EMBEDDING SDG 12 THROUGH COMPETITION-BASED LEARNING IN VOCATIONAL CULINARY EDUCATION FOR PASTRY STUDENTS

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Abstract. This paper presents a qualitative case study of how a Diploma in Pastry Arts program operationalises United Nations Sustainable Development Goal SDG 12 through a structured, plant-based competition cooking initiative called the Plant-to-Plate Challenge. Embedded within the "Essential Cookery Skills" course at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, the initiative unfolds across three progressive stages: plant-based component development, full plant-based meal design, and a judged team competition, followed by digital e-portfolio documentation. Drawing on Education for Sustainable Development (ESD) competency frameworks and the literature on competition-based learning and reflective e-portfolios, this paper analyses the pedagogical design and implementation. Respondents were semester one students (n=32) of the March 2026 cohort. As a single-semester, non-comparative case, the findings indicate that the competition format generated short-term but meaningful gains in student engagement, technical problem-solving and understanding of ingredient substitution, while the e-portfolio provided visually mediated documentation of sustainability practice. The paper argues that pastry arts education, historically anchored in animal-derived and refined ingredients and under-represented in sustainability scholarship, can meaningfully advance SDG 12 competencies when experiential, competitive, and reflective pedagogies are deliberately combined. This paper discusses implications for curriculum design in vocational culinary and pastry education and directions for future research.
Keywords: *SDG 12, ESD, competition-based, e-portfolio, pastry*

Introduction

The adoption of the 2030 Agenda for Sustainable Development placed responsible consumption and production (SDG 12) at the centre of global efforts to dissociate economic activity from environmental degradation (United Nations, 2026). Within food systems specifically, SDG 12 (Responsible Consumption and Production) calls for more efficient use of natural resources, substantial reductions in food loss and waste along production and supply chains, and consumption patterns that remain within planetary

boundaries (United Nations Department of Economic and Social Affairs, 2026). Because food systems are estimated to account for roughly a third of global greenhouse gas emissions, with meat and dairy production the largest single contributors, the professional kitchen has been identified as a strategic site for sustainability education and behaviour change (Król and Giacalone, 2026). Formal and informal education are crucial for imparting fundamental information regarding the environment, enhancing awareness, and fostering community engagement (Mazlan et.al, 2026; Shodiq et.al, 2020). Vocational and culinary programs have begun to respond to this global shift through environmental education, increasingly embedded into curricula as hands-on, learner-centred, environmentally grounded content rather than abstract policy discourse (Liu et.al, 2019). Structured cooking exercises, in particular, have proven to be a meaningful vehicle for real-time teaching and monitoring of students' sustainable culinary habits (Wang and Teng, 2019; Wang, 2016). Yet pastry arts, a discipline historically anchored in wheat, dairy, egg, and refined-sugar-based ingredients (Figoni, 2011), remains comparatively under-researched within this environmental education movement, despite growing technical interest in plant-based reformulation of baked goods, such as the use of plant proteins as egg replacers in cookies and cakes (Varshini et al., 2026). This leaves a crucial gap in sustainability pedagogy in food service education, particularly within pastry arts.

This paper documents how a Diploma in Pastry Arts program addresses this gap by embedding SDG 12 into the program. The Diploma in Pastry Arts offers two discipline courses in its first semester: a theory course, "Fundamentals of Baking", and a practical course, "Essential Cookery Skills.". "Essential Cookery Skills" teaches basic Western and Eastern hot cooking, focusing on savoury dishes like appetisers, soups, and main courses. Education for Sustainable Development (ESD) is discussed in the theory class "Fundamentals of Baking," which includes a lecture on environmental sustainability, the UN 2030 Agenda for Sustainable Development, the 17 Sustainable Development Goals (SDGs), and the need for collective action. The lecture also introduced the concept of plant-based dishes. Furthermore, the lecture reiterated the importance of resource efficiency, waste reduction, and responsible consumption and production. The theoretical lessons are reinforced by the practical class, which includes a dedicated plant-based food innovation week in the course syllabus. During this week, students develop plant-based snacks, mains, and pastry-compatible fillings, which culinary and pastry instructors evaluate. Students begin pastry-specific courses, such as cake and bread making, in the second semester. However, the curriculum review committee believes it is pertinent to introduce ESD from the beginning of the program; hence, this sustainability education was implemented in the courses mentioned. Learning is consolidated through digital E-Portfolios in which students document technical methods and recipe development decisions. Two research questions guided the case study: (1) How effective was SDG 12 embedded in the pedagogical design of competition-based learning within a pastry arts curriculum? (2) How effective is the use of an e-portfolio as a tool for students to present documentation of theigiacoler experiential learning?

SDG 12 and sustainability education in culinary and hospitality curricula

Sustainable consumption and production education in hospitality and culinary programs has typically been delivered through content addition, inserting waste-reduction or resource-efficiency topics into existing syllabi rather than redesigning learning activities themselves. Liu et.al (2019) demonstrated that environmental

education is most effective in shaping environmental ethics and literacy when it moves beyond declarative content and incorporates experiential and technologically mediated learning. Similarly, Wang (2016) study of green culinary behaviours among hospitality college students found that structured, hands-on cooking exercises were more effective than lecture-based instruction at shifting students' sustainable culinary habits, because they required students to enact, rather than merely describe, sustainability principles. At the level of student behaviour and attitudes more broadly, Weber et al. (2023) cross-sectional study of German university students found that health-promoting and sustainable behaviours tend to cluster together and are amenable to targeted curricular intervention, lending support to the view that structured, food-based learning experiences can shift broader sustainability dispositions, not only technical skill. Within nutrition and health-oriented culinary pedagogy, the teaching-kitchen model has emerged as a parallel strand of practice, positioning hands-on cooking instruction as a vehicle for both dietary and planetary health outcomes. These teaching-kitchen and structured-cooking-exercise models share a common premise with the Plant-to-Plate Challenge: that responsible consumption and production competencies are better internalised through embodied culinary practice than through classroom instruction alone.

Sustainability in pastry arts education

Pastry arts occupy a distinctive position within sustainability discourse because their foundational techniques rely heavily on animal-derived ingredients: butter, eggs, dairy, and gelatine, and refined carbohydrates (Figoni, 2011). Commercial culinary schools have begun to respond with dedicated plant-based curricula that extend farm-to-table and ingredient-sourcing principles into pastry modules, converting conventional baking recipes into whole-grain, less-processed alternatives. At the level of food science, recent work on plant protein as an egg replacer in cookies and cakes shows that the technical feasibility of plant-based pastry reformulation is an active research area (Varshini et al., 2026), providing pastry educators with an evolving evidence base for teaching ingredient substitution. Despite this, pastry-specific sustainability pedagogy as distinct from savoury culinary or institutional foodservice sustainability education remains sparsely documented in the peer-reviewed literature, which is the gap this paper addresses.

Competition-based and project-based learning in culinary vocational education

Competition-based learning (CBL) combines project-oriented tasks with a competitive structure, and has repeatedly been associated with increased learner enthusiasm, deeper engagement in technical problem-solving, and improved retention of the skills being taught (Willard and Duffrin, 2003). Consistent with this, reviews of competition-based education in tertiary institutions point to reliable short-term improvements in engagement and motivation, particularly when competitive elements are paired with explicit, subject-specific incentives and situated within low-stakes, formative assessment environments rather than high-stakes summative evaluation (Willard and Duffrin, 2003). While competition reliably raises short-term engagement (Willard and Duffrin, 2003), the literature also cautions that poorly calibrated competitive stakes can distort learning, either by inflating scores to a point where task difficulty rather than student ability becomes the binding constraint, or by crowding out

intrinsic motivation with high-stakes grade pressure. Work-based and experiential learning research in culinary programs similarly emphasises that clearly defined goals and structured reflection are central to translating hands-on activity into durable competence (Handajani et al., 2024). Engagement research conducted with food and beverage service students further underscores that structured, activity-based learning formats sustain motivation more effectively than passive instructional delivery, a pattern observed even under the constrained conditions of remote and hybrid learning during the COVID-19 pandemic (Estribor and Pagaran, 2022).

E-portfolios as tools for reflective and sustainability learning

E-Portfolios are widely used in higher and vocational education to support the collection, selection, reflection upon, and connection of evidence of student learning over time (Zainuddin et al., 2026; Walland and Shaw, 2022). Ayaz and Gök (2023) found that e-portfolio use positively affected teacher candidates' reflective thinking and learning motivation, while Di Silvestro and Nadir (2021) reported that e-portfolio development fostered reflective and deeper learning among graduate adult education students, describing the process as a bridge between technical documentation and professional identity formation. Taken together, this literature suggests that e-portfolios are particularly well suited to disciplines such as pastry arts, where visual, product-based outcomes can be captured and reflected upon more readily than through conventional written assessment alone, and where digital documentation has become an expected feature of contemporary vocational and higher education practice (McLoughlin and Lee, 2009, 2010).

Materials and Methods

The study is designed as an instrumental, bounded case study (Miller et al. al, 2023) in which a single, richly described instance of pedagogical practice is examined to generate transferable knowledge on principles of SDG 12 and ESD within vocational pastry arts education through a culinary practical class. This design choice draws on the wider Education for Sustainable Development (ESD) literature, which calls for the cultivation of transferable sustainable knowledge, critical thinking, sustainable habits, and collaborative, environmentally-oriented dialogue (Rieckmann, 2018; UNESCO, 2017), and on evidence that competition-based learning, when combined with authentic, industry-relevant tasks, supports internalised knowledge and enthusiasm (Willard and Duffrin, 2003). The case is institutionally bounded and temporally bounded, as it comprised the March 2026 cohort. Since the rubric scores, lecturer observations, and e-portfolio were generated as part of the course assessment, this activity did not require research consent. Students' anonymity is preserved, and results are reported in groups rather than individually. However, students are informed and aware, as the data collection was well documented in still photographs and video clips.

Sampling and stages of the learning experience

Thirty-two students were divided into two main groups (PHM1161A1, n=16; PHM1161A2, n=16), each taught by a different lecturer, and further divided into teams of three to four members. All enrolled students were eligible, and a whole-cohort purposive sampling approach was used, consistent with the intervention's inclusive

design per the study's requirement. The competition week was structured across three progressive stages: Stage 1: Component development - Teams created a plant-based appetiser, main course, or snack using a specified list of ingredients, with the option to add supplementary ingredients within a limited budget. Students were provided with two selected YouTube channels focused on plant-based cuisine to enhance their understanding of plant-based methods and encourage more independent investigation. Stage 2: Full meal design - Full plant-based meal design. Group PHM1161A1 was instructed to prepare two savoury plant-based dishes, while group PHM1161A2 was instructed to prepare "karipap" (curry puffs) with plant-based fillings. Teams were given one week's notice to discuss, plan, and finalise their menus. Dishes were required to be wholly plant-based, with creativity expected in substituting dairy and animal-derived ingredients and components.

Stage 3: Team competition - The competition was timetabled within regular class contact hours during the plant-based-themed week rather than as an extracurricular add-on, keeping participation compulsory and embedded in course assessment. Teams were given four hours to complete mise-en-place, production, plating, and presentation. A panel of four lecturers from both the culinary and pastry arts departments evaluated the dishes, ensuring the criteria covered fundamental cookery standards. Before Stage 3, the panels evaluating the plant-based dishes participated in a calibration session to discuss appropriate rubric criteria and score-point descriptors. Yousef and Ayyoub (2024) suggested rater-training practice in which panellists convened and gained a clear understanding of the rubrics. Subsequently, each panellist scored every team independently, without consulting, to avoid bias and halo effects. Finally, the panellists reconciled the scores and the competition results. The author team developed the three-criterion rubric (*Table 1*) by adapting standard competition-based culinary assessment criteria to incorporate a sustainability dimension, informed by the ESD competency literature (Brundiers et al., 2021).

Table 1. *Plant-to-plate challenge assessment rubric.*

Criterion	1 – Needs Improvement	2 – Acceptable	3 – Satisfactory	4 – Good
Taste & Flavour	Bland, unseasoned, overcooked soft vegetable texture	Unbalanced, little flavour, overcooked vegetable texture	Balanced flavour, acceptable al dente texture; lacks bold flavours	Good, well-balanced flavour and al dente texture
Presentation	Unappealing colour palette, messy plating, lack of care	Mediocre colour and attractiveness in plating	Appetising and neat but standard, lacks a "wow" factor	Good use of natural colours; clean, neat plating with vibrancy
Originality & Sustainability Factor	Poorly executed, without creativity	Mediocre use of plant-based ingredients, little creativity	Acceptable plant-based ingredient dish	Good understanding of plant-based ingredients; good, original dish

Results and Discussion

Participants demonstrated notable enthusiasm and initiative across all three stages of the competition. Given that the participants were in their first semester, it was understandable that their technical proficiency was inherently limited. Nevertheless, the selected YouTube resources appeared to serve their intended purpose of prompting independent exploration. Several teams took the initiative to go beyond the reference material and develop more elaborate flavour combinations and plating concepts than anticipated. The incentive structure was deliberately chosen to be pastry-related tools, albeit modest: cake decorating nozzles and piping bags. *Table 2* displays the culinary creations from each group: Group PHM1161A1 (savoury plant-based meals) and Group

PHM1161A2 (plant-based karipap), respectively. Subsequently, students are required to publish their CBL experience on an individual e-portfolio. Throughout the competition, participants capture the entire process by photographing their experiences during the challenge and uploading them to their e-portfolio. This ensures that they systematically preserve records, reflect on, and showcase their talent resources, as part of a broader digital requirement in higher education (Farrell, 2020; McLoughlin and Lee, 2010; McLoughlin and Lee, 2009). Thematic analysis of the data collected, assessed with Gemini and manual deliberation from participants' e-portfolios, identified three prominent themes. First, all participants documented their cooking process, while four participants went further by demonstrating technical understanding and problem-solving in cooking. For example, one group mentioned layering flavours by infusing herbs into oil. Second, they indicated collaborative identity and affective reward. Narrations in the e-portfolios described the win as "never a solo effort", and attributed it to "the strength of my amazing teammates". Third, the reflections on the e-portfolios lack a connection between the competition activity and environmental issues. Participants largely focused on reporting the experience of creating a plant-based dish as per requirement, without resonating with SDG 12. This provides a better basis for improving the format, instructions, and rubrics for future CBL.

***Table 2**. Plant-to-plate challenge competition results.*

Group	Team	Product	Taste & Flavour (1–5)	Presentation (1–5)	Originality & Sustainability (1–5)
PHM1161A1	1	Pasta salad with sriracha-lime peanut dressing; tofu kimchi jjigae	3	2	4
	2	Napa cabbage with garlic chilli oil; crispy cauliflower	2	3	3
	3	Vietnamese tofu roll; Korean pancake with soy-garlic sauce	3	3	3
	4	*Scrambled tofu on toast with roasted bell pepper, onion, and garlic; zucchini, eggplant, and tomato in infused olive oil	4	4	4
PHM1161A2	1	*Tempe paprika "karipap" with creamy tofu sauce	4	4	5
	2	Spicy creamy coconut milk aubergine and zucchini "karipap" with pepper sauce	4	4	3
	3	Spiced dhal "karipap" with lemon dill sauce	4	3	4
	4	Mushroom, potato, and tofu "karipap" with almond sauce	4	4	3

*Note: *Denotes the teams with the highest score*

The first research question this study explores is the effectiveness of competition-based learning (CBL) in embedding SDG 12 within the pastry arts curriculum. Although SDG12 was introduced to Pastry Arts students through savoury hot cooking in the "Essential Cookery Skills" class in the first semester, the overarching principle of sustainability was nonetheless upheld and left an impression on the students. Furthermore, this CBL supports the broader claim in the ESD literature that sustainable consumption and production competencies are best cultivated experientially rather than through theoretical content alone (Liu et.al 2019; Rieckmann, 2018; UNESCO, 2017). It is noted that espousal of SDG 12 covers many aspects of responsible consumption and production, and plant-based cookery is only part of that broader scope. The requirement

to redesign an entire dish around plant-based substitution, rather than simply learning about sustainability in the abstract, forced students into reasoning orientation and tracing change across flavour, texture, cost, and ecological impact that ESD frameworks identify as a core competency. This aligns with the findings of Wang and Teng (2019) and Wang (2016) that organised cooking activities are a more effective way to change green culinary practices than lecture-based teaching. Secondly, the study investigates the effectiveness of e-portfolio as a tool for students to present documentation of their experiential learning. The e-portfolio component addressed a documentation challenge particular to product-based vocational disciplines: technical and sustainability learning in pastry arts is often embodied in a finished dish rather than in extended written argument. The literature on e-portfolios in higher education indicates that reflective thinking and motivation benefit from digital, often visually mediated, documentation (Ayaz and Gök, 2023; Di Silvestro and Nadir, 2021; Farrell, 2020), and the present case suggests this holds particularly strongly for culinary and pastry disciplines, where a photograph of a finished plate can communicate technical and creative achievement more efficiently than a written description.

Additionally, the e-portfolio functions as a record of technical skills, a journal for sustained ideas, and a professional communication tool, including literacy and self-evaluation with culinary expertise. The e-portfolio also serves as a digital resume for students throughout their diploma tenure, capturing visual representations of their abilities to produce pastry products for future potential employers.

Limitations

The study is not without limitations. As a single-semester case study involving 32 students at one campus, the findings are illustrative rather than generalizable, and no pre/post or comparative design was used to isolate the specific contribution of the competition format, rather than the plant-based content itself, to observed engagement gains. The evaluation also relied on lecturer-assessed rubric scores and qualitative observation rather than validated engagement or sustainability-literacy instruments. Future iterations of the Plant-to-Plate Challenge would benefit from a mixed-methods evaluation incorporating student self-report measures of sustainability competency and engagement, alongside longitudinal tracking of whether plant-based technical skills and systems-thinking dispositions persist beyond the assessed week into subsequent coursework and, eventually, into professional practice. Additionally, further exploration of CBL focused specifically on pastry methods and products is needed, highlighting ingredient substitution and evaluating the outcome in taste, flavour, texture, and overall appearance and presentation.

Conclusion

Three contributions emerge from this case. The course integrates a hands-on, practical approach to plant-based skill development, moving students from brainstorming through to the preparation and production of wholly plant-based dishes. The Plant-to-Plate Challenge, conducted during the plant-based-themed week, functioned as a collaborative, competitive capstone evaluated by instructors, giving students first-hand experience of healthy, low-stakes competition among peers, a format that the literature associates with short-term but meaningful gains in engagement and technical problem-solving when carefully calibrated. The accompanying e-portfolio

documentation aligned technical evidence with reflection on sustainability, operationalising ESD competencies such as systems thinking, strategic reasoning, and interpersonal collaboration within a pastry arts discipline that has been relatively overlooked in sustainability discussions compared with savoury culinary and institutional foodservice literature (Rieckmann, 2018; UNESCO, 2017). For pastry arts educators and curriculum designers, the case suggests that SDG 12 competencies do not require a separate sustainability module to be taught effectively; they can be embedded directly into existing practical coursework through carefully scaffolded, competition-structured, plant-based assignments paired with reflective digital documentation. Future research should extend this single-semester case study into a multi-cohort, mixed-methods design capable of measuring sustainability-literacy gains directly, examining the durability of plant-based technical competence over time, and testing whether the competition-and-e-portfolio model transfers effectively to other culinary and pastry disciplines beyond the single institution studied here.

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Conflict of interest

The authors confirm that there is no conflict of interest involved with any parties in this research study. The idea for this project was also submitted to the Institute for Biodiversity & Sustainable Development, UiTM, for the 3rd Innovation@IBSD2026 event.

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