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Embedding Competencies In Sustainability And Authentic Learning Experiences In Food Science Education Through A Study Program-Driven Approach

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EMBEDDING COMPETENCIES IN SUSTAINABILITY AND AUTHENTIC LEARNING EXPERIENCES IN FOOD SCIENCE EDUCATION THROUGH A STUDY PROGRAM-DRIVEN APPROACH

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ABSTRACT

The food sector is experiencing a substantial shift towards Industry 4.0 regarding technological solutions to ensure efficient and sustainable food production. To face the required changes and be able to influence and change existing systems, future candidates must have solid capabilities in their respective subject areas as well as generic skills such as critical thinking, reflection, communication, and teamwork skills.

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At NTNU, a program-driven approach for embedding sustainability and authentic learning experiences in the bachelor program of Food Science, technology and sustainability was conducted. Thematic groups of staff members developed learning outcomes and learning- and assessment methods to ensure coherence in the study program. Sustainability learning outcomes are built into all program-specific courses. Case- and laboratory-based learning, problem-based learning, projects, and peer-review assessments have been included systematically, in addition to a mandatory internship period, to create authentic learning experiences and stimulate the development of generic skills. A significant action was establishing a course introducing sustainable food production in the first semester. Data from an external periodic evaluation of the study program, national student surveys, and NTNU's candidate survey demonstrate a well-designed study program with high overall satisfaction among the enrolled students. Compared to other natural and technical science study programs, the program scored higher on most parameters related to contact with working life. Furthermore, the majority of the candidates reported that they had developed sustainability competencies during their studies.

1 INTRODUCTION

1.1 Sustainability competencies and authentic learning experiences

Food production has a significant impact on our planet, and a joint effort in education, research, and innovation is needed to secure a sustainable food system to feed future populations. The food sector is already experiencing a substantial transition regarding technological solutions, digitalisation, and automation to ensure sustainable food production [1]. However, as Hassoun, Prieto [2] pointed out, the food industry is still in the early stage of the green transition. Universities play a crucial role in enabling students to develop key competencies for sustainable development [3]. As these competencies do not automatically develop in traditional classroom settings, continuous efforts must be made to develop innovative pedagogical approaches. Critical thinking, creative problem-solving, communication, and digital understanding are highly valued workplace skills [4]. Students must actively participate in their learning through collaborative and contextual activities to foster such generic skills. Authentic learning is debated, and multiple definitions exist in the literature. Brown, Collins [5] describe authentic learning activities as "the ordinary practices of the culture", that is, the culture in which professionals practice their domain of knowledge and skills. For food scientists, the food industry, laboratories, sales, research institutes, and academia are examples of relevant practices. Learning experiences in these environments can be achieved through internships, temporary work placements, and excursions. However, authentic learning also includes learning activities that connect learning environments in academic classrooms with professional environments beyond academia [6]. Learning activities are then constructed to give students tasks from the "real world", which supports students in translating knowledge to more practical real-life challenges [7-9]. Examples of activities include problem-based

learning, case-based learning, project work, and activities stimulating generic skills in broader terms, such as peer- and self-assessment, oral presentations, and teamwork [10]. In the present paper, the term authentic learning experiences are interpreted in its most general sense in which learning is supported by being situated in an environment that aligns learning objectives with real-world tasks, content and context. This interpretation reflects a constructivist view of learning in which students solve real-world problems through collaboration, combining practices and previous experience [10]. Authentic and contextual learning experiences support students' professional identity formation [11], acquiring an appropriate image of their future profession and how they can contribute to influencing and changing the existing food system. The present paper aims to explore and evaluate a program-driven approach to embed sustainability competencies and authentic learning experiences in a Food Science bachelor's program at NTNU.

1.2 Framework

The BSc Food Science, Technology and Sustainability has an annual admission limit of 45 students, accepted based on Higher Education Entrance Qualifications with an additional requirement of subjects in mathematics and science from upper secondary school. Most enrolled students continue directly from upper secondary school without work experience in the food industry. The study program is connected to the Faculty of Natural Sciences and the research group Food Science, focusing on optimal utilisation of raw materials and new resources to produce safe food sustainably. The research group is cooperating closely with the food industry in research projects, making the education foundation base. The study program council includes representatives of staff, students and working life. NTNU has a strategy that all study programs should be of high quality internationally and has developed a quality assurance system for education. According to this framework, every study program undergoes an annual evaluation to ensure that the course portfolio adheres to current regulations and is developed in line with societal needs. A periodical external evaluation should be conducted every five years for the strategic development of the program.

2 METHODOLOGY

2.1 Process of curriculum design

The academic staff of the Food Science research group were engaged in curriculum design through a four-step process led by the study program director (Figure 1). The staff members worked in thematic groups with a mandate to develop learning outcomes, learning activities and assessment methods of the courses within the theme to ensure proper subject strings, including sustainability and authentic learning experiences in the study program. Two stakeholder surveys were conducted to identify a comprehensive title for the revised study program. Relevant stakeholders were

identified as academic staff, students, upper secondary school pupils, industry, and alums. The surveys were distributed via social media, and answers from 996 respondents were collected. The revised curriculum was implemented in the period 2018-2020.

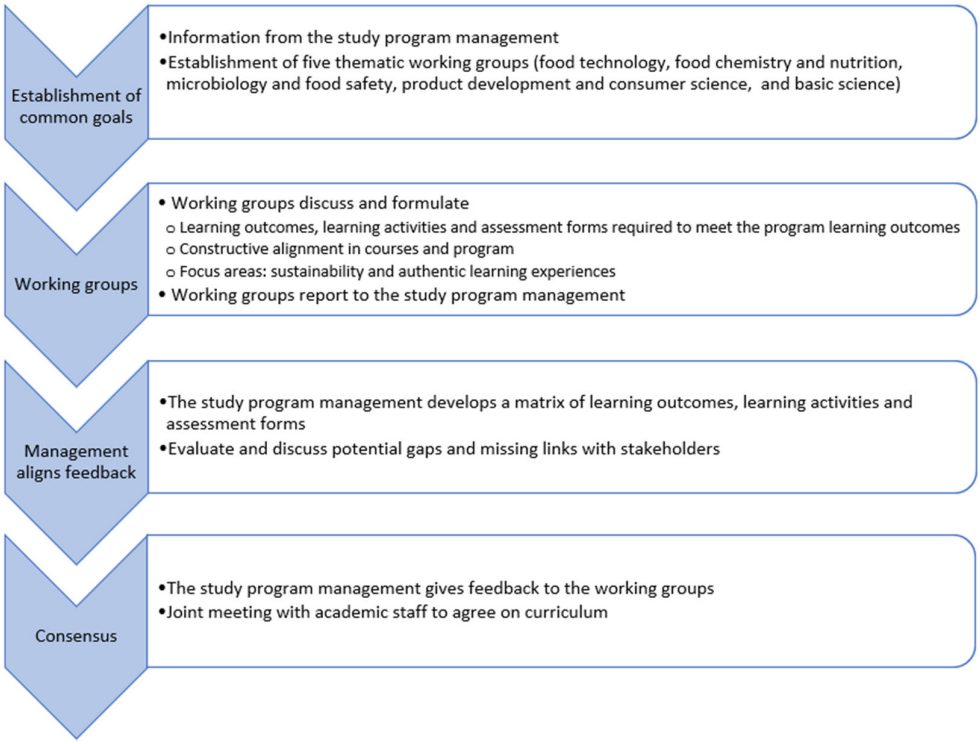

Figure 1. Program-driven curriculum design approach engaging the academic community.

2.2 Data collection for evaluation

A periodical external evaluation of the study program was conducted in 2022 by a committee including two Professors from other Norwegian universities, two industry representatives, two current students and four internal members. A mandate was prepared, and core areas to be evaluated were defined, of which one of these included societal and industrial relevance of the study program and sustainability competencies. Data from NTNU's candidate survey in 2022 were collected, encompassing candidates that finalised their education between 2019 and 2021. Thirty-four candidates with bachelor's degrees in Food Science, Technology and Sustainability conducted the survey. From NTNU as a whole, the number of responents was 8957. Data from the national student survey "Studiebarometeret" for the Food Science bachelor program and comparable study programs in the time period 2019-2022 were downloaded from www.studiebarometeret.no. The survey is sent to more than 70 000 students in Norway each autumn and includes 40 claims divided into eight subject areas.

3 RESULTS AND DISCUSION

3.1 Curriculum development through a program-driven approach implementing competencies in sustainability and authentic learning experiences

Sustainability learning outcomes (SLO) and authentic learning experiences (ALE) were developed in the majority of the program-specific courses (Table 1). A significant action was establishing the introduction course "Food, Processing Technology and Sustainability" in the first semester. In this course, the students are introduced to the food industry and trained in identifying sustainability challenges in the food value chains. Combining lectures, excursions, guest lectures from the industry, group assignments and practical work, students get an overview of the food sector from the beginning of their studies, and they are trained in system thinking, collaboration, and problem-solving. This introductory course is important for building a collaborative learning culture and clarifying the expectations of being an active student. Another important aspect is SLO integrated as part of the internship assignment, so students achieve knowledge on how companies work with sustainability issues in the short and long terms. SLO is also implemented in traditional courses, e.g. food microbiology. In this course, writing a Blog is used to develop a paper on a chosen topic combining microbiology and sustainability, such as antimicrobial resistance within the food production chain, food spoilage, and the use of microorganisms in bioplastic production. By applying Blogs, students and teachers can discuss and contribute to each other's work during the semester in a peer-assessment process. In the last semester, students write a bachelor's thesis. In 2022-2023, 60 % of the theses were related to sustainable food production. Examples of thesis topics were the processing of seaweed, utilisation rest raw materials of food, novel food products and reduced food waste.

ALE is implemented throughout the curriculum through case-, problem- and project-based learning modules. Furthermore, the study program has a one-semester mandatory internship within the food industry or research. A stepwise and systematic training in peer assessment was developed and implemented in the study program, involving two program-specific courses per study year. Peer assessment is an authentic learning experience, reflecting modern working life by training students to give and receive critical professional feedback. Based on the revised curriculum content, academic community discussions and two surveys (996 respondents) conducted among staff, students, alums, upper secondary school pupils and other stakeholders, the study program name was changed from BSc Food Technology to BSc Food Science, Technology, and Sustainability. Academics responsible for more general courses, e.g. maths and informatics, were not included in the process, as these courses are given to a broader group of students representing a high number of study programs. However, the findings of The Technology Studies of the Future [12] stated that the contextualisation of general courses is also critical and must be implemented. Several barriers exist among students and staff to student active learning methods [13], which must be solved to succeed with a curriculum as described in the present paper. Pedagogically competent staff and leadership are of

utmost importance, which stimulates a pedagogical culture of active learning among staff and students. Barriers can also be related to institutional, physical and technological factors, as reviewed by Børte, Nesje [13].

3.2 Evaluation of curriculum

The periodic evaluation committee concluded that the study program is well designed with relevant and well-described learning outcomes and highlighted the employees' strong commitment to development of educational quality and the broad experience with coordinating and leading educational projects. The committee emphasised the strong cooperation between the study program and relevant food actors and industry through cases, specifically through the internship arrangement, where the students are prepared for the working life through contextualisation of previous courses, network building and specific working experience. Although the internship arrangement was acknowledged for its potential as a valuable source of work experience, it was also proposed that students should have the opportunity to engage with different industries enabling them to gain a broader range of experiences and minimise the inherent risks associated with relying on a single business entity for professional development. One measure already implemented to provide students with a broader perspective of the food industry is a mandatory digital interaction between internship students [14], where the students get insight into the work conducted by their fellow students working in other companies. It was further suggested to increase the connection between students and industry through an annual career workshop and to continue and strengthen the already established alum network. This has now been implemented. The committee also highlighted the relevance of the study program design encompassing a large scope of courses and competencies that the industry wants and needs, and they concluded that the students have a solid foundation to build upon when entering the working life, both of knowledge and also competences in laboratory skills, relevant methods, and relevant techniques.

The National student survey during the last four years (Figure 2) demonstrated that students in the study program are generally more satisfied than those in other natural and technical science study programs. The program scored higher on most parameters related to contact with working life than comparable programs. The NTNU’s candidate survey shows that almost 60 % of the candidates that graduated between 2019-2021 started to work after the bachelor's degree, while the remaining 40 % continued studying. Approximately 90 % of the candidates who did start working, had a job within six months. This is slightly higher than other candidates at the faculty of Natural Sciences, where 85 % were employed within six months. The large majority of the candidates reported that they had developed sustainability competencies, such as assessing ethical problems (85 %), assessing cases from different sides (86 %), and having the ability to evaluate (85 %) critically (Figure 3).

Table 1. Sustainability learning outcomes and authentic learning experiences embedded in program specific courses of the bachelor program Food Science, Technology and Sustainability at NTNU.

Semester	Program specific course	Credits	Sustainability learning outcomes	Relevance to Sustainable development Goals	Authentic learning experiences	Evaluation [§]	Relevance to the UNESCO key competencies[#]
1	Food, Processing Technology and Sustainability	7.5	*Know how preservation method, packaging and logistics are related to sustainable food production *Understand what is meant by sustainable food production and identify how the UN's sustainability goals are linked to food production	1-17	*Laboratory work *Oral presentation *Group assignments	WE	System thinking, collaboration, problem-solving
	General chemistry	7.5			*Case-based laboratory work *Peer-assessment	WE	Collaboration
2	Microbiology and Food Safety	7.5	*Know the role of microorganisms in biogeochemical cycles of nature *Know the most important microorganisms associated with food and waterborne disease, and factors that affect food safety	12,3	*Laboratory work *Oral presentations *Group assignments *Peer-assessment	WE	Collaboration
	Food chemistry I	7.5			*Laboratory work *Group assignments *Peer-assessment	WE	Collaboration
	Statistics and Sensory Methods	7.5			*Laboratory work *Group assignments	WE	Collaboration
	Process Technology	7.5	*Can explain generally about process technology and energy turnover in the food industry *Can evaluate and choose methods that provide the best economic, sustainable and process technology benefit	7	*Written exercises	WE	Critical thinking
3	Food chemistry II	7.5	*Can use knowledge of food processes to make adequate choices for how to process raw materials, produce and store food in the best possible way to minimise food waste	12,3	*Laboratory work *Group assignments *Peer-assessment	WE	Collaboration
	Product Development and Sensory Analysis - Craft Brewing	7.5		8,2	*Product development process in team (including laboratory work) *Oral presentations and discussion	SA-G	Collaboration
4	Internship	30	*Know how a company is working to achieve a sustainable production and how they set their goals regarding sustainability *Apply the company's guidelines for sustainable production and achievement of sustainability goals	12,14	*Oral digital presentations *Peer-assessment *Self-assessment	SA-I	Collaboration, self-awareness, critical thinking, problem-solving

5	Food technology - meat and fish	7.5	*Knowledge of how processing of the raw material and processing conditions can be optimised to lower the environmental impact of the end products	12.3, 8.2, 14.7, 14,4	* Practical and theoretical problem-based learning in team *Peer-assessment *Oral presentation	A (40%), WE (60%)	Systems thinking, collaboration, problem-solving
	Food Technology- dairy and plant food	7.5	* Broad knowledge of product quality, as well as an understanding of how the treatment of the raw material affects the quality of the final product *Knowledge of how treatment of the raw material and processing conditions can be optimised to lower the environmental impact of the end products *Convey attitudes regarding the importance of sustainable production where most possible of the ingredients of the raw materials are used for nutritious human food	12.3, 8.2, 2.4	*Problem based laboratory exercises in team *Group assignments *Peer-assessment	WE	System thinking, collaboration, problem-solving
	Food microbiology	7.5	*Can explain how preservation methods inhibit microorganisms and how food preservation contributes to reduce food waste *Overview of the taxonomy and characteristics of the major microorganisms applied in industrial microbiology, as well as microorganisms that causing quality deterioration or food borne disease	12.3, 3	*Laboratory work *Flipped classroom *Group assignments *Peer-assessment	A (20%), WE (80%)	System thinking, collaboration, critical thinking
	Food Safety and Quality Management	7.5	*Broad knowledge of biological, chemical and physical contaminants in water, raw materials and processed food, and which factors can affect food safety (locally and globally) *Knowledge of hygienic barriers for supply of safe drinking water *Knowledge of environmental management systems (ISO 14001 and EMAS)	12.4, 14.1, 6.1, 6.3, 3	Group assignments: *Outbreak investigation log *Theoretical assignment in food safety *Theoretical assignment in quality management	SA-G	System thinking, collaboration, critical thinking
6	Nutrition	7.5	*Can summarise the main essence of the Norwegian dietary guidelines and recommendations for a more sustainable diet *Can provide simple advice for a sustainable diet	3	*Group assignments	WE	Collaboration
	Bachelor Thesis	15.0	*Knowledge of research and innovation as a promoter for sustainable development in the food sector *Critical reflection about own work and use of sources	12, 14, 3	*Oral presentation of thesis in a seminar *Poster presentation	T, OE	System thinking, collaboration, critical thinking, problem-solving

[§]WE (written exam), SA-G (semester assignment - in groups), SA-I (semester assignment - individually), A (assignment), T (thesis), OE (oral examination),
[#]Relevance to the UNESCO key competensies in Education for Sustainable Development

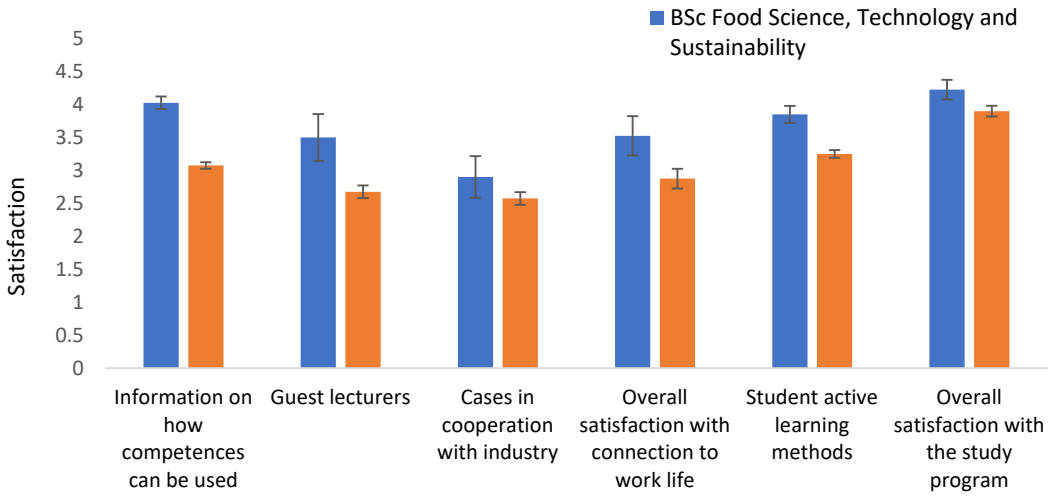

Figure 2 Student evaluation of BSc Food Science, Technology and Sustainability, compared to average evaluation of all study programmes within Natural and Technical Science. Results are presented as average and standard deviations of the years 2019, 2020, 2021 and 2022. Scale (1-5): 1 = Do not agree and 5 = Fully agree

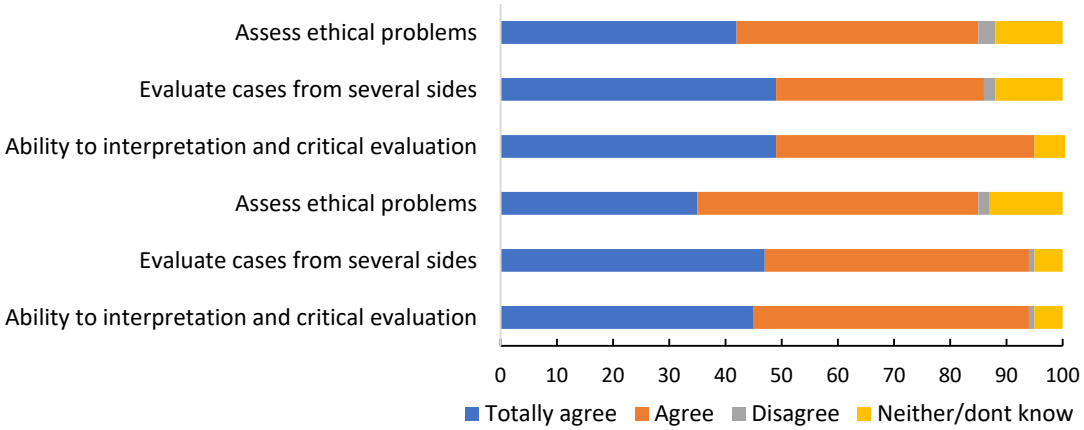

Figure 3 Candidates with a Bachelor of Food Science, Technology and Sustainability degree who graduated between 2019-2021 reported their agreement to claims regarding acquired sustainability skills during education.

4 SUMMARY

Sustainability and authentic learning experiences were successfully integrated through a program-driven process engaging different stakeholders. Curriculum development is a continuous process, and to further strengthen candidates' sustainability competence actions to stimulate interdisciplinarity across the food system educations should probably be emphasised in the coming years.

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