CROSSOVER PROJECT: INTEGRATING SUSTAINABILITY COMPETENCES INTO PROJECT BASED LEARNING

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ABSTRACT
This article describes how the authors applied Education for Sustainable Development (ESD) methodologies obtained in a teacher training to a 3rd year, Project Based Learning (PBL) course in the Industrial Design Engineering (IDE) degree at Elisava. The Crossover Project course presents students with a sustainability challenge that they address in groups (3-5 students), providing mentoring by two Elisava tutors and one external expert in the field of the challenge addressed. This paper focuses on the experiences of tutoring two of the four class groups from the course. In 2024, there were 3 and 5 student groups in each of the two class groups, obtaining results that show the integration of sustainability competencies even though these competencies were not made explicit to the students.
Reviewing the course results, it is possible to understand that Systems, Future, and Strategic Thinking competencies are intrinsic to the design process, even if they are not always framed explicitly to students. It is also clear that a six-week course duration is not enough to achieve full implementation of project solutions.

Keywords: ESD, PBL, industrial design engineering degree

1 INTRODUCTION
The authors were trained in Education for Sustainable Development (ESD) methodologies in the teacher training: *Design an activity to work SDGs in your courses* imparted by UVic-UCC. The ESD methodologies obtained were applied in the Crossover Project, a 3rd year, 12 ECTS, Project Based Learning (PBL) course in the Industrial Design Engineering (IDE) program at Elisava. It is a 6-week, 3-hour/day course that all 3rd-year students take simultaneously, mixing students from the different minors and undergraduate degrees that Elisava offers. The course was already planned as a sustainability-focused PBL task (a common approach in design education), so it was simple to implement the pedagogical tools provided. The aim of the course is to present long-term sustainability challenges, exposing students to the type of projects addressed in design research by multidisciplinary teams, under the theme "It is (still) too late to be pessimistic", which is then divided into four thematic areas: Soul & System, Care & Indifference, Love & Violence, and Bureaucracy & Chaos.

2 IMPLEMENTATIONS OF SDGS INTO COURSES
The teacher training run by UVic-UCC aimed to integrate Sustainable Development Goals (SDGs) into the university's courses. The training was structured with one initial 2-hour online session, held in January 2024, to provide the theoretical framework, followed by three sessions, where teachers would present and get feedback on how they planned to implement SDGs and sustainability into their courses. After these feedback sessions, teachers would run their courses and report the results in an article presented at the final session.
The theoretical framework presented consisted of a general introduction to SDGs, their indicators, and how they are tracked [1][2] followed by a definition of ESD, including the Transversal Sustainability Competences (TSCs) as defined by UNESCO (i.e. Systems Thinking, Anticipatory, Normative, Strategic, Collaboration, Critical Thinking, Self-awareness, Integrated problem-solving) [3]. The session also introduced the "PBL4SDGs Guide: Designing projects to develop the key competencies for sustainability" [4].

The authors who participated in the teacher training were due to impart the PBL Crossover Project course, starting in March 2024. The course was already formulated as PBL with a broad sustainability theme. Being it the first year the course would be imparted, the detailed planning of the activities was yet to be developed, and this was where the input of the teacher training was applied. The PBL4SDGs guide was used by the authors to link the time planning of the Crossover Project course to the general project development stages (see Figure 1).

Figure 1. PBL canvas from the PBL4SDGs Guide, featuring the weekly timeline in red for the Crossover Project course, which overlaps the various phases. The authors also added the Integrated Problem-solving competence to phase 3

3 CROSSOVER PROJECT COURSE

This paper focuses on the experiences of tutoring class group of two thematic areas of the four defined in the Crossover Project: Soul & System and Care & Indifference, where students work in teams of 2 to 5, on a problem they detect within their thematic area and how it was presented to them by their teachers. Class groups are mentored by two Elisava teachers and one external expert in the field related to the topic being addressed. The course is a PBL [5] that runs daily intensively for six weeks (15 in-class hours plus 35 personal work hours per week). The class groups led by IDE teachers followed the same project scheduling and mandatory deliverables, as seen in this work plan:
Research (user and contextual research): 2 weeks
Development (conceptualisation, test, and industrial and business implementation): 3 weeks
Communication: 1 week
These phases are not watertight; they overlap, and on many occasions, depending on the topic, they are reiterated.
On the first course day, the teacher in charge of the Crossover Project course introduces the subject to all third-year IDE students. From Tuesday to Friday, Elisava's teachers provide tutoring and guidance to their students, with planned activities or follow-ups. External experts involved in the course give feedback to the students on Mondays for the remaining five weeks. The last Friday of the course is the project exhibition, during which the students are encouraged to visit the presentations of the other class groups.

3.1 Deliverables and Grading

The evaluation of the four Crossover Project class groups was conducted using a standard evaluation matrix, shared among all the course teachers, specifying the deliverables and their respective weightings, which were:

- Class participation (15%): grades individually the participation in class and group dynamics.
- Design dossier (25%): compilation of the research and contextual information that justifies and supports the proposed design concept, including the following deliveries:
  - User and contextual research
  - Initial value proposal and action plan
  - Ideation and experimentation process
  - Proposed design concept (final value proposal)

- Technical Report (30%): corresponds to all documentation to deliver to the client that has requested this work, including the following deliveries:
  - Technical specifications of the product, system, or service
  - Industrial and business implementation (Business model canvas)
  - Necessary technical documentation such as blueprints, renders, 3d models, etc
- Final public exhibition (30% of the total grade):
  - Prototype
  - Presentation and communication of the project
  - Correct use of design and engineering terminology in English.
  - Selection of the correct media to present the proposal

The teacher training run by UVic-UCC proposed tools to evaluate the TSC students' adoption. Still, the grading system for the Crossover Project was already set up for all four thematic areas, and the authors couldn´t implement those tools to avoid differential treatment between class groups.

3.2 Content of the course introduction and following activities

The introduction to the course to all the four class groups, all third-year IDE students, included the following topics: It presented the theme “It is (still) too late to be pessimistic”, as well as a brief overview of Design for Sustainability approaches and a quick introduction to Systems and Future Thinking. The general introduction linked design research to long-term sustainability challenges and SDGs, presenting a diagram that visualizes how PBL helps to develop TSCs.

The session concluded with a short group exercise to describe something as a system, identifying the elements that made up a given system, its objective, and how these elements were interrelated.

The "Soul & System", group focused on the theme "Water usage". Students selected how to address this challenge based on first-person evidence of their use (or misuse) of domestic water, working explicitly on SDG 6 - Clean Water and Sanitation. For Care & Indifference, the common theme was “Mental Health”, working on SDG 3 -Health and Well-being- and SDG 10 -Reducing inequalities-, and students selected how to address this topic by exploring experiences related to mental health in their immediate environment.

3.3 Group Care & Indifference

In the first session for this class group, each student group selected a specific mental health challenge to work on. Teachers provided a template for an autoethnographic exploration, guiding students to describe two mental health issues close to them. Students were reminded to choose problems they were comfortable sharing.

In the second session, each student’s group established research strategies for the issue they had selected, considering the options within the group members, including reviewing scientific publications and interviewing relevant stakeholders. The two-week research phase aimed to help each group propose a service or product value proposition.

The following two weeks involved testing and iterating prototypes with stakeholders, then one week developing the final prototype, and finally one week designing the communication strategy. Although phases overlapped, all groups completed well-finished projects.

Every Monday, except for the first week, students were mentored by a UVic-UCC professor with expertise in mental health, entrepreneurship and social inclusion [6], whose insights helped them focus on a viable solution.

3.4 Group Soul & System

The Soul & System group was tasked with reducing urban water usage. In the first session, students were told they would have to do an individual task: reflect on their home water use, propose a behaviour change to reduce it, and monitor their progress for three weeks. They created A4 posters of their strategies and shared them in groups, discussing ease of implementation, water savings, and impact on life quality; and collaborate in groups of five to devise solutions.

The second session featured a master class from an external expert from Saneseco, a water and sanitation consultancy [7], who provided crucial insights into urban water and sanitation systems, particularly in Barcelona.

For the group project, students conducted research, identified intervention points in water systems, developed ideas, created prototypes, tested them with users, and documented the process.

4 METHODS AND DATA USED TO INFORM THIS ARTICLE

Both class groups had 15 students, all from the IDE but from different minors. Students from Care & Indifference developed five projects and Soul & System developed three projects (see 5. Results).
As mentioned in section 3.1, the TSC adoption evaluation tools proposed by the teacher training run by UVic-UCC couldn´t be applied, so the authors graded the adoption based on the positioning, attitude, and information provided by the students in:

- The daily follow-up. Tutors provide information on the project theme, guide the research, and provide strategies for understanding, assimilation, and action according to the TSCs.
- Intermediate and Final project dossiers, and exhibition with prototypes (see section 3.1).
- Participation and oral feedback from students.

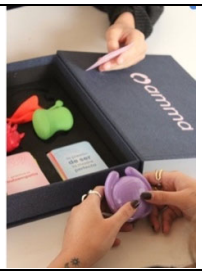
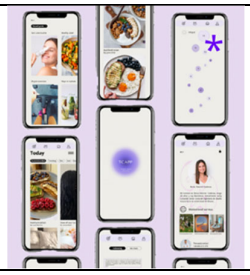
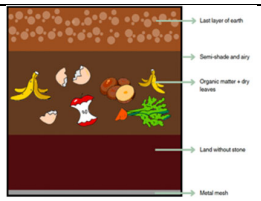
Even the TSC adoption evaluation tools couldn´t be applied, the teacher training proposed to survey students' subjective appreciation of their adoption. Students were asked about:

- Their personal appreciation of the level at which the TSCs have been worked.
- Satisfaction with the relevance of the topics dealt with.
- Satisfaction with teaching methodology, new knowledge, and competencies developed.

5 RESULTS

Table 1 compiles the projects developed by the students in both class groups, Care & Indifference (C&D) and Soul & System (S&S).

Table 1. Projects developed by the students. Description and a capture from the final report.

			
C&I - A Don't forget HD Students: M. Menchaca, and L. Muniz Gomes Wägli. Installation that brings people closer to understand and relate to what it's like living with ADHD and with that, to minimise stigma.	**C&I - Amma** Students: L. Torné, L. Carazo, and M. Jiménez. Card set for individual or group therapy use that "educates", aids, relieves, accompanies, empathizes with, and facilitates communication for women who have (or are at risk for) postpartum depression.	**C&I - Therapist Connect APPlication** Students: M. Fanlo, B. Palomer, and N. Massip Support treatment app for young women suffering from anorexia nervosa thought working on personal motivation with the aim of facilitating their recovery.	**C&I - Disconnect** Students: E. Xirau, O. Pecanins, and E. Sanz A card game designed for teenagers to encourage self-reflection and reduce reliance on social media validation.
			
C&I - Food supply in the Saharawi refugee camps	**S&S - Gotahub** Students: M. Reza, H. Skeidsvoll, M. Moje-	**S&S - Aquafocus** Students: S. Calzada, M. González, R. Haro, J. Mora, and M. Catà.	**S&S - Secoeco** Students: N. Díaz, M. Piera, M.

Students: I. Masdefiol, R. Montplet, M. Salvador, and A. Tarres Book that teaches how to build and maintain a garden, addressing issues such as mental health, basic resources, and education.	O'Brien, A. Fiocca, and A. Somenzi Kit to facilitate the reuse of grey waters from hotels in neighbouring community gardens.	Flowmeter for the shower that allows to see water consumption in real time and set use limits.	Nasarre, V. Mitjana, and P. Alberch. Semi-portable public dry toilet product service system.

The Care & Indifference students demonstrated the Collaboration, Critical Thinking, and Self-Awareness competencies by engaging with stakeholders, patients, professionals, and families. Their ability to understand systemic issues and define intervention levels within Social Ecology [8] highlights their Systemic Thinking and Integrated problem-solving approach. Through feedback from stakeholders, they refined proposals that showcased Anticipatory, Strategic, Critical Thinking, Collaboration, and Self-Awareness competencies.

The *Soul & System* students explored the complexity of urban water and sanitation systems, developing Product Service Systems (PSS) with prototypes and mock-ups to inform users. Their commitment, demonstrated through interviews and surveys with key actors, resulted in outstanding grades, showcasing their dedication.

Overall, both groups showcased strong competencies, engagement, and commitment, demonstrating the effectiveness of the course structure in fostering critical design skills. Educators expressed pride in their achievements, recognizing their capacity to shape meaningful solutions and navigate complex social and systemic challenges.

5.1 Student survey and verbal feedback

The Care & Indifference course students shared feedback on the course structure during the final session, the last Friday. They appreciated the expert Monday sessions and using class hours to do field research allowing them to balance their academic and personal lives. However, they found the progress presentations to the entire class in the initial sessions tedious due to the limited advancements at that stage, despite tutors highlighting their importance for peer contributions. Another concern was the excessive weight of the Technical Report, which required a large effort but had minimal impact on final grades.

Unfortunately, the survey was introduced in the teacher training course after the Crossover Project ended. By then, students were engaged in new courses and showed little interest in responding. The authors insisted and obtained seven responses from the Care & Indifference group.

The survey key highlights are:

- The student's appreciation of the level at which the TSCs have been worked gives the best grades to the Collaboration Competence (4.9/5), followed by Anticipatory and Self-Awareness competencies (4.6/5). Below these are Critical Thinking (4.4/5), Systems Thinking (4.3/5), Integrated problem-solving (4.1/5), Normative (4/5) and Strategic (3.9/5).
- Satisfaction with topic relevance: 4.0/5.
- Satisfaction with the project-based learning methodology: 3.9/5.
- Satisfaction with learning, new knowledge, and competencies: 3.7/5.

6 CONCLUSIONS

Reviewing the course results, we see clear development in all the competences with outstanding results for Systems Thinking, Anticipatory, and Strategic competences. These last three are intrinsic to the design process, as students analyse current situations, envision future scenarios, and develop strategic interventions. Critical Thinking and Self-awareness competences are evident due to the ethical challenges addressed and personal reflections shared. Collaboration competence emerged as students worked intensively in groups and engaged with various stakeholders, enhancing their empathy and understanding.

However, industrial implementation was not fully achieved due to the course's 6-week duration, which limited the possibility of complete interventions. Due to this limitation in the implementation process,

it would be interesting to complete the developed projects through other academic initiatives, such as final degree projects, awards, and incubator projects.

Integrating sustainability challenges into a PBL-based design course has effectively fostered the development of many Transversal Sustainability Competences (TSCs), even without explicitly emphasizing them to students. This approach aligns with common practices in design education, where such competencies are often easier to observe. Moreover, design educators could play a valuable role in supporting professionals from other disciplines in adopting and integrating PBL methodologies into their own teaching contexts.

It remains unclear whether any PBL approach addressing sustainability can achieve this, or whether making TSCs explicit actually supports learning, given that the types of projects differ significantly and it is often complex to assess students' internal learning processes.

Further research on the assessment of sustainability competences is required and will be integrated into future course evaluations by embedding relevant content across various subjects. Looking ahead, it will be important to examine how this aligns with competency-based assessment systems and to test the tools provided by the training run by UVic-UCC that support educators in monitoring the progression and acquisition of sustainability competences among students, and to develop new tools, if needed.

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