Ideation of Engineering Solutions for Sustainable Development Goals: A Collaborative Course between Thai and Japanese Students

Kodchakorn Krutphong, Natt Leelawat, *Senior Member, IEEE*, Jing Tang, *Member, IEEE*, Eri Ota, Rie Murakami Suzuki, Yuki Taoka, and Proadpran Punyabukkana, *Member, IEEE*

***Abstract*—A collaborative course called Global Awareness for Technology Implementation was conducted by the Faculty of Engineering, Chulalongkorn University, Thailand, and the Tokyo Institute of Technology, Japan. The objective of this course was to facilitate the exchange of knowledge, perspectives, and experiences between Thai and Japanese students through project work, using an engineering design approach and the design thinking process to create innovation relevant to the Sustainable Development Goals (SDGs). During the class, experts shared their knowledge and experiences with the students. The students then worked on their respective projects to develop solution concepts using the design thinking process. The proposed ideas include the application for English class, smart water quality checker, hydrogen-based energy system for rural area, reduced wasted fashion solution, and auto waste sorting machine. Finally, this study concluded with a summary of the results and findings on the empathy process in the chosen SDGs, and of the commonalities and differences between Thailand and Japan in terms of ideation.**

Keywords—Collaborative Course, Design Thinking, Engineering Education, Sustainable Development Goals, Thailand, Japan

I. Introduction

"Sustainable Development Goals (SDGs)" are a set of 17 global development objectives adopted by the United Nations member states that form the agenda for a global partnership mission for worldwide development by 2030 [1]. The SDGs also include a list of 169 SDG targets, which are tracked by 232 indicators [2]. Various SDGs aspects are incorporated into the education system to spread awareness on improving society.

The course called "Global Awareness for Technology Implementation" (GATI) was established as a collaborative course between the Faculty of Engineering, Chulalongkorn University, Thailand, and the Tokyo Institute of Technology, Japan, in 2015 [3-4]. The course aims to understand the trends and priorities of implementing problem-solving in Thailand and Japan and to understand the engineering design process and critical thinking skills through the course activities. The purpose of having a multicultural team of Thai and Japanese students is to understand how to overcome the challenges, leverage the advantages of cultural differences to work in a multicultural team, and be able to localize the technology to their respective cultures. Fifteen students from Chulalongkorn University (Thailand) and 14 from the Tokyo Institute of Technology (Japan) enrolled in this course in the academic year 2022. The participating students consist of 28 undergraduate students and 1 Master's degree student. They were from engineering and science fields with different majors, such as robotics and artificial intelligence engineering, mathematics, metallurgical and materials engineering, environmental engineering, etc.

The course was conducted remotely (online) for most of the semester. Two exchange visits were scheduled for conducting activities together onsite in both Thailand and Japan. Thus, the students had the opportunity to work together online as well as in person. They were allowed to choose the SDGs for the project goal they were interested in. A mix of Thai and Japanese students was intended to enable the sharing of their respective cultures' perspectives. Similar to the previously conducted GATI courses, this class employed project-based learning to kindle innovation from the students' cooperative endeavors [3-4], following the guidelines of design thinking [5]. First, they needed to do research, understand the current situation in their respective chosen SDGs, and conduct interviews to better relate to the problems under consideration as well as the people affected by it, to facilitate finding the root cause of the problem.

The design thinking concept was utilized extensively in the development process to develop and create solutions or innovations in the selected theme. The concept of the innovation development process was widely used in the class project and activities across various disciplines that need an understanding of the context of the development, such as sustainability, development, or marketing [6-7]. The design thinking concept consists of the steps that include empathizing, definition, ideation, prototype development, and testing, based on the main idea and the objective of the iterative process that seeks to understand user needs and create appropriate innovations [7].

K. Krutphong is with Environmental Engineering and Disaster Management Program, Mahidol University, Thailand (e-mail: kodchakorn.kru@mahidol.ac.th)

N. Leelawat is with Department of Industrial Engineering, Faculty of Engineering, Chulalongkorn University; and Disaster and Risk Management Information Systems Research Unit, Chulalongkorn University, Thailand (corresponding author, phone: +6622186841; e-mail: natt.l@chula.ac.th, n.leelawat@gmail.com).

J. Tang is with International School of Engineering, Chulalongkorn University; and Disaster and Risk Management Information Systems Research Unit, Chulalongkorn University, Thailand (e-mail: jing.t@chula.ac.th).

E. Ota is with Center for International Education, Tokyo Institute of Technology, Japan (e-mail: ota.e.aa@m.titech.ac.jp).

R. M. Suzuki is with Center for International Education, Tokyo Institute of Technology, Japan (e-mail: murakami.r.ai@m.titech.ac.jp).

Y. Taoka is with School of Environmet and Society, Tokyo Institute of Technology, Japan (e-mail: taoka.y.aa@m.titech.ac.jp).

P. Punyabukkana is with Department of Computer Engineering, Faculty of Engineering, Chulalongkorn University; and the Learning Innovation Center, Chulalongkorn University, Thailand (e-mail: proadpran.p@chula.ac.th).

979-8-3503-0219-6/23/$31.00 ©2023 IEEE

This article summarizes and discusses the results of the reviews and interviews regarding the solutions and innovative ideas that students developed during this class.

II. METHODOLOGY

At the beginning of the course, following the orientation, the instructors introduced the fundamentals of engineering design and design thinking through lectures and workshops. After this, guest speakers who had practical experience working with the SDGs in Thailand and Japan were invited to provide insights and background information. These lectures also addressed the current situation in Thailand and Japan, highlighting existing innovations and solutions aimed at addressing societal challenges. The first half of the semester included a site visit to Bangkok, Thailand, where the Japanese students joined their Thai counterparts in the activities. This was followed by site visits and lectures by the invited speakers from recognized organizations, such as the lab tour in the Faculty of Engineering, Chulalongkorn University; National Electronics and Computer Technology Center; Sirindhorn International Institute of Technology, Thammasat University; PTT Public Company Limited; and Chulabhorn Royal Academy. The objective of the site visit was to provide an opportunity for the students to understand the different perspectives and approaches employed by various organizations in Thailand. After the site visits, the students were grouped based on their topics of interest. The student group was organized by the answers to the question that asked for their interested topics in SDGs, then students who selected the same topics were grouped to work together. Each group also contained both Thai and Japanese students to foster cooperation.

The project work followed the design thinking concept, beginning with the empathy phase. Students undertook research and conducted interviews with the stakeholders in Thailand and Japan to find the commonalities and differences in both societies. These are summarized in the research results. Throughout the project development process, the course instructors allocated time for presentations, and the students dedicated 3 hours of class time per week to work on their projects. The project duration was five months, from August to December 2022, with two site-visit trips and six group presentations. The details of the activities are shown in ***Table I***.

TABLE I. DURATION AND PERIOD OF THE COURSE AND PROJECT DEVELOPMENT PROCESS

Duration		Activities
Month	**Week**	
August	**2**	Course orientation, Ice breaking activity
	3	Group work, Lecture about SDGs
	4	Thailand site-visit, Lecture, Group separation, Group work, Group presentation
September	**1**	
	2 - 4	Group work (remote)
October	**1 – 4**	Group work, Group presentations with more details in the prototype (remote)
November	**1 – 2**	
December	**3**	Japan site-visit, Group work, Group presentation to finalize the prototype
	4	Final group presentation

After the project work was completed during the semester, Thai students traveled to Japan for an overseas site visit. The visit started with a workshop on the SDGs by an invited speaker from the Tokyo Institute of Technology and a lab tour to learn about the ongoing research and development projects in Japan. Then, they undertook site visits at TEPIA (Association for Technological Excellence Promoting Innovative Advances), Google (Japan Office), Atlas Copco, Patagonia, and Kayac. These site visits were chosen to expose the students to various innovations and successful projects to inspire them for their future work. The assessment from the instructors during the course is conducted under the guideline and the idea of the design thinking method and the experience to comment and give feedback in every presentation through the working duration. The final presentations were conducted at the Tokyo Institute of Technology, with Thai and Japanese instructors to provide feedback on each project.

III. FINDINGS

Based on the reviews and interviews conducted in Thailand and Japan, the students summarized the current situation in the two countries as shown in ***Table II***.

While some situations were common, there were differences due to the different contexts of each society. For example, there were challenges to the quality of education due to the use of online methods in the COVID-19 situation and the need for local students to be proficient in English. There are also issues with tap water quality. While Thailand has a serious problem with drinking tap water, Japan also has some concerns about the quality and sanitation of the drinking water, especially in schools. On the issue of differences in the amount of plastic waste in water resources, the fact that Thailand has more than ten times the amount of waste flowing through the country than Japan also needs to be considered [8].

After reviewing information about the society and country, the next step of the development project was the problem statement, which would spark the innovation that would be developed in the project (*see* ***Table III***).

IV. SUMMARY

The findings revealed commonalities and differences in the problem statements and current situations for each of the SDGs topics in Thailand and Japan.

Moreover, according to the methodology and findings of this research, the uniqueness of the course is working using the idea of the design thinking method to create innovation by the students from two different countries with both remote sessions and the on-site session throughout a semester. The remote session challenges instructors and students to work on the project together. So, this course uses different online services to help students study and work together smoothly.

TABLE II. COMPARISON BETWEEN THAILAND'S AND JAPAN'S CONTEXTS IN THE SELECTED SDGS TOPICS

Selected topics	Japan	Thailand
SDG 4: Quality Education	+ Online classes during COVID-19/other disasters + Lack of interaction between students and the teachers + Inability of the students to ask questions	+ Online classes during COVID-19 + Lack of efficient technology + Lack of high-speed internet + Lack of interaction between students and the teachers + Unsuitable learning environments
SDG 6: Clean Water and Sanitation	+ Aging of water pipelines + Reliability of water quality + Concerns about drinking tap water	+ Pressure used in the water pipelines [9] + Tap water quality + Existing norm of drinking bottled water instead of tap water
SDG 7: Affordable and Clean Energy	+ Energy supply shortage + Greenhouse gases generated due to the use of fossil fuels [10] + Non-renewable energy + Energy transmission challenges + High cost of renewable energy [11]	+ Greenhouse gases generated due to the use of fossil fuels [10] + Non-renewable energy + Energy transmission challenges + High cost of renewable energy [11]
SDG 12: Responsible Consumption and Production	+ Clothing and fashion waste + Waste generated from online clothing purchases and consumption + Trend of fast fashion. + Excessive exports from some countries	+ Clothing and fashion waste. + Waste generated from online clothing purchases and consumption. + Low-quality clothing affecting product lifespan. + Trend of fast fashion. + Hub country
SDG 14: Life Below Water	+ Plastic waste in the water resources [6] + Illegal littering + 66% of plastics in the trash + Unfamiliarity of the tourists with the littering system	+ Plastic waste in the water resources [8] + Illegal littering + 56% of plastics in the trash + Unfamiliarity of the tourists with the littering system

The prototype solutions had been developed by the students after assessment and research in the contexts of both Thailand and Japan, taking into consideration the social conditions as well as the local perspectives in the solution design. This makes it more likely for the designed solutions and innovations to be effective in addressing the target problems in these two different countries. Furthermore, it is crucial to consider the appropriateness and localization process in line with the SDGs, which represent a global agenda. The collaborative nature of the course allows for synergy in ideation, enabling students to share their understanding based on different cultures, languages, and experiences. This could define that the students are assessed to achieve the objectives of the collaboration course through their activities and the outcome they showed in their work. Also, the practice mentioned in this course's organization and management could be applied in different contexts and themes.

TABLE III. SUMMARY OF THE PROBLEM STATEMENTS AND THE SOLUTIONS, IDEAS, AND INNOVATIONS DEVELOPED BY THE STUDENTS

Selected topics	Problem statement	Developed solutions idea and innovation
SDG 4: Quality Education	The Thai- and the (Japanese) Katakana-style English learning system need helping materials for the student to improve their English skills.	**App for an English Class**: An application to assist students in improving their English language skills, especially the pronunciation.
SDG 6: Clean Water and Sanitation	The tap water in school is either undrinkable or is not reliable enough for the parents to let their children drink it.	**Smart Checker**: Water quality checker which even primary school students can use it.
SDG 7: Affordable and Clean Energy	The use of fossil fuels creates greenhouse gases. Renewable energy is expensive and logistically difficult.	**Affordable and Clean Energy**: Hydrogen-based energy system for rural areas.
SDG 12: Responsible Consumption and Production	Overproduction and overconsumption of clothes in a non-circular pattern lead to significant waste.	**Reduces Wasted Fashion Solution**: An application that offers a variety of clothing options with the ability to measure body dimensions using AR technology.
SDGs 14: Life Below Water	Waste management is hindered due to various challenges in sorting the waste/garbage leading to pollution of the water resources.	**Auto Waste Sorting Machine**: Use image recognition to sort the waste even for users who cannot understand the sorting instructions.

ACKNOWLEDGMENT

This article was developed in collaboration between the Faculty of Engineering, Chulalongkorn University, and the Tokyo Institute of Technology, as part of the GATI course #7. We would like to thank all students who participated in the course, as well as Ms. Yayoi Katori (Tokyo Institute of Technology), Ms. Kannika Sawanpotipan, and Ms. Sirikanya Phongtongjalern (Chulalongkorn University) for their support. We also would like to acknowledge the kind support from Prof. Supot Teachavorasinskun and Prof. Tawatchai Charinpanitkul (Chulalongkorn University).

REFERENCES

[1] United Nations. "Do you know all 17 SDGs?," from https://sdgs.un.org/goals

[2] SDG Tracker. (2018). "Measuring progress towards the Sustainable Development Goals," 2018, from https://sdg-tracker.org/

[3] E. Ota, R. Murakami, and P. Punyabukkanam, "Comparative analysis on effect of multicultural project-based learning between universities in Japan and Thailand," Int. J. Eng. Edu., vol. 35 (Extra 5), 2019, pp. 1466–1479.

[4] E. Ota, and P. Punyabukkana, "Effects of bilateral problem-based learning program for engineering students: Case of a joint course with Japan and Thailand," 2016 IEEE Frontiers in Education Conference (FIE), Erie, PA, USA, 2016, pp. 1-9.

[5] V. Manna, M. Rombach, D. Dean, and H. G. Rennie, "A design thinking approach to teaching sustainability," J. Mark. Educ. Vol. 44 (3), 2022 pp. 362 –374.

[6] A.Öztürk, and F. Korkut, "Design thinking customized to support STEM teachers: Co-developing and implementing STEM activities for fifth graders in Turkey," Int. J. Technol. Des. Educ., in press.

[7] Interaction Design Foundation, “Design Thinking,” from https://www.interaction-design.org/literature/topics/design-thinking

[8] The Ocean Clean Up, “River Plastic Emissions to the World’s Ocean,” from https://theoceancleanup.com/sources/

[9] Prachathai, “Why the Thai Tap Water (still) Cannot Drink.” From https://prachatai.com/journal/2021/05/93256

[10] Client Earth, “Fossil fuels and climate change: the facts,” 2022, from https://www.clientearth.org/latest/latest-updates/stories/fossil-fuels-and-climate-change-the-facts/

[11] M. J., “Why is renewable energy so expensive?,” The Economist, 2014, from https://www.economist.com/the-economist-explains/2014/01/05/why-is-renewable-energy-so-expensive

[12] S. Rauturier, “Everything You Need to Know About Waste in the Fashion Industry,” good on you, 2022, from https://goodonyou.eco/waste-luxury-fashion/

[13] Thairath Online, “Fast fashion made 40% of Thai people throw away the clothe after wear it once,” 2017. from https://www.thairath.co.th/business/market/1156572