evaluate their product's operating based on user investigation and numerical results.

In the course CDIO 4, the selected team continues to propose some ideas to improve the operation meanwhile maintain the operation of their product in customer's place by improving some functions or adding a new function according to customer's requirement. They not only improve functionality, but also focus on the form of products: models, boxes, weight, and ability to integrate into existing systems that can become a commercial product. At finally, they evaluate their product's operating based on user investigation and numerical results.

In the last course CDIO 5, the selected team can establish a company or join an organizer to run this business project of the product family which has been developed in previous CDIO classes. The mentors provide more knowledge about business management to them and guide them how to run a business project. The students of the selected team continue proposing some ideas to bring their products to the market.

In order to assess the course learning outcome of each CDIO course, we focus on the following major evaluation criteria which similar to the criteria in (Binh Dac HA et al, 2017):

***Criteria* 1. Novelty and originality of ideas (of ideas, prototypes or products)**

This is a major issue for each project, in which the idea of promoting the project and facilitating the creation of new or prototype products is the most important. Even if a project is unsuccessful, the idea of promoting it can still earn it at a higher level if it is considered completely new and original. However, the assessment of novelty and originality of ideas is often subjective. As a result, our Faculty of Electrical and Electronics Engineering has established the CDIO Project Evaluation Board to review all of its CDIO projects in any semester. Students are required to write a report of the project ideas, their interests, who will receive benefits, how much the product will be replaced, what products are expected to exist in their market, and so on.

***Criteria* 2. Logical structure (of the project)**

With project ideas, first of all, students will need to develop a roadmap for their projects. Then, they need to choose a suitable product development lifecycle and set up all the details of their project around that lifecycle. The evaluation of the logical structures of the projects will be carried out directly by the project advisors throughout the duration of their classes. For this, we assigned our experienced faculty members to do this assessment.

Criteria 3. Design Effectiveness

Design is an important component of any electrical and / or electronic engineering project, and the advisors of each project will accompany their students through the design phase for every little assessment or evaluation needed. Typical questions about how much new design costs are, how much energy the design saves, how to integrate new designs with other designs, and so on should be on the checklist of all design reviews. However, not every mentor has mastered the skills and knowledge in various aspects of the design of the controller or circuit design or sensor design, etc.; As a result, we have made great efforts to closely connect our faculty members together for mutual consultation whenever needed. In practice, this requires not only over time but also regular championship of division leaders in specific categories of electrical and electronic projects.

Criteria 4. Market Ability (of Product or Service)

To assess the marketability of some products or prototypes of a student product is a long shot even for our CDIO Evaluation Board. Although mentors can make an assessment and classification of the product's marketing and product prototypes, only a few projects are judged to be exceptional exceptions. The above prices will be selected to assess the full potential of faculty marketing. Each faculty and student will have the opportunity to assess the marketability of this project as part of a transparent and democratic process. In addition, for CDIO 5 we also assess the project according to the comments of customers and revenue or profit.
Under the traditional CDIO model, Criteria 1 will be evaluated during conception, Criteria 2 will be evaluated during the design and implementation phase, and Criteria 3 will be evaluated during the design phase; But within the scope of our new CL CDIO model, all items Criteria 1-4 will be reassessed more comprehensively during the period considered for the Operations

phase. Assessments at this time tend to be more accurate as we have already had product or prototype student products from their Implementation phase. In addition, we also invite the business management specialists to join our Evaluation Board to assess the feasibility of a project for startup. This is very effective in helping students learn from feedback from a variety of sources, and there is plenty of time for students to acquire new knowledge in the process.

CASE STUDY AND ASSESSMENT

Case study

In this Section, we present an example to explain the process of Closed-Loop CDIO framework deployment. A typical EEE's product of our CDIO project is smart home which developed by a team from K18EVT students. The name of "smart home" means that it is an integrated electrical and electronic system that can be programmed to control the household appliances, such as home electric, furniture and so on automatically according to the user requirements.
In CDIO 1, the students are asked to investigate the market about smart home. Next, they propose their ideas in their team after they know about the product of smart home on the market. And they discuss to make the decision of the idea on smart home. Then, they design and build a simple prototype to introduce to their potential customers, as Figure. 2. Finally, they adjust their idea according to the comments they got from their survey.

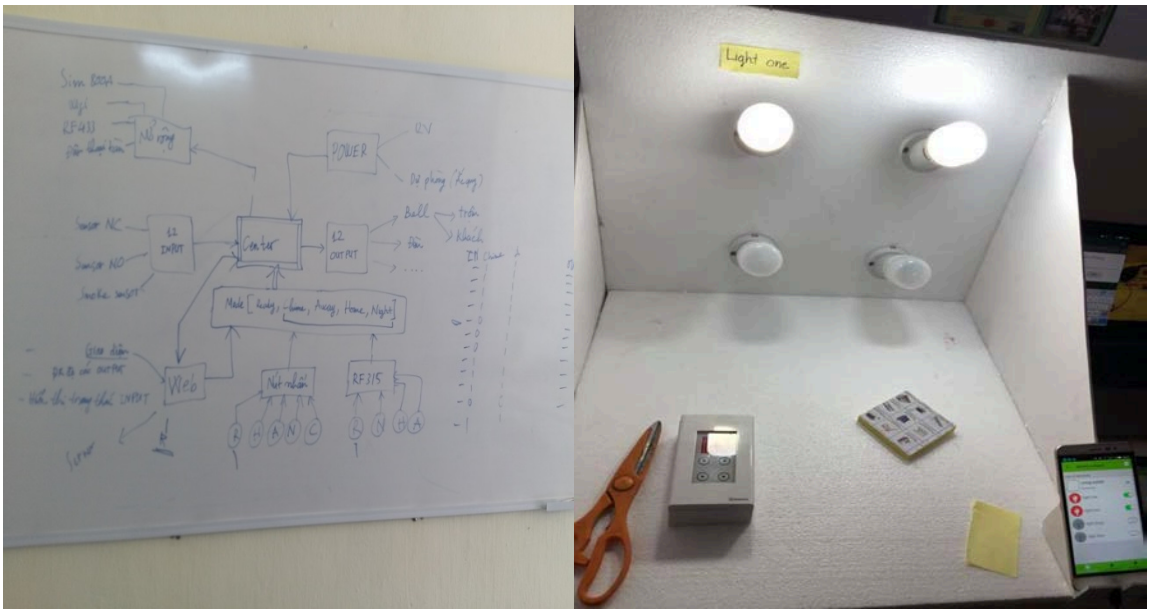

Figure 2. A design of smart home

In CDIO 2, the selected teams focused on the design of a real product. They took into account the appearance, cost, and convenience of using to meet the market's requirements. They complete their products by making a 2nd version prototype as Figure. 3. They investigated the market by asking some customers about their product's design and discussed in their team to optimize their design. For example, their design should be easier to manufacture, install and use, more aesthetic, and so on.

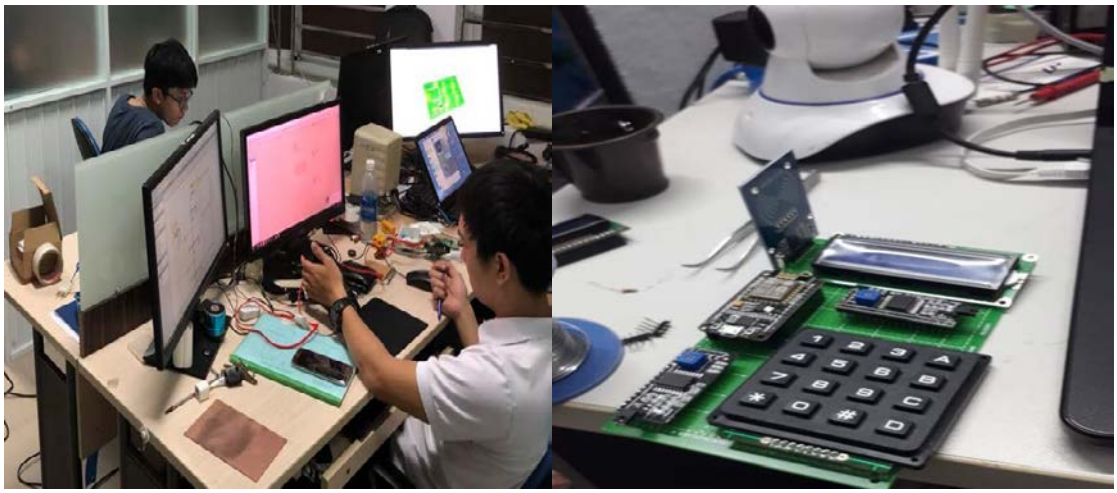

Figure 3. The 2nd version of smart home

In CDIO 3, the selected team installed their smart home product in the customer's place as Figure. 4. The team has designed the manufacturing and installing processes and then implemented product installation for their user's house. Finally, they evaluate their product's operating based on user investigation and measurement results. During this stage, they have improved the installation process; change the design to meet the personal requirements of the house's owner.

In CDIO 4, this team continued to propose the ideas to improve the operation meanwhile maintain the operation of their product in the customer's place by adding a new function according to customer's requirement. Because of the personality and tastes and preferences of homeowners per person, they have requested to add or remove some features for smart home. For example, a staircase in a Vietnamese house has a special place. It has a moderate amount of geomancy (feng shui) with high aesthetics, so the lighting system and decorative lights must also be specially designed. Or in-house washing machines are also required to automatically wash off-peak hours to benefit according to the hourly electricity price policy. Figure 5 depicts the installation of the control system integrated with smart home system. Finally, they evaluate their product's operating based on user investigation and measurement results.

Figure 4. An example of smart home installation

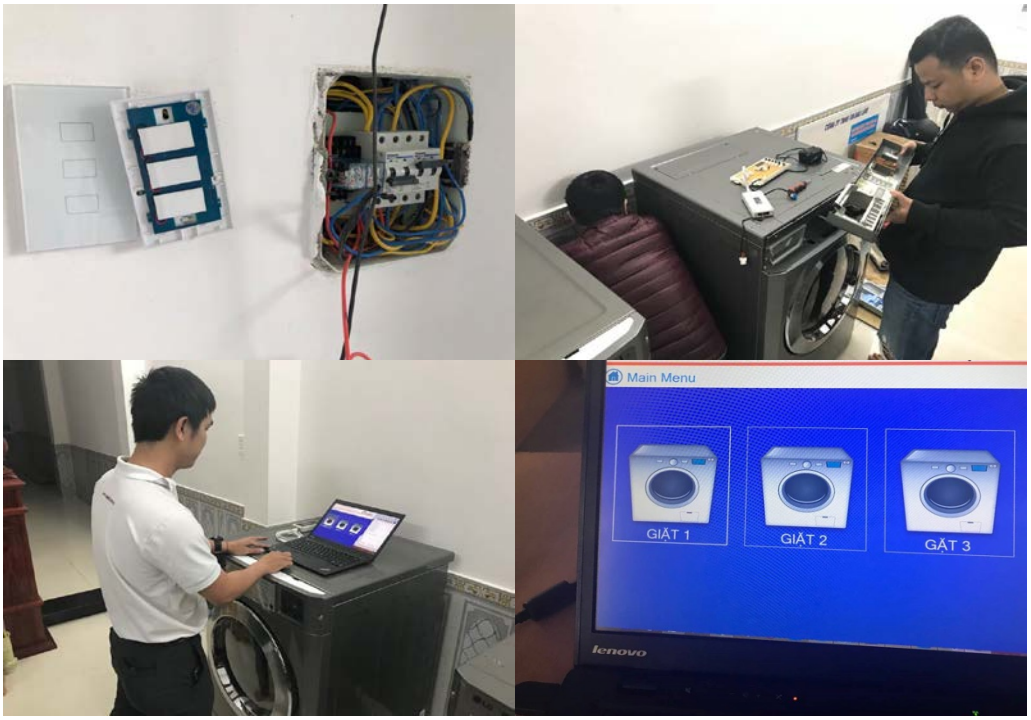

Figure 5. An improved design of smart home

In CDIO 5, this considered team established a company, namely Efil Company limited (https://doanhnghiepmoi.vn/thong-tin/CONG-TY-TNHH-EFIL-47393.html), to run this business project of the product family. The mentors, who from the Faculty of Business Management, also

help them by providing some knowledge in the business field. In addition, they have also joined Da Nang business incubator (https://www.linkedin.com/company/danang-business-incubator) to obtain more support from Da Nang city government.

Assessment

During applying this CL CDIO model in our Faculty of Electrical and Electronics Engineering, Duy Tan University, we evaluate the effectiveness of this model based on the startup spirit of students via the business projects. However, this proposed model has the following advantages and disadvantages:

Advantages:

- Can nurture the entrepreneurial spirit of students.
- Create a habit for students to constantly innovate and perfect the product.
- Give students the habit of persistence, not giving up.

Disadvantages:

- Difficult to implement due to the knowledge and skills in the field of business.
- Requires implementation of the project in real life.
- Involves many difficult issues such as safety, money, law.

CONCLUSION

In this paper, we have presented an improved CDIO implementation, namely Closed-Loop CDIO framework. The effectiveness of this framework has been verified by some practical results during implementing in Duy Tan University. The results have shown that this proposed CL CDIO model can help students improving their startup ability. We will continue implementing this model in our university to obtain more understanding and benefit from this model.

REFERENCES

Adam Szirmai, Wim Naude, Micheline Goedhuys (2011). "*Entrepreneurship, Innovation, and Economic Development: An Overview*". Oxford Scholarship Online, September 2011.

Binh Dac HA, Dong T TRAN, Bao N LE (2017). "A Proposal of the C-D-I-E Model to Improve Students' Capability". 2017 13th International CDIO Conference in Calgary, Canada, pp.415-423.

Fei, Bian (2013). "*Study on Countermeasures for Cultivating Innovation Ability of College & University Students*". 2013 International Conference on Innovation, Management and Technology Research (ICIMTR 2013), 22-23 September, 2013, Malaysia, pp. 213-217.

https://startup.gov.vn/Pages/trangchu.aspx, October 5th, 2018.

https://doanhnghiepmoi.vn/thong-tin/CONG-TY-TNHH-EFIL-47393.html , October 5th, 2018.

https://www.linkedin.com/company/danang-business-incubator, October 5th, 2018.

https://www.facebook.com/danangstartup/?rc=p, October 5th, 2018.

Wang, Yangqin et al (2013). "*Innovation Ability Cultivation of Automation Major Students*". International Conference on Education Technology and Information System (ICETIS 2013), 21-22 June *2013,* Sanya, China, pp. 971-974.
Wu, Tong Q., Xu, Nian C., Huang, Lin Q. (2013). "*Research Experimental Teaching System Based on Innovative Practice Ability*". Advanced Materials Research, Vol. 671-674, pp. 3248-3252.
Zhang, Yong et al (2013). "*Review on Innovative Practice Teaching and Its Quality Evaluation System for Software Engineering Specialty*". Advanced Technology in Teaching, Advances in Intelligent and Soft Computing Volume 163, pp. 389-397.

BIOGRAPHICAL INFORMATION

Binh D HA is the Dean of the Faculty of Electrical & Electronics Engineering at Duy Tan University. His interest is in wireless communications, robotics and physical layer security.

Truong V TRUONG, is currently the Lecturer of the Faculty of Electrical & Electronics Engineering at Duy Tan University. His research interests include image processing, design automation of embedded system. He joined the CDIO program as a lecturer of Introduction to Electrical & Electronics Engineeringcourse in 2016.

Bao N LE is the Vice Provost of Duy Tan University. He is in charge of the Technology & Science division as well as the R&D Center of DTU. His interests are in data warehousing, OLTP, graphics and animation design.

Corresponding Author

Dr. Binh D HA
Dean of the Faculty of Electrical & Electronics Engineering,
Duy Tan University
03 Quang Trung, Da Nang
Vietnam 59000
+84 935551869
hadacbinh@duytan.edu.vn