

SASICE: SAFETY AND SUSTAINABILITY IN CIVIL ENGINEERING

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EXTENDED ABSTRACT

The performance of the built environment and the construction sector are of major importance in Europe's long term goals of sustainable development in a changing climate. At the same time, the quality of life of all European citizens needs to be improved and the safety of the built environment with respect to man-made and natural hazards, such as flooding and earthquakes, needs to be ensured. Education has a central role to play in the transformation of a construction sector required to meet increasing demands with regard to safety and sustainability.

In this paper, work in progress of the SASICE (Safety And Sustainability In Civil Engineering) project is presented. The aim of this project is to promote the integration of safety and sustainability in civil engineering education. The project is organised in the context of the Lifelong Learning Programme, funded by the European Community. The coordinator organisation is the University of Bologna. Nine partner universities from different countries are involved in this transnational project. The universities participating to the project constitute a network of high level competences in the civil engineering area, with several opportunities to improve lifelong learning adopting different media: joint curricula, teaching modules and professor and student exchanges. As a response to the challenge regarding new educational methods in sustainable engineering, teaching modules are developed in 4 thematic areas: (1) Safety in construction, (2) Risk induced by Natural Hazards Assessment, (3) Sustainability in construction, and (4) Sustainability at the territorial level. The development of the teaching modules is based on an extensive analysis of the need for highly qualified education on Safety and Sustainability involving all relevant stakeholders (European and national authorities, companies, research institutes, professional organizations, and universities).

The main target is enabling students to introduce these advanced topics in their study plans and curricula and reach, at the end of their studies, a specific skill and expertise in safety and sustainability in Civil Engineering. With our natural resources fading away and our infrastructure in dire need of repair, new trends and challenges in civil engineering education in the concept of "Sustainable Development" are needed to be addressed.

KEYWORDS

Civil Engineering, Engineering education, Safety, Sustainability, Natural Hazards, Risk

1. INTRODUCTION

1.1 Need for Safety and Sustainability

The built environment is a vital part of any society. Since planning, designing and maintenance of the built environment (roads, bridges, dams, buildings and supply systems) are more or less related with human health and environmental protection, safety is an important aspect for engineers. In the past, communities focused on enforcement of structural design and related legislation for avoiding loss of life and property damage. For many years this thought was the priority in civil engineering projects. Recently, new approaches concerning risk prediction and mitigation are applied. These are known as risk-based approaches. The target is anticipating social-economic disruption and environmental degradation as well. Furthermore, in the last decades, the concept of sustainability came into focus. According to the Brundtland Report (Brundtland 1987) a broad definition of sustainability is to meet the needs of current generations without infringing upon the needs of future generations or compromising their abilities to maintain a similar standard of living with minimal environmental degradation (ASCE 2006; Institution of Civil Engineers 2006; The Hong Kong Institution of Engineers 2006). Due to the complexity of the concept of sustainable development, a multidisciplinary collaboration is required. The variety of interactions between all aspects of society and environment make the whole process really difficult.

Civil engineering, has to be sustainable by balancing the economical, social and environmental objectives. One of the factors that have most impact on the levels of regional sustainability is education (Velasquez,1999). Sustainable Development should be addressed as a holistic issue but higher education is organised by disciplines which has led many academics to become "disciplincentric" (Velasquez and Munguia, 1999). One of the main problems, which must be overcome, is the assumption that environmental issues should be addressed by environmental specialists and not civil engineers (Cortese, 1997). Engineering students should enhance their environmental capability and integrate sustainability in designing and construction. The holistic approach comprises a wider knowledge base in the social, political, and life sciences in addition to physical sciences and mathematics. It has to furnish students with the ability to analyze, comprehend and understand the multi-dimensional aspects of sustainable development problems (Chau, 2007).

1.2 Related work

In the USA, very few programs and courses on sustainability engineering are provided. As the interest in integration of sustainability into civil engineering education was growing, more initiatives derived from interdisciplinary engineers and practitioners were financed. Most of them focused on the undergraduate curriculum. A special issue on "Sustainability in Civil and Environmental Engineering Education" was published in April 2011 by the American Society of Civil Engineers (ASCE) in the Journal of Professional Issues in Engineering Education and Practice, in order to compile many of these initiatives into a single issue. The special issue starts with a forum titled "Intelligent Sustainable Design: Integration of Carbon Accounting and Building Information Modelling," by Stadel et al. (2011). It focuses on integrating life-cycle assessments and building information modelling through the example of a very difficult and important sustainability issue: carbon accounting. The issue then expands to a series of technical papers, each addressing the incorporation of specific sustainability topics into courses or evaluating sustainability learning techniques (Haselbach, 2011).

Safety and sustainability issues are on the top of interest in Europe, too. Sustainability has been addressed to varying degrees since the publication of the Brundtland Report

(1987). The European Civil Engineering Education and Training (EUCEET) Association contributes to implementing, improving and extending the curriculum by supporting activities such as new partnerships between universities and stakeholders, joint degrees at various levels, new learning techniques and multi-disciplinary programmes of education. In general, more and more initiatives aim to enable European engineering students to learn how engineers can contribute to the existence and sustainable development of society. The need for ensuring human and environmental health in an affordable and economically feasible way, intensifies the importance of providing funding to improve decision-making processes. For this purpose, the European Union sponsors a variety of Educational Programs such as the Lifelong Learning Programme (LLP).

1.3 The goal of the paper

This paper addresses the context and main activities of the Safety And Sustainability In Civil Engineering (SASICE) project which is funded by the EU within the framework of the European Lifelong Learning Programme in order to promote the integration of safety and sustainability in civil engineering education. The project is organised in five parts (a) the analysis of the needs in close consultation with all stakeholders, (b) the development of teaching moduli on safety and sustainability in civil engineering, (c) the integration of the teaching moduli in existing and new joint university curricula, (d) the pilot implementation of the moduli with an international exchange of professors between Universities and (e) the development of innovative Information and Communication Technologies (ICT)-based content and services.

The following sections present the content of the project and the way that students could benefit from the whole process. The students will be reached through the academic plans of the partner universities, with the main emphasis on current internationalization programs in the area of civil engineering. Within the framework of the project, it will also be verified how students with different backgrounds and formations are able to develop a specific knowledge on safety and sustainability. Students enrolled in existing programs at the partner universities will also be admitted to the courses to provide them with the opportunity of an "internationalisation-at-home" experience.

2. DESCRIPTION OF THE "SASICE" PROJECT

2.1 Members of the project

Nine partner universities from different countries are involved in this transnational project. Table 1 gives the participants and their countries of origin. The coordinator organisation is the University of Bologna in Italy. The project commenced in October 2010 and has a timeframe of 36 months. The universities participating to the project constitute a network of high level competences in the Civil Engineering area. The partner universities have been selected in order to meet at least two of the following three criteria: 1) a long tradition in internationalization activities; 2) a high number of students that will primarily benefit from the project results in their studies; 3) specific competences in more than one area of safety and sustainability in Civil Engineering.

Moreover, these universities are located in different countries, covering the different geographic and cultural areas of Europe. All the partner universities have the internationalization projects as a strategic priority, and some of them already have Master courses taught in English in collaboration with European or US partners, with very high level quality of education. The partner universities also have a long tradition in working together in different areas of Civil Engineering, as documented by the projects funded by the European Community where the partners are often involved.

Table 1: List of partner organisations

Partner no	Organisation Name	City	Country
P1	UNIVERSITY OF BOLOGNA	BOLOGNA	IT-ITALY
P2	ARISTOTLE UNIVERSITY OF THESSALONIKI	THESSALONIKI	GR-GREECE
P3	INSTITUTO SUPERIOR TECNICO	LISBON	PT-PORTUGAL
P4	KATHOLIEKE UNIVERSITEIT LEUVEN	LEUVEN	BE-BELGIUM
P5	UNIVERSIDAD DE CANTABRIA	SANTANDER	ES-SPAIN
P6	UNIVERSIDAD POLITECNICA DE VALENCIA	VALENCIA	ES-SPAIN
P7	UNIVERSITE JOSEPH FOURIER GRENOBLE	GRENOBLE	FR-FRANCE
P8	UNIVESTITY OF PAVIA	PAVIA	IT-ITALY
P9	UNIVERSITY OF SOUTHAMPTON	SOUTHAMPTON	GB-UNITED KINGDOM

2.2 Aims and Objectives of the project

Society, institutions, employers, enterprises and organizations, recognize the need of a highly qualified education in the area of Safety and Sustainability in Civil Engineering developed at the European Community level. Several EC initiatives in education allow students to obtain experience in foreign universities, but often the different methods of teaching and performing of design activities necessary in civil engineering education do not allow full competence to be achieved in design methods in the foreign country. For this reason, some European universities have started joint educational programmes with bilateral agreements. However, collaboration between a larger number of universities, representing the different technical approaches to civil engineering is more desirable.

The present project starts from the real needs of higher education on safety and sustainability in civil engineering to develop teaching moduli making use of the high technical and teaching expertise of the partners. These moduli will be the starting point for a real joint curriculum where the technical contents can be taught in different Universities, adopting the same criteria for the evaluation of the students. It will then be possible to see how these moduli can consider the specific technical traditions of the universities, and to compare the performances of students in different countries. Very innovative ICT-based techniques will be also used to help the partner universities to share the contents of the teaching moduli and make them available to the students. Some universities (e.g. Bologna, Leuven and Southampton) have already started to use these media with exceptional results from the educational point of view.

The teaching moduli refer to four thematic areas: (1) Safety in construction, (2) Risk Assessment induced by Natural Hazards, (3) Sustainability in construction, and (4) Sustainability at the territorial level. Development of the teaching moduli is based on an analysis of the need for highly qualified education on Safety and Sustainability involving all relevant stakeholders (European and national authorities, companies, research institutes, professional organizations, and universities). Maximum use will be made of experience and know-how available in organizations such as the European Network for Building Research Institutes (ENBRI), the International Association of Bridge and Structural Engineering (IABSE) and the European Society for Engineering Education (SEFI) which has a task force dedicated to Sustainability in Engineering Education. During the course of the project, three different ways of implementing these teaching moduli will be examined. The first option refers to the introduction of the moduli into

existing curricula of partner universities. The second option concerns the development of a joint engineering curriculum, and the last one involves double curricula leading to a double degree. In order to support the development of joint and double curricula, much emphasis will also be given to the development of appropriate ICT support.

3. WORK PACKAGES

The long term objective of achieving a more sustainable and safer built environment is reached through twelve work packages which support the SASICE project activities as given in table 2. Each partner is responsible for one or more Work Packages (WP) in collaboration with the other partners of the project. The first WP includes the initial planning, the management and the monitoring of the project. Bologna co-ordinates the whole project and shares with the partners the defined plan. Bologna will monitor also the activities that foresee multilateral co-operation among the partners and the creation of an open environment for discussion and decision making.

Table 2: Summary of Work Packages N°

Work package N°	Type of work package	Title of work package	Lead partner	Start	End	Total days
WP1	Management	Management of the project	P1	1	36	85
2	Dissemination	Dissemination of results during the project	P2	13	36	17
3	Exploitation	Exploitation of the project results	P6	19	36	18
4	Quality Plan	Quality Assurance programme	P5	13	36	20
5	Development	Needs in Europe of highly qualified education on Safety & Sustainability in Civil Engineering.	P4	1	6	24
6	Development	Teaching moduli: Safety in Construction	P9	7	24	15
7	Development	Teaching moduli: Natural Hazards and Management of Risk	P2	7	24	15
8	Development	Teaching moduli: Sustainability in construction	P1	7	24	15
9	Development	Teaching moduli: Sustainable Development and Environmental Protection	P7	7	24	15
10	Development	Development of innovative ICT-based content and services	P4	19	36	15
11	Development	Administration phase – Development of bilateral agreements	P3	13	24	26
12	Development	Teaching safety and sustainability: A pilot project	P8	25	36	18

The dissemination activity is part of the second WP, with a continuous diffusion of the results, supplemented by related workshops. The target groups that will benefit from that

activity are: 1) the partner Universities involved in the project, 2) other Higher Education (HE) Institutions in Europe and Institution Associations, 3) Existing networks in which the partners are members, 4) Universities outside Europe, 5) public and private enterprises in the Civil Engineering area, 6) the students participating in exchange programmes. The dissemination mainly concerns: a) the analysis of the needs of HE with regard to Safety and Sustainability in civil engineering, b) the proposed teaching moduli and the joint curricula and c) the agreed criteria for the student grading. The aim of the dissemination activity is to inform these target groups of the need for new training methods on the emerging fields of safety and sustainability in civil engineering and the ongoing results of the project.

As far as the exploitation strategy is concerned, it will mainly take place during the last part of the project in the context of WP3. The fact that other universities could positively and freely exploit the results of the project is a key point of the project. Particular interest will be taken in opportunities to export the results outside Europe, with the possibility of proposing, in the future, joint curriculum programmes with US and Asian universities. The development of flexible moduli to be included in different learning paths and contexts would make it easier to exploit the results in a wide spectrum of HE institutions. The needs for legislative or technical changes to facilitate the development of joint programmes in higher education, to improve student or teacher exchange and services for international students will be submitted to the main actors of the process (University administrations, Ministries of Education and of Foreign Affairs) and other universities in Europe. Comments and suggestions will be included in the Final Exploitation Report. Finally, the project supports the creation of an international open community discussing the learning needs on Safety and Sustainability in Civil Engineering in a European context. This spontaneous community will promote new opportunities for further exploitations.

WP4 deals with the implementation of a quality control system (AQS) that will monitor the overall process of development of joint study programmes in civil engineering. The project partners will carry out an "intermediate evaluation" and a "final evaluation" of the project. The AQS strategy is based on the evaluation of all the project phases and in particular: 1) of the project management, 2) of the project activities, 3) of the overall results. The tools which will be used for the quality evaluation are specific evaluation grids (both quantitative, e.g. questionnaires and qualitative, e.g. interviews and focus groups) that will be prepared by 4 internal experts and validated by the quality board. It will be used by the local coordinator in charge of the evaluation activities in each university.

The main objective of WP5 is to define the needs for the integration of safety and sustainability in Civil Engineering education. Given the important economic and societal consequences, these topics must be developed at a European level. As for safety, the application of the Eurocodes for design and the complexity of the major civil engineering projects are creating opportunities for joint collaborations between companies in different European countries. Safety targets are very important also for existing structures (cultural heritage), which need to be established at a European level. With regard to sustainability, it is fully recognised that the application of energy saving techniques in construction often requires initial investments at government level, which must be co-ordinated at a National and European level to be sustainable from an economic point of view. Sustainable development and environmental protection are closely interrelated and European recommendations for the environment, water and coastal zones must be taken into account. The increasing demands with respect to safety and sustainability require a new class of specialized civil engineers with both technical and management competencies developed at the European level. It is particularly important in the Civil Engineering

context, due to the Lisbon agreement of the recognition of the University degrees. The analysis will be carried out in close consultation with the professional world (construction companies, design offices, etc.). Quantitative (surveys and official statistics) and qualitative (personal interviews with leaders) data will be collected and analysed for the design of competences and university programmes. Maximum use will be made of know-how available in organizations such as ENBRI, IABSE, and SEFI. The final outcome of the needs analysis will be a general and detailed report on the needs and expectations that will serve as a guideline for the development of the teaching moduli in WP6-WP9.

Within WP6, the needs underlined in the analysis performed in WP5 are used as the starting point to develop a series of teaching moduli in the area of safety in construction, where the areas of Structural and Computational Mechanics, Structural Engineering and Geotechnics will mainly contribute. Presently, design codes require constructions to be designed in order to satisfy given levels of safety with respect to some performance criteria. For new constructions, these requirements are clearly stated in European codes for design (Eurocodes), whereas for existing constructions, the criteria for assessment and for design of strengthening interventions are not uniform across European countries. Existing constructions include residential and commercial buildings, bridges and retaining walls, and some are of historical and cultural importance. They can be very sensitive to actions such as earthquakes and to the effects of pollution and climate change if they have not been designed with respect to them. The modern sustainability agenda is leading to a drive to refurbish and extend the life of existing constructions rather than demolish and replace them. Hence, knowledge about the safety, assessment and strengthening of existing constructions should be shared across Europe and with the next generation of civil and structural engineers.

In WP7, a teaching module concerning Natural Hazards and Risk Management is to be prepared. Geological, hydrological and meteorological events such as volcanic eruptions, landslides, floods, tsunamis, earthquakes and snow avalanches cause loss of life and economic damage every year. To predict, manage and communicate the hazards associated with such geophysical events, a clear understanding of their physical nature is required. Explanation of disasters' causes and impact involves understanding not only of environmental hazards but also diverse social, economic, cultural, institutional and other factors which shape vulnerability. Theories of social vulnerability and protection, sustainable development and disaster risk management, the causes and consequences of natural disasters, and decision-making processes and interventions to reduce disaster risk will be presented. The linkages between hazards, vulnerability and disasters, and the factors affecting the governance of disaster risk management will be examined.

The module will be structured into two main categories: (a) Physical Processes and (b) Integrated Risk Management. The first covers the physical processes of extreme events. Basics from meteorology, hydrology, economics, engineering and planning sciences will be mapped out. The second deals with risk analysis (hazard determination, vulnerability determination and risk calculation), risk evaluation and mitigation within a system of an integrated risk management.

WP8 deals with the development of teaching moduli in the area of sustainability in the construction process, where the areas of structural engineering and infrastructure engineering will mainly contribute. Sustainability can be improved throughout the construction process, from the material production, to the impact of the construction techniques on the environment, to the energy efficiency of the final construction, to its durability during time. In the teaching moduli, these aspects will be considered, and quantitative techniques and protocols to quantify and certify the sustainability of a construction, such as the Athena or the ITACA protocols, or the LEED system of

certification of the United States Green Building Council (USGBC) will be studied. Sustainability is a problem that cannot be faced at a national level only, because the positive consequences on the environment of a sustainable construction/technique often can be recognized at a very large scale (typically transnational).

Within WP9, teaching moduli in the area of Sustainable Development and Environmental Protection will be developed. The areas of hydraulics and hydrology, geotechnics, transportation and highway engineering will mainly contribute. The concept of sustainable development (SD) has rapidly emerged as an approach similarly advocated and criticised by local and international organisations, broadly described as an envisioning strategy to save the earth for future generations. A central concern of these moduli will be to give a critical understanding of the SD debate and practice, unveiling the political, social and economic forces underlying environmental conflicts and exploring concrete approaches to address their causes. The moduli will adopt a European and international comparative perspective, exploring the specific conditions for intervention in different contexts.

Some of the contents of the teaching moduli will be supported by the use of ICT-based contents and services, in order to facilitate the effectiveness of the teaching activities of the partner universities. This process is organised through WP10. The main support will be the recording and webcasting of lectures from selected teaching moduli. This may take the form of live webcasting, where particular lectures are recorded and broadcast live so that students from different universities across different time zones can participate simultaneously, or as a library of recorded lectures which can be browsed by the student retrospectively.

Several technologies already exist across the partner universities that could be used or adapted for the needs of WP10. The University of Southampton has a system for recording a lecture and making it available as a webcast with the lecture notes integrated. A range of electronic devices can access the material (PCs, smartphones, etc.). Southampton has also innovated in the use of interactive video as a teaching aid, in the context of health and safety awareness and road safety, in which students are asked to view video footage and select on the screen where health and safety risks are seen to occur (Hammond et al., 2011). The system has the advantage that immediate feedback can be given, and could be extended to the topic areas of structural safety and environmental sustainability. Another webcasting system already available at the University of Bologna (<https://podcast.unibo.it/>) and extensively used by leading universities in the world (Stanford Univ., Berkeley Univ, MIT, Cambridge Univ. etc) could also be used. Using any of these distribution media, videos of lectures in other partner universities will be made available to the students, who will then be able to participate in a virtual European class. Some of the recorded videos will also be distributed via social networks and other similar media (You Tube, Facebook, etc.), which are more and more used by leading universities to increase the diffusion of their media contents.

The regulation for degrees of civil engineering (CE) in the partner Universities will be studied in WP11 to work out the possible ways to introduce the teaching moduli the teaching moduli on safety and sustainability developed in WP6-WP9. Three ways of increasing level of integration will be analysed: a) the introduction of these moduli in the curricula offered by the partner universities, b) a joint CE curriculum, offered by some partner universities, along side the regular curricula, devoted to safety and sustainability problems, c) joint competences with development of double curricula between the partner universities, with final achievement of a double degree by the student. In case b), the teaching moduli will be interchangeable among the universities, and adapted to the student tracks according to the university traditions. In case c), the achievement of a joint degree will require the fulfilment of 60 ECTS points in each of the two universities to

complete the Masters programme. The curricula may need to be submitted to national quality agencies for an external evaluation. WP11 also includes development of procedures for student selection, mobility rules, credit transfer and Diploma Supplement contents.

WP12 will be a pilot project developed in the final year of the SASICE project, where the universities involved in WP10 and WP11 will teach the moduli developed by the network in a co-ordinated manner. A teaching plan will be prepared, with professors going to give lectures in foreign universities. To this purpose, some moduli considered as key outputs of the project will be selected and taught at several universities. In the courses, mid-term tests, final exams and homework will be given to the students in the same manner, and evaluation criteria established and agreed by the partners will be applied to give the student scores. At the end of the courses, the quality assurance of the teaching level will be monitored with student questionnaires. Having foreign professors to teach the moduli in their own university will be a good opportunity also for the students that do not plan a mobility experience to have an interesting internationalization-at-home experience.

3. OUTPUTS AND RESULTS

The impact foreseen through the development of this project will be enhancement of higher education in the area of civil engineering in Europe, but should also have important consequences in other areas of engineering (Mechanical Engineering, Information and Communication Technology, etc.), where analogous methods of teaching and student mobility criteria can be adopted. The impact of the pilot projects where professors will go to teach the moduli in partner institution should be very high not only for the students following the educational program, but also for the entire Faculties of Engineering of the partner universities.

Moreover, these activities will enhance students and staff mobility, sharing of teaching learning experiences, conformity on joint competences and modules, assessment and evaluation criteria, and agreement on internal procedures for quality assurance. It is the reality of working together at a European level and according to European patterns.

Students should have the opportunity of achieving a joint Master degree on Civil engineering and improving their language skills and competence for intercultural relations. Departments should be able to enrich their teaching, research and management experience by sharing and debating during the development of the project. Multilateral relations among European partners could increase the formation of a common identity for European education by co-operation and collaborative work. The new generation of professional engineers which will be formed with deeper knowledge in safety and sustainability will then have a great impact on the society and the economy in the civil engineering sphere.

The partner universities presently have several partnerships in European research projects and all have a strong interest in collaboration in teaching activities. Once a solid base for the integration of safety and sustainability has been provided by this project, it will be easy to continue in the following years with professor exchanges to teach and refine the teaching moduli. Some of the partner universities are presently introducing joint curricula in their regulations, and these collaborations will help to arrive at a stable and durable collaboration between the universities. For five years after the end of the project, a series of workshops will be held annually at one of the partner universities, mainly involving students and stakeholders, to verify how a wide expertise on safety and sustainability topics in the civil engineering area may open new job opportunities and be

an important resource for a actual integration of the different technical cultures of the member states.

4. CONCLUSIONS

The SASICE project which is part of the EC Lifelong Learning Programme will contribute to a more competitive Europe. The programme focuses on issues concerning education in civil engineering in different regions of the EU and how to form a new generation of civil engineers with a deep knowledge on safety and sustainability problems, assessment and design methods and guidelines adopted in different European countries, thus striving to achieve the Lisbon agenda goals. The consortium is formed by universities representing very different regions of the EU with diverse social models, so providing a unique experience for education and research for future students, as well as new employment possibilities after graduation.

The development of teaching moduli developed together by universities from different countries and with traditionally different methods (inductive vs deductive methods) has the goal of experimenting with novel techniques for academic teaching. Joint degrees contribute to putting into evidence university excellence and European competitiveness. The quality control guarantees excellence in teaching and research supervision, sharing their expert knowledge. The programme will contribute to the quality and visibility of European higher education through implementation of a well-defined joint curriculum offered jointly by some of the partners.

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