CDIO APPROACH ON O2O INTERNATIONAL LEARNING MODEL THROUGH SDG COURSE

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ABSTRACT

This study explores the experiences of an online and on-site (O2O) learning model of the seven international institution courses on Sustainable Development Goals from multidisciplinary fields. The paper explores what makes for effective teaching of sustainability within a multidisciplinary online and on-site context. This experience has impacted social, economic, and environmental sustainability from an engineering perspective. One of the learning outcomes of this course, as stated in CDIO Standard 3.0, is that students had interpersonal learning outcomes that focus on individual cognitive and affective development, such as personal and group interactions, teamwork, and communications in foreign languages. Opportunities are made available for students to study abroad and have international experiences such as internships and exchanges. This course is to practice the actual case studies from global communities in a collaborative manner. The 17 SDGs goals related to Smart Green Synergy were expecting to be understood by students. Member universities and research institutes give the online lecture presentation where students may have global insight into synergy, especially in the engineering implementation, leading to intelligent and green resources to overcome the climate change issue. The pandemic of the Covid-19 situation constrained the five universities in South East Asia to carry out online classes. In contrast, an on-site course was performing by Feng Chia University students with normal class activities. Students are encouraged to think critically to formulate problems, provide a solution internationally and define issues and solutions tailored to SDGs. Students' grade distribution showed a good result of achievement, which implied the expected learning outcomes had been achieved. Result analysis showed that from the 16.67% "Very Good" category in the mid-term, it increased to 42% in the final term. Other classes have decreased, but some are stable. Overall, there was an increase in the study results' improvement by approximately 150%.

KEYWORDS

SDGs, smart green synergy (SGS), CDIO, online and on-site (O2O), international course, Standards: 2, 3

1. INTRODUCTION

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet (Murphy, 2006). The Sustainable Development Goals (SDGs) constitute a working agenda for the international community to ensure a better world for future generations (Zamora-Polo, Sánchez-Martín, Corrales-Serrano, & Espejo-Antúnez, 2019). In

response to the growing urgency for sustainable solutions, society's stakeholders increasingly take action against this negative development and contribute and make the planet, economy, and society more sustainable. The SDGs offer an opportunity to extend Education for Sustainable Development (Shiel, Smith, & Cantarello, 2019). Education for Sustainable Development (ESD) was defined as a learning process (or approach to teaching) based on ideals and principles that prepare people of all walks of life to plan for, cope with, and find solutions for issues that threaten the sustainability of our planet (Rieckmann, 2017).

The CDIO Initiative is an innovative educational framework for producing the next generation of engineers, which is introducing in the early 2000s. It adopts 12 standards to provide education guiding principles as guidelines for educational program reform and evaluation, create benchmarks and goals with the world-wide application, and provide a continuous improvement framework. It supports students in acquiring a rich understanding of technical fundamentals while simultaneously developing the necessary professional skills required of a practicing engineer (Malmqvist et al.). The purpose of the CDIO is summarized as having an in-depth understanding of the core technologies and innovating in engineering, and appreciating the broader long-term influence on society (CDIO 2010) (Summers, Corney, & Childs, 2003). The goals of CDIO include educating graduates with a deep and working knowledge of engineering fundamentals, leading in the development and operation of complex technical systems, and who have a strategic understanding of the role and impact of technology in society (Jambari et al., 2018). Providing students with dual-impact learning experiences based on an engineering project's lifecycle, the Conceiving – Designing – Implementing – Operating (CDIO) of real-world products, processes, and systems (Zamora-Polo et al., 2019). CDIO Standards 3.0 that was implemented in 2020is an update of Standards 2.0. The UN goals for sustainable development (Assembly, 2015) challenge engineering programs to broaden the taught goals for engineering, i.e., optimizing technical and economic performance to the simultaneous achievement of economic, environmental, and social sustainability (Malmqvist et al., 2019).

Universities play a crucial role in sustainable development and for adopting the SDG agenda, such as through University Social Responsibility (USR) program to help the community have better knowledge to increase the quality of life. There is no doubt that education is crucial for achieving the SDGs (Vladimirova & Le Blanc, 2016). Although education is directly related to Goal 4, education is transversal to many SDGs (Lee et al., 2016). The promotion and teaching of SDGs at university should consider the global education concept for Sustainable Community Development. Teaching and promoting the SDGs requires developing students' competencies; these competencies must be worked on through strategies and teaching methodologies and must be evaluated. Smart Green Synergy (SGS) is an international course designed by the Feng Chia University in collaboration with five universities in South East Asia and one research council in Europe. The seven Institutes are Institute of Technology Bandung (ITB), Indonesia, Sam Ratulangi University (UNSRAT), Indonesia, Chiang Mai Rajabhat University (CMRU), Thailand, Mae Fah Luang University (MFU), Thailand, Mae Jo University (MJU), Thailand, and National Research Council (CNR), Italy. Eighty students participated in this course, with 45.7% from ITB, 40.7% from FCU, 4.9% from CMRU, 4.9% from MJU, 2.5%, and 1.2% from Unsrat and MFU, respectively (Fig.1).

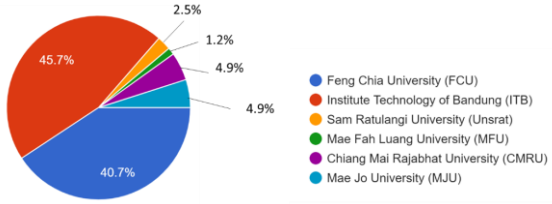


Figure 1. Percentage of students participating in SGS international courses

This study explores an online-to-on-site (O2O) learning model for the new normal via the international course on Sustainable Development Goals. One of this course outcomes is that students had individual and group interactions, teamwork, and communications in foreign languages. Opportunities are made available for students to study abroad and have international experiences such as internships and exchanges. This project aims to bring forward the experiences from the O2O teaching method, by CDIO approach, and to evaluate the students' outcomes through the project. If it is significantly successful in gaining students' targeted outcomes, this project can be an excellent model to disseminate to other educational institutions.

2. METHODS

The strategy for engineering education known as the CDIO Initiative through the guidelines of CDIO standards 3.0 refers to an international project to emphasize learning through practice by following the stages of Conceive, Design, Implement and Operating that adopting the principle of sustainable product, process, system, and service lifecycle development and deployment. The value of following the CDIO standards has been recognized in secondary and higher education and practitioners extending their knowledge (Summers et al., 2003). Students to be in a position to succeed the CDIO structure should cover technical expertise and reasoning, personal, professional, and lastly be able to implement the CDIO steps in organizations and society (Berggren et al., 2003), interpersonal skills, and a focus on developing a good understanding of the core theory, related technical skills and teamwork (Zarifis, Efthymiou, Demetriou, & Cheng).

Distance learning in online programs has been gaining popularity, particularly in the past five years. As with face-to-face education or possibly to an even greater extent, there has not been one delivery model with general acceptance and adoption, but some imaginations of what distance education and the technology, processes, and people that deliver it should embody (Loyer et al., 2011). Blended learning is a mixture of O2O learning. In the literature, blended learning is also known as 'hybrid learning' or the 'flipped classroom' (Bowyer & Chambers, 2017). Blended learning focuses on the students, where knowledge is co-built, created, and shared by both teachers and students. It also emphasizes the pre-class and post-class activities and online interaction (Cheung, Lam, Lau, & Shim, 2010). The blended learning model is "learner-centered" and aims to realize students' in-depth and personalized learning through "pre-class, in-class, after-class" and "online + offline" teaching (Li & Mu, 2019).

The O2O teaching method used in this course is a hybrid method that can be delivered during the Covid-19 pandemic to sustain the students' learning environment in these universities. Students in South East universities could not attend the on-site course at campuses due to the Covid-19 situation; on the other hand, students from Feng Chia University attend the SDG-SGS course on-site. The course was delivered using Microsoft Teams by the professors from the six universities each week in turns, and the students follow it through online and on-site at the campus. Teaching as transfer of knowledge turns into teaching as guiding and providing conditions for learning and competence acquisition.

A series of topics about renewable energy technology and its environmental and social impacts were first selected in the study to share the professors' experience with the students based on the actual projects from each institution. There were a full 18 weeks, which are 12 weeks of online and offline teaching and sharing project experiences, and the rest of the courses were students' evaluation and site visit, as shown in Table.1. There were a total of 81 students from six universities taking this course. Data for the evaluation method was taken from surveys before and after the class started and ended. Students' outcome result was taken from the mid and final exams.

3. SMART GREEN SYNERGY INTERNATIONAL COURSE (SGS)

3.1. Course Design

Teaching Smart Green Synergy with sustainability concepts to multidisciplinary students is challenging due to their diverse background and discipline-specific skill set and the interdisciplinary nature of the sustainability issues. The course's overall objective was to make students understand the 17 UN SDGs and practice the international case studies to solve relevant problems by green energy. Based on the CDIO standards 2, to do this, students must at the end of the course be able to:

- Interpret the knowledge of the importance of implementing green energy in the digital era;
- Compare the project-based experience from different countries;
- Defining a problem from the target location;
- Presenting the alternative solutions in group interactions or teamwork.

The Smart Green Synergy course design has shown in Table 2.

Table 1. SGS Teaching Schedule

Week	Content	Institution	Online/ On-site
1	Course introduction on UN SDGs and Smart Green Synergy	FCU – Taiwan	Online & On-site
2	Chapter 1: How to introduce green technology into villages	FCU – Taiwan	Online & On-site
3	Chapter 2: Advanced Biogas Technology in a Smart Green Synergy Area	FCU – Taiwan	Online & On-site
4	Chapter 3: Green Synergy in Rural Community	FCU – Taiwan	Online & On-site
5	Visiting green synergy field in Dongshi	FCU Taiwan & CMRU Thailand	Online & On-site
6	Chapter 4: Smart & Green Community Development via Living Laboratory in Campus		
7	Chapter 5: Smart e-Waste Monitoring	MFU-Thailand	Online
8	Chapter 6: Smart Seaweed Cultivation: Design, Implementation, Testing, and Monitoring	ITB – Indonesia	Online
9	SDGs & SGS Mid-term Exam	All Institutions	Online & On-site
10	Chapter 7: Sharing of Smart Green Synergy Planning and Actions	FCU – Taiwan	Online & On-site
11	Chapter 8: Symbiosis Energy in Manado City Indonesia	Unsrat – Indonesia	Online & On-site
12	Chapter 9: Environmental impact of Symnergy Model in Rural Community	Unsrat – Indonesia	Online
13	Chapter 10: Smart Green Campus	MJU – Thailand	Online
14	Chapter 11: Sustainable Islands	CNR – Italy	Online
15	Chapter 12: Social Impact of Smart Green Synergy	FCU – Taiwan	Online & On-site
16	Final presentation (I)	Each Institution	On-site
17	Final presentation (II)	Each Institution	On-site
18	Final report submitting	Each Institution	On-site

Table 2. SGS Course Design

Course No.	xxx	Subject No.	General Education Center	Credit	2
Course name	Sustainable Development Goals – Smart Green Synergy				
Course description	All United Nations Member States in 2015 provides a shared blueprint for peace and prosperity for people and the planet, now and into the future, known as the 2030 Agenda for Sustainable Development. At its heart are the 17 Sustainable Development Goals (SDGs), an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.				

Correlation between Course and Ability: 1. Memorization; 2. Comprehension; 3. Application; 4. Analysis; 5. Critique; 6. Creation	
Goals	Ability
1. To understand 17 UN SDGs and Smart Green Synergy.	A2
2. To practice international case studies via synergy and sharing.	X3
Six soft powers (for 1st ability): A. Knowledge Exploration; B. Information Cultivation; C. Communication Skills; D. Value Judgement; E. Pursuit of Joyful Life; F. Civil Practice	
Competitiveness (for 2nd ability): U. Systematic Thinking; V. Critical Thinking; W. Creativity; X. Collaboration; Y. Self-Management; Z: Complex Problem Solving	

3.2. Learning Process

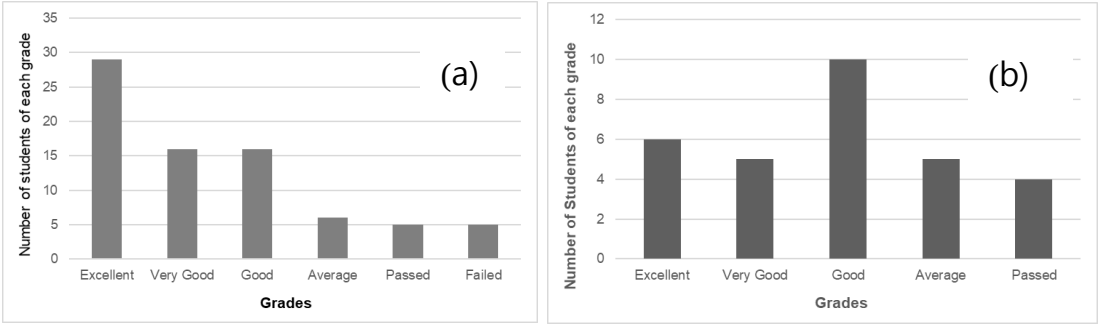
Various learning experience on green energy projects in other countries was arranged for students during this course; including twelve instructional sessions led by different professors from the seven institutions through Microsoft Teams. The lecturers delivered the topics every week, followed by interactive questions and answers from the university students. The first week started with the course introduction by the teachers from Feng Chia University, Taiwan. In the second to fourth weeks, the teacher introduces the green technologies into villages with the Symnergy Model's pilot projects in Manado city, Indonesia (Sinsuw, Wuisang, & Chu, 2020). Students have to learn the knowledge and suitable and affordable technology to the rural community development through this topic, impacting social, economic, and environment. In CDIO model is called the *conceive* stage, wherein this stage is necessary to know the community's needs, affordable, appropriate technology, and implementation strategies. Feng Chia University students have an on-site visit to Dongshi village in weeks five and six to learn the actual condition. At the same time, the students from other universities have joined the activity online. During the on-site visit, students have joined the online lecture from Chiang Mai Rajhabat University, Thailand. Students have to define some problems on-site to provide solutions tailored to green energy. Following the CDIO model, this stage is called the *Design* stage. Students have focused on designing a solution to the addressed need, which contained planning, drawing, and algorithm that describes what could be implemented. In weeks seven to fourteen, the course was conducted by different professors from different universities to share the green energy project-based experience of the global environment to be exposed to a rich set of international affairs. According to the course design, the CDIO model approached on this course can only fulfill the first two stages, Conceive and Design.

The role of teacher-instructors has been identified as highly important for successful group work management and performance. SGS is an interdisciplinary course. Engineering course content combined with social science to learn about social impacts. Teachers using the CDIO 3.0 standard 7, about the integrated learning experiences to create students' activities to stimulate creative and critical thinking consideration of the product planning and design with its responsibility to the social, economic, and environmental impacts. At the end of the course, the students were divided into five groups and used creative thinking to build a feasible concept run on the FCU campus. Using some information and example from other institutions and designed it according to their logical creativity only for 50 minutes. And the further 50 minutes, students have presented their project in a group. This activity has strengthened students' teamwork, capacity building, creativity, initiative, competitive and communication skills. Then, in the final term, students from FCU were divided into ten groups, whereby each group consist of 4 to 6 students. Every group has chosen one project idea that feasible to implement to overcome the climate change issues. Each group present it and choose the best idea, concept, and assumptions to provide the solution, such as drawings, argumentation, explanation, logical reason, and successful project examples as seen in Fig.2.

Figure 2. Group activities: Conceive and Design

3.3. Students Evaluation

Student learning is an essential outcome of education and is used to examine the quality of courses. Learning may be classified into two sub-constructs: achievement (actual grades) and perceived learning (self-report of learning). Achievement is generally measured by grades that students have earned in the course activities throughout the course (Rovai, Wighting, Baker, & Grooms, 2009). Evaluation helps to build an educational program, assessing its achievement and improve upon its effectiveness. It also provides valuable feedback on the design and the implementation of the program. There were two times evaluation on the SGS International course. The first evaluation is Mid Term. The midterm evaluation was distributed to all participants from six universities which are 80 students in total, whereby 30 were from Feng Chia University, Taiwan. A set of multiple-choice questions regarding the material course during half-semester was distributed using Google form to the six university students. Students have to answer and submit it within 60 minutes. The score intervals are divided into six classes, namely *Failed* (0-50), *Passed* (51-60), *Average* (61-70), *Good* (71-80), *Very Good* (81-90), and *Excellent* (91-100). Based on the mid-semester evaluation results, 38.75% got excellent results, 21.25% were very good, 20% were good, 10% on average, 8.75% passed, and 6.25% had failed. The evaluation results, particularly for 30 Feng Chia University students who attended the on-site lecture, 20% were excellent, 16.67% were very good, 33.33% good, 16.67% and 13.33% were average and passed, respectively. Students who were not attending the mid-term exam were given another opportunity to take the following week's exam. Fig. 3 shows the result of students' achievement in Mid-term evaluation.



(a) Six universities students' grade distribution on Mid-term, (b) Feng Chia University students' grade distribution on Mid-term

Figure 3. Students' achievement on Mid-term exam

The second evaluation is the final semester exams conducted by the respective university. Feng Chia University students are divided into eight groups consisting of three to four students.

Each group must define problems related to the predetermined SDGs. Furthermore, each group presented the solution to the problem using designs, pictures, slides, and other creativity using English. It is in the CDIO stages of *conceive* and *design*. Through this grouping system, students are trained to work together on teamwork and more engaging in applying ideas. Active learning in CDIO standard 8 said that small-group suitable method for teachers to get feedback through discussion, debates, and feedback about what students are learning. It can be seen in Fig. 4 that the distribution of final semester test scores has increased when compared to the mid-term. The final-term evaluation results showed 42% were Very Good, 33.3% were Good, 13% Excellent, 10.6% were average, 10.43% and 3.67% were passed and failed, respectively.

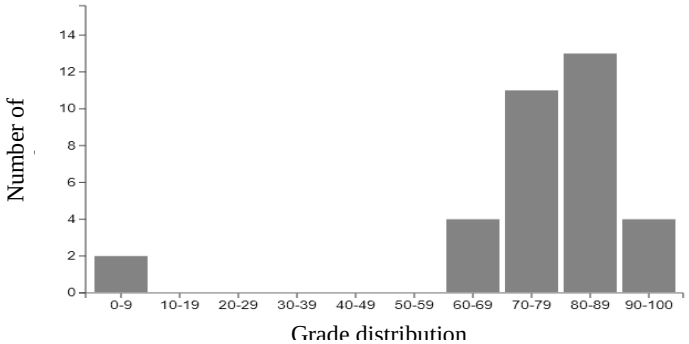


Figure 4. Students' achievement on Final-term exam

3.4. Course Enhancement

When this two-credits course was being offered for the first time, the five institutions in Southeast Asia agreed with it enthusiastically. Several insights in light of contents, process, and outcomes were gained for continuous course improvement. The course was set as the first international course among the six universities consortium as a starting point for the future international curriculum. Each university in the consortium adopts this course as one elective course in the curriculum that the students from the undergraduate level may elect as one of the credits. Besides, students who have taken this course have priority as exchange or intern students among the consortium if they meet the faculty's main requirements.

4. DISCUSSIONS

This paper aimed to explore an online-to-on-site (O2O) learning model of an international course on Sustainable Development Goals. Following the CDIO standards 3.0, students showed solid teamwork in groups on how students define and solve problems based on the sharing experience internationally at the end of the semester. Based on the CDIO 3.0 Optional Standard 4, students taking this course have more opportunities to apply for internships or exchange students.

Students' ability, which was designed in this curriculum, is to achieve the A2 and X3. For A2 ability, students have to understand the knowledge exploration. With the knowledge exploration, students can cultivate interest in learning in multiple fields, integrate knowledge across domains, and continue to engage in cross-field learning. The X3 ability expects students to collaborate. With collaboration, students will have the ability to respect differences, emphasize complementarity, adequate division of labor, integrate expertise from different backgrounds, and complete projects that individuals cannot overcome

Based on the mid-semester student evaluation results and the distribution of scores shown in the bar chart above, the results achieved tend to be high in general. From the 16.67% "Very Good" category in the mid-term, up to 42% in the final term. There are other categories that have decreased but some are stable. From the results of the analysis, there was an increase

in the improvement of the study results by approximately 150%. Thus, the teaching approaches and methods used in this course are following the expected outcome. Although there are still students who fail, the percentage is deficient. Several factors influence student failures, such as withdrawing or dropping courses, not attending lectures, or other conditions that hinder the classes. The results achieved by Feng Chia University students who took on-site courses, the distribution of scores tended to be in the middle. The majority of students get "good" grades. It is not too high. This condition shows a pattern that students who take on-site lectures tend to attend classes regularly because other factors influence it, such as meeting college friends and lecturers directly to discuss or ask questions to get a clearer understanding. However, the lack of mastery of foreign languages such as English, which is the language of instruction for the international course, could be one reason for the achievement of FCU students' scores who are not many in an excellent position.

5. CONCLUSIONS

This study has explored the CDIO implementation to the s.School course at Feng Chia University. Bloom's taxonomy divides learning into three potentially overlapping domains; one of them is the cognitive domain which includes six different classification levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Bloom, 1956). Based on Bloom's taxonomy, this course design only reaches the second level, Knowledge and Comprehension, because it is generally offered for all undergraduate students, from first-year students to senior students. This course aims to give a deep understanding of UN SDGs to the students, and later students will know how to implement it in their fields.

The CDIO standards 3.0 approach of learning outcome on personal and interpersonal in this study has good result as can be seen from the students' achievement by grade distribution of the exams. Individual achievement results can be seen through the mid-semester exam. The results of group work achievement and the percentage of the ability to define problems and provide solutions are seen in the final semester exams' results. The increase in student learning outcomes can be seen clearly from the above bar chart. Through the improvement of learning achievement, it can be implied that the CDIO approach is suitable for online to on-site international courses. Thus it can be concluded that the CDIO approach was successful in the SDG-SGS course with the expected outcome.

For future perspectives, the CDIO method is suitable for online, on-site, and blended learning lectures. This method can be applied for engineering study by considering social, economic, and environmental sustainability. This is in line with UNESCO's programs, Education Sustainable Development, which empowers learners to take responsible actions for environmental integrity, economic viability, and society. It is about lifelong learning and is an integral part of quality education which addresses learning content and outcomes, pedagogy, and the learning environment. It is sustainability education that empowers students to create positive change for our evolving world.

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BIOGRAPHICAL INFORMATION

Alicia A.E Sinsuw is an Assistant Professor at the University of Sam Ratulangi, Electrical Engineering Department, Faculty of Engineering in Manado city, North Sulawesi Province, Indonesia. Her major field was Telecommunication Engineering and Computer Networks as she reached her Master's degree from Institute Technology of Bandung (ITB) Indonesia in 2007. Her research focus to renewable energy issues to upgrade the quality of community quality of life in those remote areas. She is now joined as a Ph.D. candidate of Mechanical and Aeronautical Department, Feng Chia University, since February 2019. Her research field is to study the environmental and social impact of implementing renewable energy biogas systems to the community and its additional value to reach a better quality of life.

Tsung-Hsien Chen is a Ph.D. candidate of Mechanical and Aeronautical Engineering, who already had working experience over ten years in the industry. He worked in several domains when he was an engineer, such as electronic, chemical engineering, biotechnology, etc.

During his work in Humboldt Advanced Material Co., Ltd., he co-published several patents in reactor design and related devices. He helped Nympheas International Corp design a manufacturing factory and make it built up and make several improvements in manufacturing problem. When he went back to university, he assisted Prof. Chen-Yeon Chu in executing a National Energy Program-Phase II (NEP-II) from MOST, which was Gaseous Biomass Energy System Demonstration in the Rural Area of Manado City Indonesia.

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