# TABLE OF CONTENTS

## Session 1A: EESD Evolution

1A.1  *J. Segalas, R. Drijvers, J. 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Ecological economics and engineering education


Circular Design - adventures in interdisciplinary collaboration and learning for a circular economy

2C.3 Elise M. Barrella and Mary Katherine Watson................................................................. 101

Identifying Imbalances in Sustainable Design Curricula: A Spotlight on Economic Sustainability

Session 3A: European Initiatives in Sustainable Education


The EDINSOST project. Training sustainability change agents in Spanish and Catalan Engineering Education.

3A.2 Kiyohisa Nishiyama and Emanuel Leleito..................................................................... 117

Testing Effectiveness of a Proposed Template for Supporting Multidisciplinary Research Communication in the Engineering Field

3A.3 Nand K Jha..................................................................................................................... 126

Environment, Sustainability, and Mechanical Engineering

Session 3B: Innovative Curriculum for Sustainability

3B.1 Kauser Jahan, Roisin Breen, Patricia Hurley, Erin Pepe, Jiayun Shen......................... 136

Teaching Sustainable Development Using Algae

3B.2 Pritpal Singh.................................................................................................................... 142

A New Course on Sustainable Product Development for Low Resource Settings

3B.3 Elena Tsalaporta, John J. Fitzpatrick and Edmond P. Byrne........................................ 149

Cycling for a sustainable future: Considerations around the Development of a Masters Level Module on Carbon Capture, Sequestration and Utilization

3B.4 Deborah Grubbe............................................................................................................ 158

Enhancing Engineering Education in Occupational Safety and Process Safety

Session 3C: Sustainable Community Development

3C.1 C. Colaux, Y. Beckers, Y. Brostaux, C. Charles, H. Claessens, B. Heinesch, M. Sindic, A. Degré................................................................. 159

Soft Skills: how to make the young engineers aware of their new talents?
Overview of a Whole Systems Multidisciplinary Sustainable Engineering Research Program

Environmental Engineering for Community Development - Engineering Design for Non-Engineering Majors

**Session 4A: Attitudes in Sustainable Education**

**4A.1** Abdullah Atmacasoy, Ahmet Ok, Güvenç Şahin
An Evaluation of Introduction to Industrial Engineering Course at Sabanci University Using CIPP Model

**4A.2** Cory D. Jensen
Piloting the flight, a systems methodology for sustainability education.

**4A.3** Jon-Erik Dahlin, Ola Leifler
Attitudes towards curriculum integration of sustainable development among program directors in engineering education

**Session 4B: The Holistic Engineer**

**4B.1** Michelle K. Marincel Payne and Wayne T. Padgett
Teaching Engineers to Think Appropriately by Thinking Holistically

**4B.2** Salwa Beheiry
Rethinking Curricula to Develop the Holistic Engineer

(abstract only included)

**4B.3** Jennifer S. Mueller
Incorporating a holistic approach to Senior Capstone Design

**Session 5A: Peace Engineering**

**5A.1** Cheryl A. Bodnar, Kaitlin Mallouk and Courtney Faber
Student Approaches to Ambiguity while Working on a Community-Based Design Problem

**5A.2** Iain J. Hunt and Jordan F. Ermilio
Leveraging Experienced Graduate Students to Enhance International Service Learning Programming

**5A.3** Deborah Grubbe
Ethics in Sustainability and Engineering
Session 5B: Sustainable Education

5B.1 Edmond P. Byrne*, John J. Fitzpatrick................................. 242
Embedding sustainability to produce an award winning chemical engineering programme: some challenges and learnings

5B.2 Dai C. Morgan, Edmond P. Byrne*, Susan Nesbit, Naoko Ellis, Kas Hemmes and Javier Orozco-Messana................................. 253
Process, Improvisation, Holarchic Learning Loops and all that Jazz: Experiences in Transdisciplinary Education for Sustainable Development

5B.3 Vivian Neal, Kevin Oldknow, John Edgar, Ivan V. Bajić, Marilyn Trautman and Mehrdad Moallem................................. 262
A New Program in Sustainable Energy Engineering - Balancing subject matter with transformative pedagogies to produce Global Citizens

Session 5C: Sustainable Research: Case Studies

5C.1 Bartlett Jones, Timothy Wilson, Joe Gossen, Bradley A. Striebig................................. 271
Comparing Point-of-Use Water Treatment Technologies for Emergency Response

5C.2 Bradley Striebig and Eric Smits................................. 280
GREET-based comparison of carbon emissions from locally and non-locally sourced food for a college dining hall

5C.3 Zenaida Otero Gephardt................................. 295
Media Loss Minimization in Simultaneous Air/Water Backwash Operations of Gray Water Filtration Systems

Session 6A: Sustainable Education with Industrial Ties

6A.1 Jess Everett, William Riddell, Samantha Valentine, Kevin Dahm, Sarah Zorn, Shalyn Brangman, Robert Krchnavek................................. 296
Project-based learning with a real client: Sustainable Facilities

6A.2 C. Stewart Slater, Mariano J. Savelski, Christian M. Wisniewski................................. 305
Partnering Academia with Industry to Engage Students in Providing Sustainable Solutions for Water Recovery in Food Manufacturing

6A.3 James Porter................................. 313
Ensuring Organizational Sustainability in Today's Challenging Work Environments

(Abstract only included)
Session 6B: Developing a Sustainable Mindset

6B.1  Scott Daniel, Llewellyn Mann ................................................................. 314
       Using a practice-based approach to develop the holistic engineer

6B.2  Katherine A. Whalen, Dr. Tatiana V. Vakhitova .................................... 322
       Creating experiences, not lectures: experiential methods in the context of sustainable development teaching

6B.3  Joseph Stanzione ....................................................................................... 330
       CREATING THE HOLISTIC ENGINEER VIA SUSTAINABLE MATERIALS
       RESEARCH THAT UTILIZES ALTERNATIVE, YET COMMONLY RECOGNIZABLE RESOURCES

(Abstract only included)
The EDINSOST project. Training sustainability change agents in Spanish and Catalan Engineering Education.

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Abstract

EDINSOST is a Spanish R&D+I funded project. The objective of the EDINSOST project is to facilitate the training of graduates capable of leading the resolution of challenges in our society through the integration of sustainability training in the Spanish University System. The project focuses in engineering degrees, given their great impact of engineering graduates on the short-term, and education degrees, in view of its multiplier and long-term effect, because graduates from these courses will be the future teachers of new generations of citizens. The project is organized around four specific objectives:

1) To define the Sustainability Competency Map of each of the participating degrees and establish a framework for incorporating the map into the degree in a holistic way;
2) To validate different didactic strategies for addressing sustainability from a constructivist and community pedagogical approach;
3) To diagnose the status of the sustainability training needs of the teachers of each degree, as well as to develop and test training proposals and
4) To diagnose the sustainability competency level of current university students and to develop and test training proposals.

The EDINSOST project involves fifty-five researchers from ten Spanish and Catalan Universities. This paper presents the results of the project in the field of engineering education. In relation to the first objective it has been defined a sustainability competency map. Based on this map, the most appropriate didactic strategies for sustainability training are been analyzed and tested, the state of the sustainability training requirements in teachers and students are diagnosed, and finally, proposals will be made for training both groups. In this paper, the objectives of the EDINSOST project are presented, as well as early results: the sustainability competence map for engineering degrees, faculty capability and training needs to teach students according to the competence map.

10 Introduction

Sustainability issues are widely recognized as wicked problems (Yearworth, 2016), which should not be regarded as problems to be solved, but rather as conditions to be managed. A general agreement exists about the need to reform the scientific expertise required to deal with sustainability challenges by developing new ways of knowledge production and decision-making. In that sense, Stephen Sterling (2005) maintains that the nature of sustainability requires a fundamental change in epistemology, and therefore in education. As regards technological education, the experience here presented aims at graduating engineers with the
competences stated by the Barcelona Declaration (2004), approved during the Engineering Education for Sustainable Development Conference in 2004.

11 The EDINSOST project

EDINSOST is the acronym for the project "Education and social innovation for sustainability. The training in Spanish Universities of professionals as agents of change to face the challenges of society". The project is funded by the "Spanish Program for Research Facing the Challenges of Society" over the period September 2016 to August 2019.

Fifteen degree courses in the fields of education and engineering are involved in the project. These degrees are taught in ten Spanish Universities (Universidad Autónoma de Madrid, Universidad de Cádiz, Universidad Camilo José Cela, Universidad de Cordoba, Universitat de Girona, Universitat Internacional de Catalunya, Universitat Politècnica de Catalunya, Universidad Politécnica de Madrid, Universidad de Sevilla and Universidad de Salamanca). Fifty-five researchers belonging to the research team and the work team are engaged in the project. The ten universities work on sustainability within the framework of the Sustainability Commission on Sustainability (SCS) of the Conference of Presidents of Spanish Universities.

The EDINSOST research methodology adopts an interpretive approach employing both quantitative and qualitative techniques. The work is carried out in different degree courses at three levels of incidence:

- Six Bachelor engineering degrees and one Bachelor Degree with significant implication in short-term social challenges: the Bachelor degrees in Mechanical Engineering, Design Engineering, Electrical Engineering, Informatics Engineering, Chemical Engineering and Architecture.
- Three degrees related to the three dimensions of sustainability (environmental, social and economic): the Bachelor degree in Environmental Sciences, the Master degree in Science and Technologies of Sustainability and the Bachelor degree in Administration and Business Management.
- Finally, and in view of their multiplier and long-term effect, the project is working on five education degree courses, given that such graduates will be the future teachers of the new generations of citizens: Bachelor degree in Early Childhood Education, Bachelor degree in Primary Education, Bachelor degree in Pedagogy, Bachelor degree in Social Education, Master degree in Secondary Teacher Training and Inter University Master Degree in Environmental Education.

The EDINSOST project has the following four specific objectives:

- Objective 1 (O1): To define the Sustainability Competency Map of each of the participating degrees and establish a framework for incorporating the map into the degree in a holistic way;
- Objective 2 (O2): To validate different didactic strategies for addressing sustainability from a constructivist and community pedagogical approach;
- Objective 3 (O3): To diagnose the status of the training needs, in terms of sustainability, of the teachers of each degree, as well as to develop and test training proposals;
- Objective 4 (O4): To diagnose the sustainability competency level of current university students and to develop and test training proposals.
The scope of this paper is limited to the results in the engineering education degrees in February 2018: Objective 1: Sustainability competency Map and Objective 3 Diagnose of the statute of engineering faculty in relation to the competency map. The results generated by the project will be transferred to other universities nationally through the SCS, and to other universities internationally through its diffusion and transferability plan. An Education in Sustainability observatory will be established to carry out this dissemination.

12 Sustainability Competency map.

The SCS (CADEP-CRUE, 2012) identified four sustainability-related competencies to be developed for inclusion of the ESD in the curriculum.

- C1: Critical contextualization of knowledge by establishing interrelations with social, economic, environmental, local and/or global problems.
- C2: Sustainable use of resources and prevention of negative impacts on the natural and social environment.
- C3: Participation in community processes that promote sustainability.
- C4: Application of ethical principles related to the values of sustainability in personal and professional behavior.

Around those competences and based on previous experiences in developing sustainability competency maps the Sustainability Competency Map for Engineering Degrees was developed (Table 1). This map shows the definition of learning outcomes at three domain levels for each of the competency units.

The Sustainability Competency Map of engineering Degrees defines the learning outcomes in sustainability for students when graduating. Subjects must set realistic goals to achieve these learning outcomes, and these objectives must be developed in different subjects for the entire map to be covered. One of the greatest challenges to the achievement of this objective is the lack of adequate training for teachers in sustainability. The Sustainability Competency Map helps to correct this problem, since it clearly defines the aspects in which teachers must be trained. Objective O3 of the project is aimed at identifying these teacher-training needs. Furthermore, teachers also need help in using the most appropriate educational strategies to achieve the learning outcomes. The purpose of Objective O2 is to define those strategies. The Objectives O3 and O4 are just focused on developing training proposals for teachers and students, including the corresponding rubrics for competences’ assessment. On the EDINSOST project, experts on pedagogy are discussing about the final format of the assessment of the learning outcomes.

With regard to Objective O1, one of the most important results is that the Sustainability Competency Maps developed may easily be adapted to any degree in the university system. This observation may be verified by the fact that the five Engineering degrees involved in the project (Mechanics, Design, Electrical, Informatics and Chemistry), as well as the Bachelor Degrees in Architecture, Environmental Sciences and Administration and Business Management, make up a map based on the one presented in this paper (with very few differences between them, except those related to the specificity of each degree).
<table>
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<th>C</th>
<th>Competency unit</th>
<th>Domain levels (according to simplified Miller Pyramid )</th>
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<tbody>
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<td></td>
<td></td>
<td>1. KNOW</td>
<td>2. KNOW HOW</td>
</tr>
<tr>
<td>C1</td>
<td>Has a historical perspective (state of the art) and understands social, economic and environmental problems, both locally and globally.</td>
<td>Knows the main causes, consequences and solutions proposed in the literature regarding the social, economic and / or environmental problems, both locally and globally.</td>
<td>Analyses the different dimensions of sustainability when solving a specific problem related to the Engineering.</td>
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<tr>
<td></td>
<td></td>
<td>Is creative and innovative. Is able to see the opportunities offered by the Engineering to contribute to the development of more sustainable products and processes.</td>
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<td></td>
<td>Knows the concept of cost of use, direct and indirect, of the products and services of the technologies related to the Engineering.</td>
<td>Is capable of assessing the impact (positive and negative) that different products and services related to the Engineering have in society and in the sustainability of the planet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knows the concept of cost of use, direct and indirect, of the products and services of the technologies related to the Engineering.</td>
<td>Knows how to use techniques that stimulate creativity, the generation of ideas, and manages them in such a way that they become an innovation. Participates actively when used.</td>
</tr>
<tr>
<td>C2</td>
<td>Takes into account sustainability in his/her work as an engineer.</td>
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<tr>
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<td></td>
<td>Is aware that products and services related to the Engineering have an environmental impact throughout its life. Is capable of measuring the environmental impact of the use of technologies related to the Engineering using appropriate metrics (e.g. pollutant emissions, resource consumption, etc.).</td>
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<tr>
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<td></td>
<td>Takes into account the environmental effects of the products and services related to the Engineering in the projects and technological solutions in which he/she participates. Includes in his/her projects indicators to estimate / measure these effects from the resources used by the project (e.g. energy consumption, pollutant emissions, consumption of resources, etc.).</td>
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<td></td>
<td>Takes into account the social impact of his/her work as an engineer.</td>
<td>Knows the problems associated with accessibility, ergonomics and safety of products and projects of the Engineering. Knows the problems associated with social justice, equity, diversity and transparency (gender perspective, needs of the most vulnerable groups, strategies against corruption, etc.). Knows the direct and indirect consequences that the products and services related to the Engineering have on the society.</td>
<td>Knows how to assess the degree of accessibility, ergonomic quality, the level of safety and the impact on society of a product or service related to the Engineering. Takes into account the rights of people in their work as an engineer. Understands the need to introduce social justice, equity, diversity, transparency (gender perspective, needs of the most vulnerable groups, anti-corruption, etc.) in projects of the Engineering. Can assess whether an engineering project contributes to improving the common good of society.</td>
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<td></td>
<td>Is capable of successfully carrying out the economic management of a project of the Engineering.</td>
<td>Knows basic concepts about organizations. Knows the fundamental points of a business plan. Knows the process of managing a project. Knows project-planning techniques.</td>
<td>Understands the different economic parts of a project: amortizations, fixed costs, variable costs, etc. Analyses real planning cases and project budgets.</td>
</tr>
<tr>
<td>C3</td>
<td>Identifies when the sustainability of a project can be improved if it is done through community collaborative work. Responsibly performs collaborative work related to sustainability.</td>
<td>Knows the concept of community collaborative work and its implications in the transformation of society. Knows examples of projects that have been successfully implemented with community collaborative work in the field of the Engineering. Knows the tools of collaborative work in the field of the Engineering.</td>
<td>Given a project in the field of the Engineering, that includes a collaborative community work, is able to assess the implications of such work in the sustainability of the project.</td>
</tr>
<tr>
<td>C4</td>
<td>Behaves according to the deontological principles related to sustainability.</td>
<td>Knows the deontological principles related to sustainability. He is aware that there are laws and regulations related to sustainability in his professional field. Knows the concept of social and corporate responsibility in general and its possibilities and limitations.</td>
<td>Is able to assess the implications of the deontological principles related to sustainability in a project in the field of the Engineering.</td>
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13 Training needs of Engineering Faculty.

In order to evaluate the training needs of Engineering faculty a questionnaire has been validated. The questionnaire evaluates three dimensions of the teaching-learning: competences of the faculty in relation to the competency map (21 questions), pedagogical approaches (20 questions), and teaching practice (8 questions). This paper present the results in the competency dimension.

The questionnaire has been applied to the University of Cordova (faculty population: 211; sample: 26; participation: 12%), Universidad Politécnica de Madrid (faculty population: 2919; sample: 182; participation: 6%) and Universitat Politècnica de Catalunya (faculty population: 3056; sample: 322; participation: 11%) with an overall faculty population of 5196, a sample of 530 questionnaires and a participation rate of 9%.

The questionnaire uses a Likert scale of four levels (Totally disagree, Quite disagree, Quite agree and Totally agree) to statements related to each of the four competences and competency units and evaluating the three levels of the competency. (See example in figure 1)

![Example of question. Question related to Competence 4 of the competency map.](image)

Figure 5: Example of question. Question related to Competence 4 of the competency map.
We are still on the process of analyzing all statistical data. The first results show that most of the surveyed (63%) agree with the statements, therefore they master to a certain extent the competencies, however there is still a 37% of the surveyed that show disagreement with the statements so there is a clear need of training for that sample. The analysis by competences shows (see figure 2) that competence C1 (Critical contextualization of knowledge by establishing interrelations with social, economic, environmental, local and/or global problems) is the most mastered (71% of agreement). The analysis also shows that the competence C2 (Sustainable use of resources and prevention of negative impacts on the natural and social environment), with a 38% of disagreement, is the least mastered.

![Agreement with the statement of the Competence](image)

Figure 2: Results of the faculty assessment in relation to the four sustainability competences evaluated.

### 14 Conclusions

In this paper, the Sustainability Competency Map for engineering degrees, as the initial result of the EDINSOST project, is presented. The map may easily be adapted to any engineering degree.

While a general agreement exists about the importance of sustainability in today's world, and given the need to include it as professional competency for university graduates, sustainability is also one of the most difficult competencies to address in engineering studies, especially if it is holistically approached throughout the curriculum. A tool such as a Sustainability Competency Map, that is easily adaptable to any degree, may prove to be of great help for curriculum designers. The Sustainability Competency Map will enable teacher-training needs, as well as the didactic teaching strategies enabling educators to train their students in sustainability, to be defined, thereby providing them with the competencies defined at the 2004 Education in Sustainable Development Conference.

The analysis of engineering faculty in relation to the competency map shows that there is still around 40% of the faculty members that need training in relation to the sustainability competences analyzed. However we should take into account that only 9% of the faculty answered the questionnaire which we can assume they are the most concerned about
sustainability education and are going to be easily involved in the training. There is still need to analyze the other 91% of the faculty members and diagnose their concerns and training needs.

Over the next two years, the EDINSOST project will continue working on the O2, O3 and O4 objectives, for which the Sustainability Competency Map obtained in Objective O1 and faculty assessment are used as a starting point.

15 Future work

As regards Objective O1, the next step is to compare the curricula of the degrees analyzed in the project with the competency maps introduced herein. From this diagnosis, suggestions for improvements in each degree curriculum will be made to the Spanish accreditation agencies and CSC. The different educational strategies for addressing sustainability, that must therefore be validated in Objective O2, are currently being analyzed by considering each of the competency units of the map and each of the learning outcomes. With regard to Objectives O3 and O4, we are now analyzing the questionnaires of faculty and collecting questionnaires from students. Questionnaires have been designed in accordance to the Sustainability Competency Map. Questionnaires will be surveyed the second semester of 2017 and the first semester of 2018. As a result of the diagnosis, training action plans and educational resources will be developed for both faculty (Objective O3) and students (Objective O4).

Acknowledgments

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References


