INTEGRATING SUSTAINABILITY AND SOCIAL COMMITMENT TRANSVERSAL COMPETENCE ACROSS CIVIL ENGINEERING CURRICULA THROUGH CASE STUDIES AND A COMMON EVALUATION RUBRIC

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Key words: Education for Development, Civil Engineering, Case studies, Evaluation rubric.

Abstract. The Civil Engineering School of Barcelona has a long tradition applying own experiences from international co-operation for development projects to teaching and learning activities. The continuous work carried out in this line has been supported by three pillars: i) motivated lecturers and professors, ii) institutional framework (including support for teaching innovation and Int. Cooperation for Development), and iii) increased networking with Education for Development (ED) partners. This paper presents a number of teaching materials, i.e. Case Studies, developed within an ED initiative supported by the Municipality of Barcelona during 2016-2017. The approach adopted is aligned with the European Global Dimension in Engineering Education (GDEE) initiative. Specifically, seven case studies are introduced, covering from first year of civil engineering to compulsory/master courses. The case studies include different kind of activities, which can be integrated and evaluated within the course, but also under the framework of a common evaluation rubric divided in three levels (basic, intermediate, final). This rubric makes operative the definition of Sustainability and Social Commitment cross-cutting competence at the Universitat Politècnica de Catalunya, UPC (one of the common competencies to all UPC studies). The teaching materials are the result of collaborative experiences of School's students, lectures and professors. Some of them have been already implemented successfully in previous years and others are being tested during the year in course. This paper discusses about drivers and barriers for the development, application and consolidation of these materials.

1 INTRODUCTION

The Civil Engineering School of Barcelona (ETSECCPB) of the Universitat Politècnica de Catalunya (UPC) has a long tradition applying own experiences from international co-operation for development projects to teaching and learning activities [1, 2, 3]. Specifically, in the late nineties, UPC decided to launch a Development Education (DE) program (2000 - 2005) jointly with campus-based groups on co-operation for development [4]. The final goal of this program was to include a stable offer of DE activities specifically designed for engineers and technicians. This was co-ordinately carried out between engineering schools and engineering-focused organizations with links with the international co-operation for development sector (i.e. professional accreditation agencies/associations, non-governmental organizations, international agencies, third countries or privates) [4]. In parallel, UPC and its Co-operation for Development Centre (CCD, for its acronym in Spanish) have actively promoted the involvement of its academic community in co-operation for development activities, particularly through regular competitive calls for development projects, mobility grants and awareness-raising activities.

With this background, UPC has effectively adapted its DE program in the context of Bologna [4], paying special attention to the issue of evaluation by competences. Engineering competences were defined and assessed at various levels: the department, the engineering school, and the university. Their formulation process also included a common set of competences to be integrated in all undergraduate studies. Among them, Sustainability and Social Commitment (SSC) is a cross-cutting competence which is defined as i) the ability to know and understand the complexity of the economic and social phenomena typical of the welfare society, ii) the ability to relate well-being to globalization and sustainability, and iii) the ability to use technique, technology and economy in a balanced and compatible way [5]. The curricular goals are gradually presented in three acquisition levels, in consistency with different degrees of complexity [5]:

- Level 1: Systematically and critically analyse the global situation, addressing sustainability in an interdisciplinary manner as well as sustainable human development, and recognize the social and environmental implications of professional activities in the same field;
- Level 2: Apply sustainability criteria and deontological codes of the profession in the design and evaluation of technological solutions;
- Level 3: Take into account the social, economic and environmental dimensions when applying solutions and carry out projects coherent with human development and sustainability.

In 2013, the University Research Institute for Sustainability Science and Technology at the UPC coordinated the "Global Dimensions in Engineering Education, GDEE" European initiative, which aimed to increase the awareness, critical understanding and attitudinal values of undergraduate and postgraduate students in technical universities related to Sustainable Human Development (SHD) [6, 7, 8]. To achieve this, the focus was on integrating SHD as a cross-cutting issue in teaching activities by improving the capacities of academics and through engaging both staff and students in initiatives related to SHD [9]. This initiative was complemented by the implementation at the local level of two subsequent projects, funded with support from the Barcelona City Council.

The last of these two projects selected and accompanied a reduced group of professors in the effective implementation of the SSC cross-cutting competence, linking this to the global development framework provided by the 2030 Agenda for Sustainable Development [10] and the Sustainable Development Goals (SDGs). The major novelty in the methodological approach adopted was the collaborative definition of a new set of case studies, which were based on a common evaluation rubric, as an easy-to-use tool to implement SSC competence in the classroom. In this process, additional support from the ETSECCPB Teaching Innovation program and the CCD promoted the active participation and involvement of students. This paper presents achieved results, and discusses the main findings and lessons learnt during the process.

2 METHODS

The project promoted the co-development between faculty staff and project staff of case studies, as supporting teaching materials to be used by academics with students in the classroom [2, 6]. In terms of methods, the key implementation steps included:

- Dissemination of the initiative and enrolment of participants;
- Development of six working sessions (two hours per session), including i) theoretical background, ii) design of case studies, and iii) evaluation rubric proposal and discussion.
- Technical and pedagogical support during the design, implementation and documentation (about six months) of case studies.

To support the active engagement of participants, a closed follow up by project staff was regularly performed throughout the process. The project also provided editing services of case studies, including language correction or translation, ISBN registration and open source publication of the materials. Moreover, all participants received a participation certificate to acknowledge their merits during the accreditation of teaching innovation in academic evaluation processes (such as tenure track or similar ones).

3 RESULTS AND DISCUSSION

Case studies (CS) developed as teaching materials are all based on real-life experiences. They provide a practical resource to support students in the acquisition of the SSC cross-cutting competence. Each case study includes the following materials [11]:

- Description of the CS, including an introduction (disciplines covered and learning outcomes), the context - from a Human Development perspective and linked to related SDGs -, two teaching activities and useful annexes;
- Class presentation (in PowerPoint), to assist academics in the classroom with the introduction of the context and the description of teaching activities;
- Classroom activity, designed for a session of two hours. It includes work methodology and one possible solution. The classroom activity seeks to promote debate among students about the topic at hand, and also equips the student with the basic knowledge to carry out the homework activity autonomously;
- Homework activity, with varying teaching loads (ranging from twelve hours to one

semester). For the resolution of the proposed activity, the student will need to apply the technical and contextual knowledge acquired in the classroom;

- Evaluation rubric, as a practical tool to assess the proposed activities and students performance.

In total, seven CS were developed (see Table 1). Apart from the common features detailed above, other specificities define each CS. First, the academic degree covered. Second, the level of implementation as regards the SSC competence (see Table 2). Third, the application of specific software (i.e. Matlab, Autocad, Excel or R). Fourth, the possibility to employ the teaching materials in more than one subject. Finally, the translation of the case study into different languages.

Table 1: Resulted case studies from project implementation

Case study title	Academic degree	SSC[1] level	Specific software	Interdiscip.[2]	Multi-language
Tanzanian's Rural Water Supply and Sanitation Programme: Introduction to Economy and Calculus for Engineering	1	1		□	□
Algebra and Large-Scale Dam Assessment: The Case of Merowe Dam in Sudan [3]	1	1	□		□
Exploring the Use of Recycled Aggregates in Concrete Mix Proportion: An Alternative for Haiti?	2	1			□
Widening Horizons to the Design of a Pre-Stressed Concrete Slab: A Case Study in Barcelona	3	2	□	□	□
Dimensioning a Drinking Water Distribution Network in Collique (Lima): Introduction to the Human Right to Water and Sanitation	4	2			□
Multivariate Analysis and Indices Construction: Data Mining Applied to the Rural Water and Sanitation Sector in Honduras	MSc	1	□		□
Assessing Faecal Flows in Low-Income Countries: The Case of Bure, Ethiopia	MSc	1	□		

1: SSC refers to the transversal competence of "Sustainability and Social Commitment"
2: Interdisciplinary applies for materials which can be used in more than one academic subject
3: This case study was developed by professors of the Applied Math department, within the curricula of Industrial Engineering at ETSEIB, UPC. All the others by professors of the Civil and Environmental Department and within bachelor or master degrees driven by the Civil Engineering School.

One of the salient aspects, as previously mentioned, is the development of a common rubric to evaluate the SSC cross-cutting competence. In turn, this rubric was adapted to the singularities of each CS.

Table 2: SSC competence evaluation rubric proposal. Only maximum degree is shown for each level.

<table>
<tr><th>Dimension</th><th>Level 3</th><th colspan="2">Level 2</th><th>Level 1</th></tr>
<tr><td>Sustainability: Environmental aspects</td><td rowspan="3">REFLECTS critically on the professional practice from the ethical, social, environmental, economic, technical and temporal point of view systemically

INTEGRATING knowledge and information of different nature

DEVELOPING engineering projects consistent with the promotion of human development and sustainability

AND EVALUATING the impact and the direct and indirect social, environmental and economic implications and consequences of the decisions</td><td rowspan="4">LINKING professional practice with such reflections AND PRIORITIZING the alternatives according to all these criteria</td><td>REFLECTS from the environmental, technological and temporal point of view

DESIGNING the solutions or proposals for improvement based on flow analysis (materials, energy, LCA)</td><td>REFLECTS from the environmental, technological and temporal point of view

IDENTIFYING the technical needs (evaluating them environmentally)

AND DESCRIBING the direct and indirect environmental impacts of the decisions</td></tr>
<tr><td>Sustainability: Social aspects</td><td>REFLECTS from the social, technological and temporal point of view

DESIGNING the solutions or proposals for improvement according to the needs of the most vulnerable groups</td><td>REFLECTS from the social, technological and temporal point of view

IDENTIFYING the technical needs (evaluating them socially)

AND DESCRIBING the direct and indirect social impacts of decisions, and integrating the gender perspective</td></tr>
<tr><td>Sustainability: Economical aspects</td><td>REFLECTS from the economical, technological and temporal point of view

DESIGNING the solutions or proposals for improvement based on the direct and indirect economic impacts of the decisions</td><td>REFLECTS from the economical, technological and temporal point of view

IDENTIFYING the technical needs (evaluating them economically)

AND DESCRIBING the direct and indirect economical impacts of the decisions</td></tr>
<tr><td>Social Commitment</td><td>IDENTIFIES the rights and aspirations of individuals and social groups

DEVELOPING projects that explicitly integrate cooperation mechanisms between parties and / or third parties

CONSIDERING criteria of sense of belonging, efficiency, impact, etc.

AND EVALUATING the generation and transfer of technology and knowledge between the parties and with society</td><td>IDENTIFIES the rights and aspirations of individuals and social groups

DESIGNING the solutions or proposals for improvement based on criteria of sense of belonging, efficiency, impact, etc.</td><td>REFLECTS from the ethical point of view

IDENTIFYING social, economic, environmental, technological, geographical inequalities, etc.

PRESENTING historical and political arguments to explain them

AND DESCRIBING links with geographically remote societies</td></tr>
</table>

Table 2 presents the general rubric for the set of dimensions that need to be evaluated, and for three levels of SSC competence acquisition. For each dimension, and for each level, specific attributes are detailed. For simplicity, only the maximum degree of expected achievement is shown.

A grading score is proposed (from 1 to 4) based on the attributes addressed. To illustrate it, for instance, if the dimension of "social commitment" is to be evaluated at level 1, one point is given when the student carries out the proposed activities by considering the ethical point of view. This punctuation would be increased if social, economic, environmental, technological, geographical inequalities are identified within the resolution of the activities. In the same way, if these inequalities are explained by presenting historical and political arguments, an extra point is given. Finally, and in order to get the maximum score, students should complement previous aspects with a description of the links with geographically remote societies.

In other words, the rubric shows the knowledge that students are expected to acquire and the criteria that will be used to evaluate the resolution content associated with the activities proposed. It is worthy to note that students must be provided with the rubric in advance, prior to the implementation of the activities. In doing so, some guidance is given to students in relation to how the proposed activities will be evaluated. The rubric should be therefore employed to define the final punctuation.

It should be mentioned that only the first two levels are addressed in proposed CS. The third level is related to a more extensive work or research, such as the final project of undergraduate studies or master thesis. In order to ensure that the entire cohort deals with the competence on SSC, it should be enough to activate one case study for level one and another for level two in mandatory courses of the curricula.

4 CONCLUSIONS

The project has successfully completed two key deliverables; i) a set of field-based case studies, as supporting teaching materials aimed at integrating SDH in engineering courses, and ii) an evaluation rubric, which puts the SSC cross-cutting competence into a functional framework. A posterior analysis of the experience shows that the academic involvement required for case studies conceptualization, draft preparation, testing and final edition is high. The support of students through collaboration grants although extremely helpful is limited. Incentives for academics received reduced interest (conference fees, granted assistants). The involvement of academics seems more related to personal commitment rather than incentives.

This paper presents an overview of the case studies and a proposal of evaluation rubric to assess the SSC competence. The work done shows that bottom-up proposals can be devised; in concordance with the particularities of the case studies. Each level of the rubric has a specific grading system that is tuned up in each particular application.

We conclude that further work is needed to consolidate the proposal. Previous experiences show that teaching materials evolve in the process of appropriation by lecturers and teachers, as they will then adapt the materials to meet their teaching needs. However, once the first step is done, there are fewer incentives to pursuit in the same direction, and the risk of involution from a teaching perspective increases as it is left to personal commitment of some academics. From an institutional perspective, the development of a strategy for continuous innovation is mandatory to keep sustainability and social commitment close to the core of civil engineering studies.

ACKNOWLEDGEMENTS

We gratefully thank the Ajuntament of Barcelona for its financial support. In addition, it is gratefully acknowledged the support received by the UPC's Civil Engineering School Teaching Innovation Programme and by the UPC's Centre for Development Cooperation. We would like to extend thanks to all students and colleagues who have been participating in material development, supervision and advice.

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