GREEN GROWTH AND CDIO APPROACH IN FOOD ENGINEERING: INITIATIVE AND IMPLEMENTATION MODEL

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ABSTRACT

Currently, the idea of "green growth" represents the modern paradigm for climate change mitigation that economists and policymaker's support. The need to lower greenhouse gas emissions linked to economic growth necessitates the development and application of sensible policies. Despite differences in viewpoints regarding the risks and difficulties involved, green growth is still a seemingly unstoppable option to meet the demands of climate change and guarantee the sustainability of human existence. In this context, it makes sense in this situation to incorporate green growth concepts into engineering education. Including instructional modules that highlight sustainable practices is crucial given the widespread impact of technological practices on the economic and environmental landscapes. Future food engineers must be prepared to handle the difficulties posed by the impact of the food industry, as food engineering is crucial to human development. By that way, future professionals can effectively contribute to the demands of sustainable development by fostering an awareness of green growth in engineering education, which strengthens the mutually beneficial relationship between environmental responsibility and technological advancement. Using the CDIO approach to combine green growth into food technology training programs will help guarantee that this content is efficiently developed and turns into a beneficial skill that complement the development of future engineers as well as food technology. In order to effectively develop future food engineers' skills in line with the demands of the modern era, this article offers a model that incorporates green growth content into university not only food technology (FT) programs but also Engineering/Technology (ET) programs using the CDIO approach.

KEYWORDS

Green Growth Indicators, Sustainable Development, CDIO Framework, Engineering Education, Curriculum Integration, Standards: 1, 3, 4, 5, 7, and 8.

NOMENCLATURE

OECD	Organization for Economic Co-operation and Development
GG	Green Growth
CDIO@FT program	CDIO integrated Food Technology
CDIO@ET program	CDIO integrated Engineering/Technology
GGI	Green Growth Indicator
EEPs	Energy-Efficient Products
GCE	Green and Circular Economy
R&D	Research and Development

INTRODUCTION

The significance of sustainable development has gained widespread recognition in recent decades due to significant negative effects of global environmental changes. Numerous conservation activities and industry-wide laws are being improved to control human negative impacts on nature. There are many technological alternatives whose development is encouraged to bring cost-effective, environmentally friendly technologies into human life. Future engineers must have sufficient knowledge and skills to control the negative impact of production and consumption on the environment, which must fundamentally be carbon neutral. This is not only a requirement of this time, but also the responsibility of engineers, since they are the main actors in the conception, design, development, manufacture and operation of products in practice, with the aim of reducing the negative impact of production systems on the environment. In this context, the CDIO curriculum has been further developed with content on sustainable development and places a greater emphasis on environmental issues. Based on these sustainability aspects, the CDIO curriculum with several environment topics has been integrated into version 2.0, including sections 4, 4.1, 4.1.7, 4.4.6, 4.5.1 and 4.6.1.[1] The update of curriculum from the prevailing version 2.0 to a new version 3.0 was motivated by the emergence of external change drivers and internal experiences within the CDIO community.[2] CDIO syllabus, in both versions 2.0 and 3.0, has incorporated elements of sustainable development, recognizing its growing importance in engineering education. There, sustainability is one of four themes that categorized in the curriculum. It can be concluded that the current version of the CDIO curriculum is partly based on sustainability competencies to ensure the development of engineers in the time of adaptation (Table 2).

Green Growth (GG), one of the concepts, is also a vision or an economic development approach that also includes and takes into account aspects of the living environment. This term is also applied to the sustainable development approach that the world is pursuing today to address the crisis of our time: Climate change.[3] Green growth includes Growth (Economic sustainability), Clean (Environmental sustainability) and Resilience (Social sustainability). These three poles are about optimizing the use of natural resources, minimizing pollution and environmental impacts, as well as managing natural hazards and the role of governance environmental and natural resource management in preventing natural disasters. Green growth is economic development that must be low-carbon and resource-efficient, socially inclusive and adaptable, create new jobs, often include innovative approaches and new technologies, while protecting environmental biodiversity and ecosystems. Innovation is the linchpin when managing the delicate balance between growth and environmental sustainability while aligning with social sustainability. Pushing the frontier outward through innovation is not merely about finding more efficient ways to use natural resources, but also about fostering a mindset of continuous improvement and creative adaptation. Innovation not only helps decouple growth from natural capital depletion but also catalyzes a ripple effect:

spawning new ideas, entrepreneurs, and business models. Not only does this contribute to economic growth, but it also emphasizes the symbiotic relationship between green practices and overall prosperity. As playing a key role in the development and implementation of new products that serve human life, engineers must not only have strong skills to adapt in the new context of the economy but also have practical experience to acquire creative thinking skills integrated green growth requirements.

With the aim of collecting the specified index for analysis and monitoring the progress of the transition to green growth, the OECD has established a small set of measures.[4] In the framework of measurement, a logical starting point for identifying Indicators of Green Growth (GGIs) for goods or services is the area of production where growth directly contributes to economic expansion, utilizing natural resources as inputs and releasing pollutants and residues into the environment. The indicators include monitoring environmental and resource productivity, monitoring the natural asset base, monitoring the environmental quality of life, and monitoring economic opportunities and policy responses. To integrate sustainable development principles into CDIO, GGIs can be used as a framework that adapts the curriculum to the needs of new global situations. The indicators can also be used as a benchmark and motivation for development of products that contribute to sustainable development. Integrating green growth indicators into every phase of product development according to the CDIO curriculum not only creates an innovative framework aligned with current trends, but also ensures that green skills become an important part of the skills of future engineers.

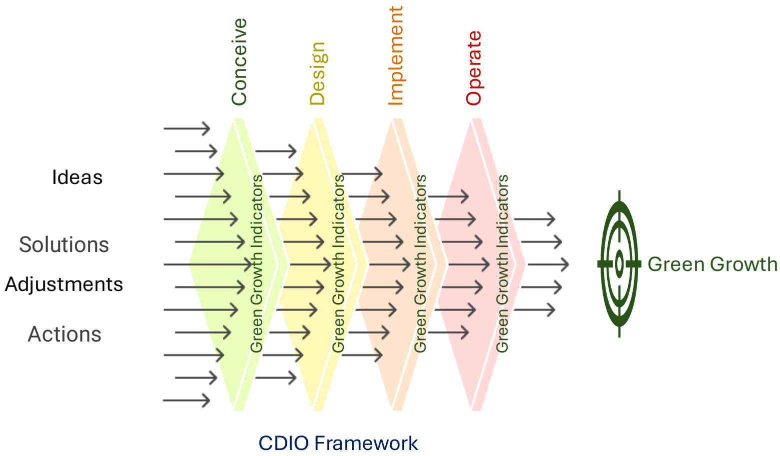

Figure 4. Application of Green Growth Indicators in the CDIO Framework

The pressing need for sustainable practices and the rising demand for safe, high-quality food products are driving a significant transformation in the modern food industry. To address these issues, Duy Tan University's Food Technology (FT) program has painstakingly developed a thorough curriculum that not only provides a solid grounding in the scientific principles of food technology but also cultivates the hands-on abilities and creative thinking required for success in this fast-paced industry. The curriculum is carefully crafted to produce future food engineers who are not only technically skilled but also capable of spearheading innovation and leadership in the sector. Conceiving, Designing, Implementing, and Operating (CDIO) principles are seamlessly incorporated into the curriculum's core, guaranteeing that students obtain practical experience and cultivate a thorough understanding of the full product development lifecycle. Furthermore, the program actively integrates Green Growth Indicators (GGIs) into its curriculum in recognition of the critical role sustainability plays in the contemporary food industry. By using these indicators as a framework, the curriculum is modified to meet the needs of a world that is changing quickly and to guarantee that our graduates are equipped to help create a more sustainable future.

Table 2. Examples of CDIO and green applications in projects

Project Area	CDIO Stage Focus	Green Growth Principle Addressed	Reference
Clean Technology Integration in Engineering	Design, Implement	Innovation, Reduced Pollution	[5]
Petroleum Engineering Curriculum Reform	Conceive, Implement, Operate	Environmental Responsibility, Carbon Footprint Reduction	[6]
Solar-powered Water Purification System	Implement, Design	Resource Efficiency and Environmental Sustainability	[7]
Sustainable Urban Drainage Systems	Implementation	Resource Efficiency and Environmental Sustainability Within Urban Infrastructure	[8]
Sustainable Wastewater Treatment System	Design, Implement	Environmental Sustainability, Low-energy, Ecological Balance, Resource Efficiency	[9]
Sustainable Design and Build Project	Design, Implement, and Operate	Sustainable Development, Environmental Stewardship, Environmentally Friendly Materials, Energy Efficiency, Waste Reduction, Sustainable Infrastructure	[10]

This article introduces the set of indicators based on green growth principles suitable for application and integration into not only Food Technology programs but also other CDIO integrated Engineering/Technology (CDIO@ET) curriculums.

INDICATORS SET FOR CDIO@ET CURRICULUMS

By the original purpose, the GGIs developed by the OECD serve as a flexible framework for measuring and monitoring progress towards green growth across various aspects of society. This framework is intended for a wide range of stakeholders, including nations, industries, organizations, and individuals. Moreover, the GGIs also offer an approach to assessing and fostering green growth.

By integrating GGIs into the CDIO@ET curriculums and syllabus, educators ensure that engineering students understand the importance of sustainability in their field. On the other hand, CDIO focuses on connecting engineering education with real-world applications. By incorporating GGIs, students can apply their technical skills in projects and designs that are aligned with sustainable development goals. Additionally, sustainability and environmental responsibility are among the most important ethical considerations in modern engineering practice. GGIs provide a structured opportunity to teach students these ethical principles and prepare them for responsible engineering careers. As many industries shift to sustainable practices, CDIO@ET programs with GGIs equips students with the skills and mindset required in industries that increasingly emphasize green growth and environmental awareness.

Incorporating sustainable design principles into each phase of CDIO can contribute to GG by ensuring that engineering projects align with the green growth strategy. Furthermore, implementing engineering solutions consistent with sustainable practices can contribute to GGIs by emphasizing the long-term sustainability of engineering, taking into account sustainable development factors. Additionally, in addressing complex environmental challenges that often require solutions that span multiple engineering disciplines, CDIO will encourage interdisciplinary collaboration, and bring together different fields of engineering where GG become more of a reality. This makes CDIO's project-based learning approach a good fit not only with GG, but also with a deeper understanding of green growth principles. Furthermore, CDIO encourages innovation, creativity and problem-solving scenarios in technical solutions. This can contribute to GG by encouraging the development of innovative, environmentally friendly technologies and practices and addressing real-world issues related to sustainable development.

Essentially, GGIs integrated CDIO@ET curriculums provide a framework for training engineers guided by the principles of green growth and sustainability. CDIO, which focuses on conception, design, implementation and operation, can contribute to several key elements of green growth through a set of indicators that are selected and flexibly changed according to the processes in each phase of the engineering project. This approach allows educators to design curricula to address not only technical issues but also environmental concerns. This ensures that engineering students graduate with a comprehensive understanding of how their work can positively impact the environment and contribute to sustainable development.

Environmental and resource performance indicators

Box 1. Key indicators for productivity categories

Labor Productivity
- Output per hour worked
- Output per employee
- Value added per worker

Environmental Productivity
- Carbon intensity
- Water use efficiency
- Energy efficiency

Resource Productivity
- Material efficiency
- Land resource efficiency
- Water resource efficiency

GGIs must accurately identify key environmental services and seek to quantify, where possible, their impact on economic growth. In the indicators set of environmental and resource productivity, the measures can be divided into labor productivity, environmental and resource productivity.

The natural asset base

GGIs not only focuses on traditional measures of output and income growth but must also consider the preservation and sustainability of critical assets. These assets include both produced assets and, crucially, natural assets and environmental resources. The measurement includes carbon balance as well as natural quality and health.

Box 2. Key indicators for the natural asset base ***Carbon-related rates*** • Carbon emissions • Carbon sequestration ***Natural quality and health*** • Availability and quality of freshwater resources • Soil quality and health • Biodiversity • Forest cover, deforestation rates • Health of marine ecosystems

Indicators of the environmental quality of life

In addition to the consideration of keeping society's asset base intact, GGIs must also reflect the quality of life and the direct impact of the environment on people's quality of life. Environmental quality of life indicators includes environmental quality, environmental risks and basic environmental services.

Box 3. Key indicators for the environmental quality of life ***Environmental quality*** • Air quality • Water Quality • Health-Related Indicators ***Environmental risks*** • Industrial pollution • Hazardous waste • Pollution intensity • Natural disasters ***Basic environmental services*** • Clean water and treatment • Sanitation and sewage treatment

Indicators of economic opportunities and policy responses

GGIs must reflect the potential for green growth and the effectiveness of policies to promote environmentally sustainable economic development. Collectively, these indicators provide insights into the economic opportunities and policy responses related to the transition to green growth and provide a comprehensive overview of efforts to balance economic development with environmental sustainability.

Box 4. Key indicators for economic opportunities and policy responses ***Green and Circular economy*** • Renewable energy generation • Energy efficiency

- Green jobs
- R&D focusing on green technologies and sustainable practices
- SDGs Achieving
- Environmentally sustainable projects and businesses
- Percentage of waste recycled and diverted
- Product life cycle and recycling efficiency
- Adoption of carbon pricing mechanisms

Social and Inclusive Growth

- Reduce poverty rates and income inequality
- Education and training for sustainable development

Environmental Performance

- Emissions reduction targets
- Air and water quality reflection

Resilience and Adaptation

- Country's or region's resilience to climate-related risks
- Preparedness and response capabilities for natural disasters

Consumer and Corporate Behavior

- Consumer behavior promoting sustainable and eco-friendly products
- Businesses' environmental and social performance

CDIO@FT PROGRAM AT DUY TAN UNIVERSITY

Duy Tan University's 4.5-year Food Technology program (151 credit hours) provides comprehensive food technology education, integrating lectures, labs, e-learning, communication, ethics, and critical thinking. Hands-on learning is emphasized through CDIO projects, real-world applications, and a graduation internship.

Food Technology program, built on the CDIO framework, features a core structure of four courses designed to progressively develop students' skills in conceiving, designing, implementing, and operating innovative solutions within the food industry. These courses—FSE 296, FSE 396, FSE 496, and FSE 447—guide students through increasingly complex projects, culminating in a capstone graduation project.

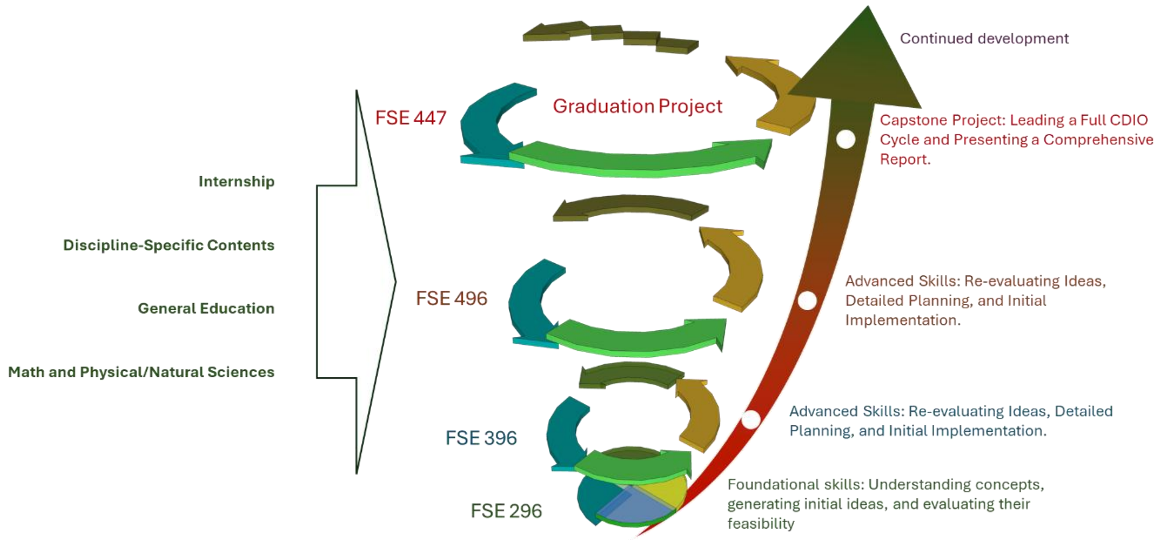

Figure 5. CDIO@FT Program at Duy Tan University

With an emphasis on the project lifecycle and conceiving/designing solutions, students in FSE 296 acquire the fundamentals of CDIO, generate preliminary concepts, and assess viability. Building on this, FSE 396 requires students to reorganize groups, polish concepts, and prepare for execution, including preliminary testing. With a focus on assessing practical value through the application of scientific methods in food technology, FSE 496 leads students through the entire CDIO cycle, which includes reevaluating concepts, restructuring, and executing conceive, design, implement, and operate.

In this capstone project (FSE 447), each student leads a team of second and third-year students, mentoring them through a complete CDIO cycle. Teams re-conceive and implement innovative ideas, producing a comprehensive graduation project report. This report is presented to a faculty scientific committee for evaluation, showcasing students' comprehensive understanding and application of CDIO principles.

INTEGRATION GREEN GROWTH INDICATORS INTO CDIO@FT CURRICULUM

Integrating GGIs into the CDIO@FT curriculum can be a mutually beneficial process, with both GGIs and CDIO contributing to each other. Linking the goals and methodologies of GGIs and CDIO, educators can create a comprehensive learning experience that provides students with the knowledge, skills, and motivation to contribute to green growth and sustainable development in their engineering practices.

Integrate Green Growth into the Conceive phase

Food technology faces the complex task of providing safe, nutritious, and appealing food for a growing population while minimizing its environmental impact. While addressing fundamental challenges like food security and nutrition remain paramount, integrating Green Growth Indicators (GGIs) into the Conceive phase can ensure that sustainability is considered alongside other critical factors.

GGIs can promote or upgrade ideas for new food products to ensure that from the earliest stages, engineering and technology solutions are aligned with the goals of green growth and sustainable development. By focusing on the greener ideas, the food products can take lower carbon products, water use efficiency and energy efficiency into account in their products' ideas to promote conservation of water and energy resources. To solve practical problems, instead of opting conventional solutions, food engineers can think about environmental-friendly alternatives, recyclable resolutions, waste-free products, thus food engineers can emphasize the efficient use of materials and contribute to sustainable practices early in conceive phase of products. If the operation (production, distribution, consumption) of the product has any impact on the environment, freshwater resources, land resources, forests or marine ecosystems in the future, food engineers can direct their ideas towards solutions that do not harm the environment, protect ecosystems and biodiversity, and promote a circular economy in which inputs are adopted aligned with the natural asset base indicators.

To develop a new idea, food engineers can invest in concepts that emphasize the environmental quality of life. They can direct their creativity and innovative solutions to improve both human well-being and environmental sustainability, contributing to a more harmonious and balanced life. In addition, inventors can develop technologies and products that actively contribute to improving air and water quality, solving pollution and waste problems, preventing risks and mitigating disasters - all of which always affect people in recent times and are their concerns.

By evaluating ideas in the context of green growth and sustainable development, which involves refining and enhancing concepts with the keys set out in GGIs, a food production project will not only meet current requirements but also future-proof evolving sustainability standards. A thorough evaluation of ideas using GGIs helps identify and rectify potential errors in the design and implementation phases. This proactive approach minimizes the risk of overlooking critical sustainability issues, fosters innovation, resilience and a proactive approach to sustainability, and contributes to the creation of food products that better meet the evolving needs of sustainable development.

Integrate Green Growth into the Design phase

In the product design phase, GGIs can play a crucial role in promoting and upgrading sustainability by guiding the decision-making process. GGIs can be used effectively to improve food product design while encouraging designers to focus on technologies and materials with lower carbon emissions per unit of output. Quantifying consumed resources including raw materials and energy-related greenhouse gas emissions using carbon footprint calculators is a method that creates opportunities to reduce carbon intensity in products plan process. With eco-friendly alternatives, recyclable materials, reduced waste generation designs or ready-reuse designs, food engineers can emphasize the efficient use of materials and contribute to sustainable practices early in design phase of products. Additionally, engineers can explore materials and ingredients and technologies that support carbon sequestration, such as using resources from sustainable forestry or incorporating carbon-absorbing, carbon-storing materials into product or packing design.

During the design process, food engineers can assess the impact of their products on freshwater resources, soil quality, biodiversity and marine environments to prevent harm from the manufacture or use of a product by employing alternative, more sustainable designs. Even in the design of the products themselves, engineers can incorporate environmentally friendly designs that help users to eliminate or reduce their environmental risk during product consumption or at their disposal. Additionally, in the case of product operations that involve water consumption or degradation of soil quality, engineers can design their food products components that are related to usage and conservation of freshwater and soil, both manufacturing processes and product use. Furthermore, considering products adaptability can include designs that take into account climate fluctuations or evolving ecosystem dynamics and minimize disruption to ecosystems and biodiversity. By integrating these GGIs-led considerations into the design phase, engineers contribute to the overall goal of sustainable development for the environmental quality of life.

By developing and optimizing new EEPs, including adopting renewable energy trends and minimizing energy consumption during the manufacturing, use and end-of-life phases, the food products are ready to participate in GCE. Furthermore, R&D activities focus on green technologies to commercialize products that promote a socially responsible approach with the creation of new green jobs and are in line with the SDGs. By integrating the economic opportunity and policy response indicators into the design process, food designers can create products that not only meet current sustainability standards but also align with future economic and policy expectations.

Integrate Green Growth into the Implement phase

In the implementation phase of food projects, GGIs can be integrated to guide and assess the execution of sustainable practices. Sustainability of employees is about enhancing workforce productivity that ensures fostering a culture of efficiency and labor-intensive tasks are optimized by reducing the overall environmental impact per unit of production. In addition, when implementing projects with building a culture of organization that promotes and supports sustainable and labor productivity, value-adding tasks are also considered that make a positive contribution to environmental and social aspects and invest in the well-being of people.

The food projects might also take into account policy responses for sustainable development as well as economic opportunities. Some examples include: establishing job opportunities that align with the principles of green growth; investing in research and development that emphasizes green technologies and sustainable practices, or implementing the outcomes of the aforementioned process; working with environmentally sustainable projects and businesses, and joining a network of organizations that are exhibiting positive environmental and social performance with green growth principles; and, if feasible, implementing carbon pricing mechanisms to account for environmental externalities.

Integrate GGIs into the implementation phase, food projects can ensure that sustainability considerations are embedded in the execution process, contributing to overall green growth objectives. Through the practical application of GGIs to monitor and evaluate adjustments and improvements throughout their CDIO project, engineering students can engage in real-world projects and gain hands-on experience with a deep understanding of green growth principles and how these can be translated into practical measures.

Integrate Green Growth into the Operation phase

During the operation phase of food projects, the integration of GGIs is crucial to ensure sustainability and minimize environmental impact. Based on GGIs framework, food engineers could continue to collect relevant data and monitor the ongoing performance of the project in terms of environmental impact, resource efficiency and other sustainability criteria. In addition, assessing and optimizing energy, water and resource efficiency over the life of the project allows food engineers to conduct ongoing life cycle assessments, taking into account the entire life of the project. On the other hand, engineers can identify negative environmental impacts during the operation phase and take corrective measures in a timely manner. Through practice, food engineering students gain hands-on experience in implementing and maintaining sustainable technologies, as well as making adaptive adjustments based on GGI data to ensure the project remains aligned with sustainability goals over time.

CASE STUDY

Every student enrolled in Duy Tan University's CDIO@FT program must complete a final project that is planned and carried out in groups. Instructors then use rubric with assessment components to evaluate the projects. Through the integration of green growth and the circular economy, the project is assessed for sustainability with regard to people, the environment, and society in addition to the Conceive-Design-Implement-Operate criteria in this evaluation table. Throughout the entire ideation and project completion process, CDIO approach and GGIs have been utilized to give students a thinking scaffold as well as the drive to improve their concepts and streamline the project implementation procedure.

Case study 1

In order to determine a production process for beetroot wine using Saccharomyces cerevisiae yeast, the project with initial tiles is "Study on the Production Process of Beetroot Wine Using Saccharomyces Cerevisiae Yeast", aims to investigate the variables affecting the fermentation process. The project was scheduled to be carried out in laboratory and involved five steps: Analyze the chemical and microbiological makeup of beetroot; Establish the ideal temperature and duration for sterilization; Determine the appropriate concentration of sugar, pH, and yeast ratios; Examine the effects of fermentation duration on quality; and Assess the sensory and microbiological qualities of the finished product. A standardized method for making beetroot wine would be created, considering all important variables influencing fermentation, and the finished product was assessed for quality, safety, and consumer acceptability. These are the anticipated results of the project.

Figure 6. Beetroot: The original root, juice and produced wine

Through the use of mentioned tools kit to promote or upgrade ideas and throughout the project, CDIO approach and GGIs were utilized to develop these goals. The project was tiled as “Development of a Closed-Loop System for Beetroot Wine Production with Enhanced Nutritional and Functional Value” with the main goals were to design a closed-loop system for beetroot wine production, optimize the production process for increased nutritional and functional value, and carry out a thorough analysis and evaluation of the system. To produce beetroot wine, the project successfully designed and implemented a closed-loop system, proving that this method is feasible for producing food in a sustainable manner. Furthermore, creative methods for maximizing resource use and reducing waste production were created for beetroot pulp and fermentation by-products. A superior product with more health advantages was produced as a result of the production process being optimized to improve the beetroot wine's nutritional and functional value. Its economic and environmental sustainability was demonstrated by a thorough analysis and evaluation of the system, underscoring its potential for broader food industry adoption.

Case study 2

The goal of the project with initial tiles is "Research on Producing High-Protein Vegan Floss from Oyster Mushrooms" is to create a high-nutrient vegan food product. The study emphasizes the rising popularity of vegetarianism in Vietnam as well as the need for easily accessible vegan goods that respect environmental and health concerns. The selection of oyster mushrooms was based on their high protein content, texture, and nutritional advantages—such as their high vitamin and mineral content and low fat and carbohydrate content. The expected outcomes include the establishment of an ideal procedure for producing high-quality vegetarian floss and thorough assessments of its nutritional and sensory attributes.

Figure 7 Developing of a high-protein vegan floss product using oyster mushrooms

The process of re-thinking concepts, creating experiments, putting the product creation process into practice, and running it has all incorporated the GGIs set and CDIO approach. Improvements to the project are evident when it concentrates on creating a wholesome and sustainable vegan floss product with oyster mushrooms, which fits in with Vietnam's rising vegetarianism and health consciousness. In order to minimize environmental impact and maximize resource utilization, the project combines the principles of Green Growth and the Circular Economy. Its goals include: developing a high-protein vegan floss product using oyster mushrooms that are sourced locally; optimizing processing methods (soaking, shredding, mixing, and drying) for quality, protein retention, and minimal environmental impact; making efficient use of resources, minimizing waste and energy consumption throughout the production process; investigating and putting into practice strategies for the valorization of by-products generated during mushroom cultivation and floss production; designing packaging and distribution systems that conform to circular economy principles, encouraging reuse and recycling; and evaluating the production process's environmental impact, taking into account factors such as energy consumption, water consumption, and waste generation.

The findings included the creation of a thorough report on the nutritional and sensory qualities, the design of an optimized process for producing high-quality vegan floss with little environmental impact, the development, application, and evaluation of waste reduction and value-adding strategies, as well as an assessment of the production process's environmental impact.

CONCLUSION

In conclusion, integrating GGIs into the CDIO framework, as demonstrated with the CDIO@FT program at Duy Tan University, offers a transformative approach to engineering education across various disciplines. This synergistic framework not only aligns with the global shift towards sustainable development but also provides a measurable and actionable way to equip future engineers with the skills, knowledge, and mindset necessary to become responsible and environmentally conscious professionals.

While the CDIO@FT program showcases the specific application within food technology, the integration of GGIs holds immense potential for other CDIO@ET programs as well. By embedding sustainability considerations into each phase of the CDIO process – Conceive, Design, Implement, and Operate – engineering programs across various disciplines can foster a holistic understanding of green growth principles and empower students to create innovative solutions that address the complex environmental challenges of our time.

GGIs bring a unique value to CDIO@ET programs with providing a structured framework for incorporating sustainability into every stage of the engineering process, regardless of the specific discipline. Moreover, this integration connects engineering education to real-world sustainability challenges relevant to each field, such as renewable energy development, sustainable manufacturing, and green infrastructure. Fostering a holistic understanding of the interconnectedness of environmental, social, and economic factors in sustainable development across different sectors is also an advancement. By this method, the program equips students with the practical skills to assess, monitor, and improve the environmental performance of their engineering projects, regardless of their specific focus.

GGIs integrated CDIO@ET programs across various disciplines can cultivate a new generation of engineers who are not only technically proficient but also deeply committed to ethical and sustainable practices. These future leaders will be prepared to drive innovation and shape a future where engineering solutions contribute to a healthier planet and a more sustainable society. This integration is not merely a curriculum enhancement; it is an investment in a future where technology and society harmoniously coexist with the environment.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Duy Tan University for its support and resources provided throughout this research. We also extend our appreciation to the faculty and students of the Food Technology program for their contributions to the case studies presented in this paper.

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