Development of Educational Programs for System Creators and Business Producers in Future Strategy Design Based on Action Project Group Activities through Industry-University Cooperation

Kinya Tamaki¹, Masahiro Arakawa², Maki Arame³ and Yoshiyuki Ono⁴

1. School of Business, Aoyama Gakuin University, 4-4-25 Shibuya, Shibuya-ku, Tokyo 150-8366, Japan

2. Nagoya Institute Technology, Nagoya 466-8555, Japan

3. Polytechnic University, Tokyo 164-8678, Japan

4. AOYAMA Hicon, Tokyo 150-8366, Japan

Abstract: Our Japanese industry-university project group of Aoyama Gakuin University investigated and studied new educational programs to cultivate “future strategy design” human resources over several years. The purpose of this research paper is to describe two types of educational programs. The first program proposes the system creator, which is capable of new product design and innovative management that use advanced technologies such as internet of things (IoT), artificial intelligence (AI), and augmented and virtual reality. The second program proposes the business producer that is capable of platform service business modeling, product development and strategy, and customer service. The characteristics of these programs involve applying new educational methods to combine project-based learning (PBL) and active learning.

Key words: PBL, active learning, new product development, platform service, IoT, AI.

1. Introduction

National Science Foundation (NSF) uses a broad definition of Science, Technology, Engineering, and Math (STEM) subjects that include subjects in the fields of chemistry, computer and information technology sciences, engineering, geosciences, life sciences, mathematical sciences, physics, astronomy, social sciences (anthropology, economics, psychology and sociology), and STEM educational research [1].

The character of STEM education has evolved from a set of overlapping disciplines into a more integrated and interdisciplinary approach to learning and skill development. This new approach includes the teaching of academic concepts through real-world applications and combines formal and informal learning methods in

schools, the community, and the workplace. It seeks to impart skills such as critical thinking and problem solving alongside soft skills such as cooperation and adaptability.

However, there is no systematic policy for STEM education in Japan. Saitama University has established the only STEM education and research center in Japan.

The Conceive, Design, Implement, and Operate (CDIO) concept was originally conceived at the Massachusetts Institute of Technology in the late 1990s. “The CDIO Initiative” [2] is an educational framework that stresses engineering fundamentals set in the context of conceiving, designing, implementing, and operating real-world systems and products. CDIO Initiative collaborators throughout the world have adopted CDIO as the framework of their curricular planning and outcome-based assessments. The CDIO

Corresponding author: Kinya Tamaki, Ph.D., professor, research field: future-oriented business model innovation.

approach uses active learning tools, such as group projects and project-based learning, to better equip engineering students with technical knowledge and communication and professional skills. Additionally, the CDIO Initiative provides resources for instructors of member universities to improve their teaching abilities.

Kanazawa Institute of Technology introduced CDIO to Japan for the first time in order to create a curriculum framework for science and engineering education.

Yamauchi [3] analyzed and considered academic papers about the processes that Active Learning had accepted as new teaching methods in Japanese higher education. He had reviewed the research trends on active learning that had been published over the past ten years in the *Japan Journal of Educational Technology*. This analysis of historical academic papers established that research had been conducted in four significant areas: class design, class evaluation, learning environment, and learning support.

Ozaki et al. [4] proposed Project-Based Learning (PBL) with a view toward continuously improving the contents of classes, for the purpose of acquiring the basic necessary skills for working people. They had identified effective factors for improving learning outcomes, and had developed strategies for class improvement. The factors that led to PBL lessons and learning outcomes were structured, and their interrelationships were visualized through multiple regression analysis.

Based on the above situation, our Japanese industry-university project group of Aoyama Gakuin University investigated and studied these new educational programs for cultivating future strategy design human resources throughout several years [5, 6]. This research paper describes two types of educational programs:

(1) Curriculum design of the new practical hands-on training program for system creators in future strategy design aiming at experiential learning of the basic operations of advanced technology;

(2) Curriculum design of the new educational

method combining PBL and active learning (AL) for business producers in future strategy design, aiming at group work training on business models, marketing and promotion, product architecture, and platform service.

The first educational program proposes that the system creator should be capable of new product design and innovative management with advanced technologies such as the internet of things (IoT), artificial intelligence (AI), and augmented and virtual reality. The second educational program proposes that the business producer should be capable of platform service modeling, product strategy, product development and customer service. The characteristics of these programs are applied to the new educational methods to combine PBL and AL.

2. System Creators in Future Strategy Design and Educational Environment Infrastructure

A curriculum that consists of five subjects for system creators in future strategy design is proposed, as shown in Table 1. Various necessary laboratory instruments and software are indicated, in addition to the respective training content for the respective five subjects.

The practical hands-on training program for a system creator with future strategy design is currently being created to cover the following five subjects:

- (1) IoT and platform services;
- (2) Pattern recognition (audio/image recognition) and natural language processing (machine translation) using AI;
- (3) Creating gamification and virtual reality (VR) contents;
- (4) New product development and service planning with augmented reality (AR) and plot typing that uses a 3D printer;
- (5) Survey method of the sea or the sky, utilizing unmanned aircraft (drone).

As an example of the applications to adult education shown in Table 1, hands-on training in IoT

involving advanced technologies was already conducted. This hands-on training was performed over a three-day learning period. On the first day, we visited the Fujitsu OYAMA Factory to investigate how the IoT system was effectively utilized within various advanced production systems. On the second day, we practiced the Subject (1) IoT and platform service shown above. On the third day, a workshop was executed, which asked what kind of future IoT system should be introduced to each learner's production site.

For the improvement of educational environment infrastructure of an advanced technology learning laboratory, the various laboratory instruments and software must correspond to the respective five subjects, which are properly collected and connected with each other to prepare for each session of practical training. Additionally, it is necessary to define operational programming procedures to make connections between mutual laboratory instruments and platform service.

A university-industry collaboration action project has been carried out in preparation for the development and research about future strategy design from 2018. The research and development of the educational technology used to define experimental procedures and create experiment textbooks is handled by faculty and research assistants corresponding to each specialized field through inter-university collaboration. Industrial research members of software vendors and other software users such as manufacturing industry representatives are supported by the appropriate collection of laboratory instruments and software, which make up the educational environment infrastructure.

3. Business Producers in Future Strategy Design

A group work training curriculum is proposed as an example of the IoT subject in the education programs for business producers in future strategy design, as shown in Table 2.

Table 1 Curriculum of the system creator, laboratory instruments and software, and training contents.

Subject	Laboratory instruments and software	Training contents
(1) IoT and platform service	Educational one-board microcomputer (micro:bit)	Embedded programming
	Educational edge server (Raspberry Pi)	Role of edge server: collection, storage, and analysis of sensor data
	Cloud platform (Node-RED)	Programming for operating the platform
(2) Pattern recognition using AI	Smart speaker	Speech recognition by using AI
	AI-OCR	Image recognition, face recognition, and facial expression recognition using AI
	Platform service	Natural language processing (machine translation)
(3) Gamification and VR	Game software (Unity)	Gamification: 3D content production and editing (simulation)
	VR device (Oculus Rift)	Manipulation and expression of virtual reality 3D content
	Creation of 3D content by applying the above VR technology	Future space design using gamification and VR devices
(4) New product development service prototype with AR and 3D-printer	AR device (Android phone)	Manipulation and expression of augmented reality 3D content
	3D-CAD	3D model creation training by using 3D-CAD
	3D-printer	Creation training of a 3D prototype using a 3D printer
(5) Survey method of the sky or the sea, utilizing an unmanned aircraft (drone)	Sky survey drone	Control method and photography techniques for sky environment investigation using a ground drone
	Sea survey drone	Control method and photography for sea environment investigation using an underwater drone
	Moving video content editing software	Editing practice moving video content of the sky environment or sea environment

Table 2 Curriculum of business producer in future strategy as an example of the IoT subject.

Number	Group work in charge of G1	Group work in charge of G2	Group work in charge of G3	Group work in charge of G4
1	Introduction, team building			
2	Team common work (1): IoT function and role in smart product service, collaboration between IoT system and edge server			
3	Team common work (2): Total collaboration system with platform service corresponding to IoT system and edge server			
4	Team common work (3): Determining the business planning theme of the next-oriented product service (new smart product, IoT system, and platform service)			
5	Team common work (4): Determination of target customer who wants to provide new business services, analysis of customer characteristics, and customer value			
6	Team common work (5): Consolidating the result of team common work activities in "new business concept book (new smart product, IoT system, and platform service)"			
7	1) Co-creation value between the company and the customer realized by the provided service 2) Differentiation strategy against competitors (1)	1) Analysis of usage scenes of services provided to target customers [Persona analysis] 2) Customer purchasing decision model	1) Product architecture (1) linked with smart product and IoT system [Required specifications of mechanism, electric, and software]	1) Requirement specifications of application software provided by platform service (1) (2) 2) Conceptual design of application software provided to target customer through platform services (1) (2)
8	3) Formulation of a basic business model 2) List of stakeholders in the basic business model 4) Differentiation strategies against competitors (2)	3) Customer behavior process of target customer 4) Service process [pre-, during-, post-service process]	2) Product architecture (2) linked with smart product and IoT system [structural design of mechanism, electric, and software]	
9	5) Formulation of business process diagram (representing commercial flow, distribution flow, cash flow and information flow in the business process diagram)(1) 6) In the business process diagram, stakeholder management (1)	5) New service planning (planning of new application software) realized by smart product in response to the above service process	3) Processing algorithm for application software linked with smart product and IoT systems	3) Information communication technology (ICT) that links the IoT system with the platform for the smart product used by target customers (1) (2) 4) ICT (1) (2) linking the company and other partner companies to realize integrated application software
10	7) Formulation of business process diagram(2)(3), representing with the "improved version business model canvas" as a business process diagram	6) New plan for integrated application software realized by linking smart products and platforms in response to the above service process	4) Design of each screen content and transition of each content when the customer uses the application software in the smart product	
11	8) In the business process diagram, stakeholder management (2)(3)	7) Promotion strategy (1) [customer journey map]	5) Operability verification of application software provided to customers through all service processes (smart product, IoT system, linkage among platform)	5) Algorithm of collection, accumulation and analysis of usage data and behavior data of integrated application software for each customer
12	9) Decision of own revenue models (selection and combination of own revenue models from various types of revenue models)	8) Promotion strategy (1) [contents marketing]	6) Customer's user interface (ease of use) for smart product and application software	6) Digital marketing corresponding to usage / action data of each customer
13	Team common work (6): Formulation of a business implementation plan for new smart products, IoT system, and platform service] (1)			
14	Team common work (7): Feedback from teaching staff for the above (1) ⇒ Revised business implementation plan (2)			
15	Team common work (8): Feedback from teaching staff for the above (2) ⇒ Submission of the final version of the business implementation plan (3) ⇒ Comprehensive evaluation of each student's score [team evaluation + group evaluation + evaluation of individual's score]			

PBL focuses on relatively integrated units of instruction where learners focus on complex projects consisting of multiple cases. This involves debating ideas, planning and conducting experiments, and communicating their findings. PBL integrates courses at a curricular level, requiring learners to self-direct their learning while solving numerous cases across an entire curriculum. Case-, project-, and problem-based learning represent an approximate continuum of complexity, however, all share the same assumptions

about active, constructive, and authentic learning.

The PBL theme of business producers in future strategy design is treated with a virtual case study, which proposes a new product/service planning project for next-generation application software, with smartphone or smart movable devices connected with platform service through IoT.

As a team building exercise for the AL method, all learners are divided into four project groups (Group 1, Group 2, Group 3, and Group 4). Each group works

on editing the new product/service planning business implementation plan, based on the group work procedure guidance notes of the active learning method. Each group uses the same PBL theme as the next-generation application software planning project, with the following varied business roles:

(1) Group 1: differentiation strategy, business model, stakeholder management model, and revenue model;

(2) Group 2: customer behavior process of target customers, service process, new service planning, and promotion strategy;

(3) Group 3: product architecture, specification design of application software, and customer user interface;

(4) Group 4: platform service, processing procedure of application software and platform service, algorithm of collection/accumulation and analysis of usage and behavior data, and digital marketing.

4. Conclusion

To improve the quality of educational programs for business producers and system creators, a teaching organization needs to be established for the research and development of new educational methods. This organization should include instructional design for new educational methods, faculty development, teaching assistants, grading evaluation methods, and course evaluation methods.

Prior to implementing these programs, the competencies (abilities in their respective fields of study) of business producers and system creators must be formulated in order to clarify the goals of the learning objectives related to each educational program. Based on the developed competencies, individual courses in the educational programs must be designed and teaching materials must be produced using instructional design techniques [7]. Additionally, the comprehensive course evaluation must be performed by contrasting the results of the individual course implementation according to each competency.

The above-mentioned curriculum for business producers in future strategic design had been applied to special subjects in the Aoyama Gakuin University School of Business, led by Professor Tamaki, and had been demonstrated in their lessons, during classes from fiscal year 2015 to fiscal year 2019. These subjects, which were geared toward business producers, involved a virtual case study that proposed a new product/service planning project for next-generation application software using smartphones connected to the platform service through IoT.

Additionally, as a team building exercise for the AL method, learners had been separated into four project groups, and each individual group had worked on editing the new product/service planning business implementation plan.

References

- [1] Committee on STEM Education. 2018. *Charting a Course for Success: America's Strategy for STEM Education*. National Science & Technology Council.
- [2] Department of Mechanical and Materials Engineering, Queen's University. 2018. "The CDIO Initiative."
- [3] Yamauchi, Y. 2018. "Educational Technology and Active Learning." *Japan Journal of Educational Technology* 42 (3): 191-200. (in Japanese)
- [4] Ozaki, T., Hirose, H., Ichikawa, H., and Yamamoto, Y. 2018. "Proposal for Class Improvement of Project-Based Learning to Acquire Soft Skills." *Japan Journal of Educational Technology* 42 (3): 243-53. (in Japanese)
- [5] Tamaki, K. 2011. "Management Process of Product Strategy Integrated with Platform Strategy and Product Line Strategy." *Journal of Strategic Management Studies* 2: 3-10.
- [6] Tamaki, K., Park, Y., and Goto, S. 2015. "A Professional Training Program Design for Global Manufacturing Strategy: Investigations and Action Project Group Activities through Industry-University Cooperation." *International Journal of Business Information Systems* 18 (4): 451-468.
- [7] Jonassen, D. 1999. "Designing Constructivist Learning Environments." In *Instructional-Design Theories and Models*, edited by Reigeluth, C. M., Volume II, Lawrence Erlbaum Associates, Inc.