Learning Engineering With EPS@ISEP

Developing Projects for Smart Sustainable Cities

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Abstract—This paper presents an overview on how the European Project Semester capstone programme offered by the Instituto Superior de Engenharia do Porto (EPS@ISEP) fosters learning by challenging engineering, business and product development undergraduates to address sustainability issues afflicting cities and communities nowadays. This will be done by analysing the reports and the learning journey of three multicultural and multidisciplinary EPS@ISEP teams during the design, development and test of a smart billboard, a self-oriented solar mirror and a level monitoring system for waste oil bins. These three projects were conducted within EPS@ISEP, a project-based learning framework dedicated to the development of key engineering skills, namely multidisciplinary teamwork, intercultural communication, ethical and sustainability-oriented problem-solving. The involved students contributed, not only, to make cities more inclusive, safe, resilient and sustainable, one of UNESCO's sustainable development goals, but learnt and practiced together sustainability-driven design, while searching for an innovative solution for a smart city problem. This conclusion is supported by the analysis of the content the three project reports.

Keywords—Engineering education, capstone programme, project-based learning, teamwork, smart sustainable cities, education for sustainable development

1 Introduction

In many schools, senior-level capstone courses have been developed to bring the practical side of engineering design into the engineering curriculum. Such courses provide an experiential learning activity in which the analytical knowledge gained from previous courses is joined with the practice of engineering in a final, hands-on project [1]. The European Project Semester (EPS) is an engineering capstone programme provided by a network of 19 European higher education institutions[1]. The programme was designed by Arvid Andersen for engineering students, however, students from other disciplines, such as product design and business, may also participate [2]. The key elements of the EPS concept, also known as the 10 Golden rules of EPS, are available at the EPS website[2]. EPS adopts collaborative, experiential, project-based learning methodologies. It exposes students to cultural and scientific diversity and promotes learning autonomy by making the teams fully responsible for the project management, the solution discovery, selection of materials and components, as well as the assembling and testing of the prototype, as suggested by [3]. The aim of the EPS is to provide students with the experience of working in an international, multidisciplinary project team to foster the kind of team-working skills sought after by employers. According to the American Management Association, these skills include critical thinking & problem solving, effective communication, collaboration & team building and creativity & innovation, known as the four C [4].

The European Project Semester at Instituto Superior de Engenharia do Porto (ISEP) is the programme offered in Portugal[3]. Since the academic year of 2010-2011, EPS@ISEP has welcomed a cohort of 157 students from 53 different degrees. From a diversity and inclusion perspective, the participants came from 20 countries distributed over three continents and the percentage of women amounts to 34 %, a considerably higher percentage than the typical 10 % to 20 % of the engineering workforce [5]. In terms of skills, EPS@ISEP aims to foster, in addition to the four C skills, the adoption of ethical and sustainable design practices. Considering the collection of projects developed so far, there has been a stream related to smart cities. Developing solutions to societal problems, such as those involving smart cities, requires in-depth exploration, as well as collaboration across different types of expertise. Students need to develop not only content knowledge and analytical skills but interpersonal competencies and multidisciplinary work experience. These skills cannot be developed through lecture-based activities alone, but require hands-on practice, teamwork and community engagement opportunities [6].

According to the United Nations Economic Commission for Europe (UNECE) and the International Telecommunications Union (ITU), a "smart sustainable city is an innovative city that uses information and communication technologies (ICT) and other means to improve quality of life, efficiency of urban operation and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural, aspects." [7]. This transformation of ordinary into smart cities can take many forms, from driverless cars or Internet of Things (IoT), to better healthcare, transportation or education. In 2014, the United Smart Cities platform elected urban mobility, sustainable housing, clean energy, waste management and ICT as key intervention areas for smart cities [8]. Later, in 2016, UNECE and ITU launched the United for Smart Sustainable Cities worldwide initiative to help cities not only to become smarter, but also sustainable [7], which constitutes a global partnership for the achievement of the Sustainable

[1] http://europeanprojectsemester.eu
[2] http://www.europeanprojectsemester.eu/concept
[3] https://www.isep.ipp.pt/Course/Course/44

Development Goals (SDG) set by the United Nations Educational, Scientific and Cultural Organization (UNESCO) [9]. A sustainable city serves and operates as a city while upholding a balanced ecosystem in terms of infrastructure and governance, pollution and waste, energy and climate change, social issues, economics and health [10].

By proposing problems within the scope of the 17 SDG identified by UNESCO, EPS@ISEP intends to challenge the students to contribute to the well-being of the society. Such topics contribute to raise their awareness to sustainable development issues, motivate them to deepen their knowledge to find solutions with a positive impact on the daily life of communities, and lead, ultimately, to the adoption of sustainable development practices in their future professional lives. The projects analysed in this article are:

- Billy, a smart billboard for monitoring urban areas and displaying real time information regarding the air of public green spaces as well as recommendations to citizens on how to improve the local air quality, contributes to the "Sustainable cities and communities" goal (SDG 11)
- SUNO, a self-oriented solar mirror for daylighting or solar cooking, contributes to the "Affordable and clean energy" goal (SGD 7)
- OiLevel, a level monitoring system for public waste oil bins, contributes to the "Responsible consumption and production" goal (SDG 12)

These projects share another ulterior goal in the context of engineering education: to help the students develop personal, teamwork and problem-solving skills while applying and enriching their technical-scientific knowledge. This ability has been coined by Gopakumar as public leadership, i.e., engineers who excel not only in technical problem solving but also have the understanding and skills to operate within a complex, fast-changing social, political and cultural environment [11]. To determine the student perspective on the EPS@ISEP learning experience, the final reports of the three teams were processed automatically, using KH Coder[4], and manually, looking for first-hand testimonials.

Following this introductory section, this article is organised as follows: Section 2 introduces the EPS@ISEP engineering education framework, Section 3 describes the selected projects, Section 4 identifies and discusses the results and Section 5 presents the conclusions.

2 EPS@ISEP Framework

EPS@ISEP is an implementation of the EPS project-based engineering capstone framework. Its main objective is to foster teamwork, communication, interpersonal and problem-solving skills in an international, multidisciplinary engineering environment during the capstone semester [12]. Moreover, the programme is very aligned

[4] KH Coder is an open source text mining software for quantitative content analysis (http://khcoder.net).

with the Engineering for Sustainable Development concept, fostering the development of ethical and sustainable development practices [13].

This engineering capstone programme, which is part of ISEP's international student mobility portfolio, runs for 15 weeks during the spring semester. The programme accounts for 30 European Credit Transfer System Units (ECTU) distributed over six modules: Project (PROJE) (20 ECTU), Ethics and Deontology (ETHDO) (2 ECTU), Marketing and Communication (MACOM) (2 ECTU), Project Management and Teamwork (PRMTW) (2 ECTU), Energy and Sustainable Development (ESUSD) and Portuguese (PORTU) (2 ECTU). Except for Portuguese, the remaining 2 ECTU subjects are project supportive modules, where the teams, together with the teachers, analyse and brainstorm ideas from the perspective of the different topics. The project module is organised around the weekly meeting between each team and the multidisciplinary panel of advisers.

Before the start of the semester, the students are organised in teams of 4 to 6 students with different cultural and scientific backgrounds, according to the EPS rules and their Belbin Team Roles [14], and a list of project proposals is prepared. The project briefs are purposely short and open-ended, specifying a topic and a set of general mandatory requirements, such as the compliance with the International System of Units or applicable European directives. The teams chose their projects in the first week and, from that moment onwards, are dedicated to find a solution, which implies the design, implementation and test of a proof of concept prototype. The following five weeks are dedicated to the specification of the requirements, design of the solution and the selection and procurement of the materials and components necessary to build the solution. The requirements and the design must be supported on state of the art, sustainability, marketing and ethical research. After the interim presentation, the focus shifts to the development, test and debugging of the prototype, as well as to the documentation of the process. The teams are expected to produce multiple deliverables: wiki, report, poster, brochure, leaflet, manual, video and a proof of concept prototype. The template of the report includes nine mandatory chapters: introduction, state of the art, project management, marketing, sustainability, ethics and deontology, project development, conclusions and references. Throughout the semester the teams pre-define the agenda, lead and write the minutes of the weekly project meetings. The advisers discuss the agenda topics with the team and provide constant feedback regarding the progress of the tasks, the status of the deliverables and the upcoming deadlines.

Figure 1 illustrates the main activities and milestones of the programme. The learning process has two main events: the interim presentation (7th week) and the final presentation (15th week). The first event is dedicated to the presentation and discussion of the proposed solution. Teachers and project advisers provide feedback based on the interim report, presentation and discussion, and students perform self and peer evaluation. The last event is focussed on the presentation, discussion and evaluation of the result (deliverables and learning process). The project management, marketing, sustainability, ethics and deontology chapters are mainly assessed by the corresponding module teachers. The introduction, state of the art, project development and conclusions are project-related chapters assessed by the project advisers. The communication assessment is based on the set of deliverables produced. The evaluation combines self, peer, teacher and adviser inputs.

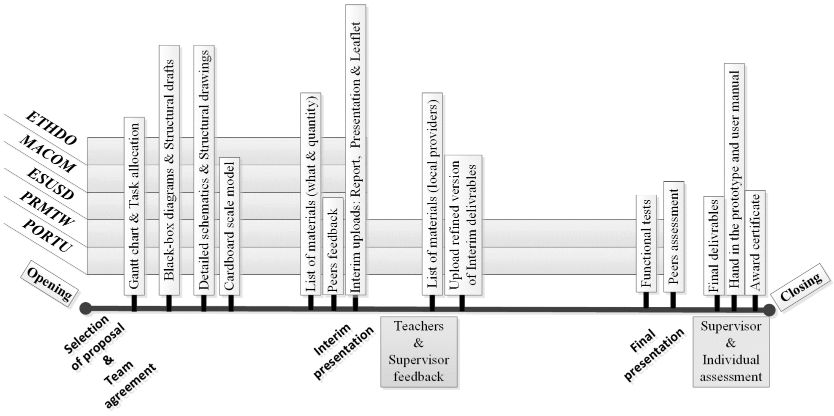

Fig. 1. Main activities and milestones of EPS@ISEP

3 EPS@ISEP Projects for the Smart Sustainable City

Finding smart sustainable solutions for cities is of the utmost importance given the fact that it is expected that two-thirds of the world population will be living in urban areas by 2050 [5]. The selected projects contribute to the smart sustainable city (SSC) paradigm in different ways, addressing urban air quality (Billy), cleaner energy (SUNO) and waste recycling and transportation (OiLevel).

According to the SSC concept, urban equipment needs to become smarter, meaning it should be connected, interactive and involve the people. Billy, besides providing environmental information, raises the awareness and concern of citizens towards air pollution. This is achieved by displaying invisible air characteristics and providing a meeting point.

SUNO harnesses and reflects solar radiation for lighting purposes, saving energy and money. While it was conceived for domestic use, involving the final user on the installation and maintenance of the device, it can be deployed at a larger scale.

The OiLevel system contributes at various levels to the SSC. The outdoor container collects waste oil for recycling and the level monitoring system provides data on the volume of waste oil stored and eventually recycled, enabling the intelligent scheduling (in real time) of the pickup time and circuit. This way, resources are saved by recycling the waste oil and minimising the energy used for the pickup.

One common characteristic of the three projects is their public visibility, disseminating the sustainability message, vital for the SSC.

3.1 Billy

Billy is a smart billboard designed by a team participating in EPS@ISEP during the spring semester of 2018. The goal was to design, develop and test a multi-purpose urban sensing and displaying equipment to inform citizens of nearby environmental conditions [15].

Team and Motivation: The team was composed of five students from France, Greece, Netherlands and Scotland, studying Industrial Engineering and Management, Industrial Design, Mechanical Engineering, Environmental Engineering and Electrical Power Engineering. Inspired by European Union (EU) clean air package, the team decided to create a public product to display the air pollution and advise on how to improve the air quality at the urban scale. Poor air quality has a negative impact on the quality of life, causing several health issues, such as breathing or cardiovascular problems. These issues are even more critical in urban areas, where there is often a poor air quality, with the air often polluted with small harmful particles [16]. However, frequently, people are unaware of the actual level of air pollution. Although there are smart phone applications which provide related information, there is still a great lack of knowledge about this topic, as there is no system or object providing real and trusted local information. To contribute to the minimisation of these problems, the team decided to build a connected billboard to provide citizens with real time air related data concerning local and remote urban locations. The team's vision regarding the design of a smart billboard was to create "a trusted equipment which informs and empowers people with the knowledge on how to improve air quality. This will not only benefit the public, but also governments by helping them to comply with the EU rules" [17].

Requirements and Design: Based on existing products and following several studies on marketing, ethics and sustainability, the team decided to create an interactive smart billboard to collect and share publicly information on the weather and pollution, using IoT Cloud[5]. The billboard, named Billy, was designed to monitor and display local temperature, humidity and air pressure and estimate the local air quality. Billy can operate in stand-alone or networked mode, monitoring and displaying local and remote air quality, creating a distributed urban sensing network. In addition, it displays useful advice on how to improve air quality and reduce the carbon footprint as well as informs on upcoming local activities. Therefore, the main purpose of Billy is to improve the air quality and avoid of air quality related health problems. For sustainability reasons, the team chose to use wood as building material, a solar panel as renewable energy source and a proximity detection sensor for energy saving. The total budget was 100 €.

The main functionality of the billboard is to publicly display the temperature, humidity, air pressure and the air pollution, according to the design features depicted in Figure 2 (right). Billy is designed to sense these parameters, process the readings and display the results individually. The map-based display is colour coded to indicate acceptable and high values of the air quality, using green and red light-emitting diodes

[5] https://www.arduino.cc/en/IoT/HomePage

(LED). The map of the enlarged urban area is dotted with green and red LED over the locations of the billboards deployed in the urban area. It additionally displays complementary information about the air quality, health and safety, and public activities to assist citizens in keeping a high standard life style. Finally, Billy was designed to be eco-friendly as it is solar powered. It includes a photovoltaic system and a battery to sustain its 24-hour operation.

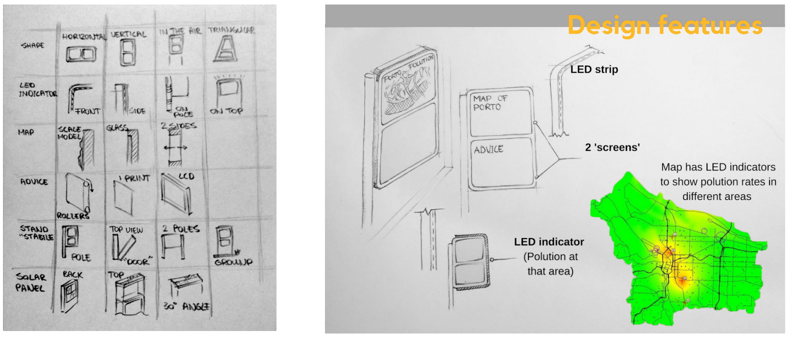

Fig. 2. Morphological scheme for the smart billboard (left), showing its different planned functions, and Billy design features (right)

The structure of the product, drawn in SolidWorks, is illustrated in Figure 3 (left). It was divided into top, middle and bottom to make it easier to develop and assembly. The top part holds the sustainable energy source—the solar panels—which powers the system. The middle part—the core of the billboard—houses the control system, the map-based display with the LED indicators and the text-based display to inform and advise people, e.g., on how to reduce their ecological footprint. The bottom part, or stand, holds the remaining parts and provides the necessary structural support.

Fig. 3. 3D model of the designed structure (left) and completed prototype (right)

Prototype: The system was successfully prototyped (see Figure 3, right) and the team performed a set of functional tests to ascertain whether Billy complied with the requirements and was ready to be transformed into a product for release in the market. The results show not only that the prototype functions according to derived specifications and design, but that the team members were able to learn, together and from each other, how to solve this multidisciplinary problem [15].

3.2 SUNO

SUNO is a self-oriented solar mirror designed to track and reflect the solar radiation onto a pre-defined target area. It was designed, developed and tested by a group of five students in the spring of 2017 [18].

Team and Motivation: The team consisted of five students, all from different countries and with a different education background. The team included students from Belgium, Finland, Poland, Scotland and Spain, who were studying Civil Engineering Technology, Computer Science, Electrical Power Engineering, Mechanical Engineering and Industrial Management. The team chose this project because of the current relevance of the topic and, consequently, the need to acquire further knowledge and experience in this unfamiliar field. Global warming is a serious issue affecting people from all over the world. It gives rise to climate change and has serious negative consequences for all life on the planet [19]. One way to combat climate change is to reduce CO_2 emissions by encouraging a more environmentally friendly way of living [20]. Nowadays, non-renewable sources of energy are overused and cause pollution and global warming, therefore, an increase in the use of clean energy is needed. A solar mirror is a simple way to harness and transform solar energy for daily usage. According to the students, SUNO constitutes a novel way to reduce domestic electrical energy consumption.

Requirements and Design: SUNO requirements were defined based on the state of the art, marketing, ethics and sustainability initial studies. The considered mirror uses included: reflecting natural sunlight into a room to reduce the need for electrical lighting and alleviating the symptoms of seasonal affective disorder; and increasing the efficiency of thermal water heating or solar cooking. The team decided to use the mirror for domestic lighting, which implies tracking the movement of the Sun and reflecting the sunlight onto a predefined area.

The concern with the environmental sustainability led the team to choose sustainable materials, such as wood for construction, as well to reuse materials already available at ISEP rather than purchasing new materials. The commercial product is to be delivered unassembled to minimise the package volume. The user manual provides assembly, repairing and end of life recycling instructions.

The biggest challenge of the project was the tracking of the Sun. The team had to choose between a sensor-based system, which uses light sensors to track the position of the Sun, or a position-based system, which calculates the relative position between the Sun and the mirror. Limited by the 100 € budget, the team decided to use a sensorless system. This enabled the team to use less electronic components and motors, reducing the cost of the prototype as well as simplifying the design and increasing the accuracy of the Sun tracking system, as sensors can be influenced by external disturbances. However, on the other hand this system required more complex programming to operate.

The positioning of the SUNO relies on two axes (see Figure 4, right and left), which are controlled by a Tiva-C micro-controller. The mirror's geodetic location and the corresponding Sun's position throughout the year are stored in the memory of the micro-controller. A real-time clock is used to keep track of the current time. The user can change the orientation of the mirror to reflect the sunlight to the desired location through the user interface. The system will then track the Sun and orient the mirror to its target position.

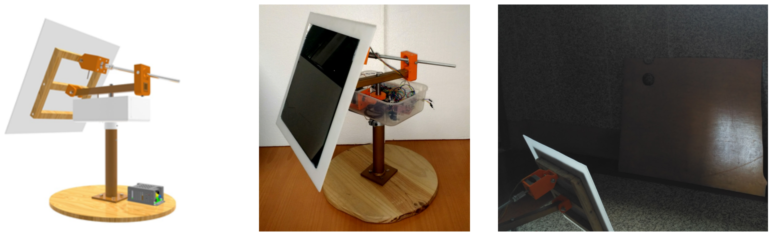

Fig. 4. Structural drawing (left), prototype (middle) and tests (right)

Prototype: Due to the complexity of the project, tests were conducted during the development process before the final assembling the prototype. Each electrical component (and related code) was tested separately, before the final version of the software was created. This process allowed the team to discover minor problems, which were solved without delaying the overall development process.

The final test of SUNO is illustrated in Figure 4 (right). The mirror was placed near a window, switched on and the target was set onto a wooden panel, using the focus buttons. The test lasted one hour. As expected, the mirror repositioned itself every minute. With the help of a video camera, it was possible to confirm that the correct operation of the positioning system, maintaining the target enlightened.

For this team, working within the time and budget constraints of the EPS meant creating the SUNO proof of concept for domestic use, while considering the features that the final commercial product should have.

3.3 OiLevel

By equipping oil containers with a level monitoring system which, periodically, reports the level and alerts when it reaches a pre-set threshold, oil recycling companies can streamline the oil collection process and, thus, reduce the operation costs while maintaining the quality of service [21].

Team and Motivation: In 2012, a multinational and multidisciplinary EPS@ISEP team designed a level monitoring system for waste oil containers. The team was composed of four elements, from Estonia, Germany, Poland and Portugal, studying Biomedical Engineering, Sales and Marketing Engineering, Engineering Materials and

Marketing and Electrical and Computer Engineering. The goal was to develop of a level monitoring system for a real-world outdoor waste oil container. The problem was proposed by a local recycling company with 214 waste oil containers that relies on an inspection team to verify the level of the containers. The containers with a level above 50 % of their capacity are scheduled for the next oil collection trip. The group was motivated with the opportunity to create a solution for a real problem, acquire new knowledge and learn to cooperate.

Requirements and Design: The initial project requirements were intentionally broad to allow the team to make design choices and autonomously find solutions. In particular, the requirements specified the development of a level monitoring system that should:

- Send automatically alert messages when the container is almost full
- Display the reported data via a Web interface
- Be robust
- Comply with a 300 € budget.

After performing the initial state of the art, marketing, ethical and sustainability analyses, the team members experienced some difficulty in converging to the final solution due to the low budget available. This problem of finding adequate components at affordable prices is shared with most teams. The team started by analysing the inside of the container. This was necessary because they had to decide where and how to place and fix the system components. For the development of the system, the team first needed a level sensor. Generally, these sensors produce an analogue output that directly correlates to the level in the container. To create a level management system, the level sensor output signal can be connected to a micro-controller. Secondly, they had to develop the monitoring system that would send automatically an alert message when the container would be full.

The overall system architecture comprises two ultrasonic sensors plus control, communications, power and Web application modules. The block diagram of the developed system is presented in Figure 5 (left).

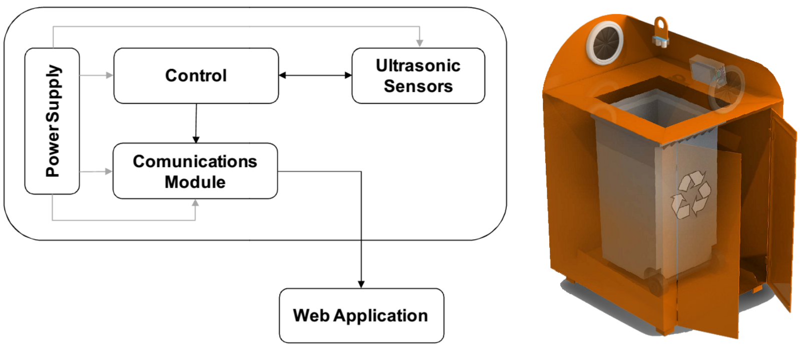

Fig. 5. System architecture (left) and container with the level monitoring system (right)

The level monitoring system had to be placed inside the waste oil container, on top of the bin, as shown in Figure 5 (right). Additionally, all components were placed inside an aluminium protective box, also developed by the team. The Web interface was developed in Java and was deployed on an Apache Tomcat application server. The main page offers two options: to check the container status and to edit the container settings. The container status button redirects the user to a dedicated servlet, which reads the container content level data from a file and displays this information to the user.

Prototype: Several tests were performed along the implementation of the prototype to identify and debug problems. When the system was fully integrated, it was successfully tested. The prototype fulfils the requirements and has a level reading resolution of 1 cm.

4 Results and Discussion

Sustainability-focused engineering capstone courses affect positively students' critical thinking skills and student knowledge of sustainability [18]. This is the case of EPS@ISEP, where both staff and students address problem-solving from an ethical and sustainability-driven perspective. In addition, working in a multinational and multidisciplinary teamwork setting, can help students to appreciate differences of opinion and work toward a consensus on the value of sustainability considerations within the design process [24]. Students prefer to feel in control of their learning process and work for a meaningful purpose, such as solving SSC problems, instead of developing unrealistic projects in controlled environments. This was identified by [25], who states that the millennial student prefers to learn in environments which are collaborative, incorporating teamwork, cooperative learning and constructivist principles, and challenging, driven by goals and oriented by achievements aligned with plans of the learner. Moreover, solving "real-world" problems, using a multidisciplinary approach, prepares students better for their professional lives [24].

The three projects described share application domain (SSC), learning framework (EPS@ISEP) and successful accomplishment. Smart sustainable cities challenges were embraced with enthusiasm by the teams, facilitating the learning process. The project work, while essential, was the motif for exploring new contexts and developing new hard and soft skills together, namely, sustainable and ethical design and development practices. The reports were analysed to extract the student perspective, using automatic (term co-occurrence network) and manual processing (testimonials).

Content analysis is a research method that analyses the content of text and has been previously used in studies exploring student learning and sustainability [24]. The content of the three reports was analysed with KH Coder to create the corresponding term co-occurrence network, representing the centrality, frequency and relations between terms. First, the reports were pre-processed to remove student data and stop words. The list stop words used was composed of the long list from Ranks NL[6] plus

[6] https://www.ranks.nl/stopwords

the terms "figure" and "table". Next, the term frequency (TF) of nouns, adjectives, verbs and adverbs was determined. Finally, the TF co-occurrence network was created using the following configuration: term frequency above 35, nearest 60 terms (Jaccard distance) and centrality analysis. Figure 6 displays the obtained term co-occurrence network.

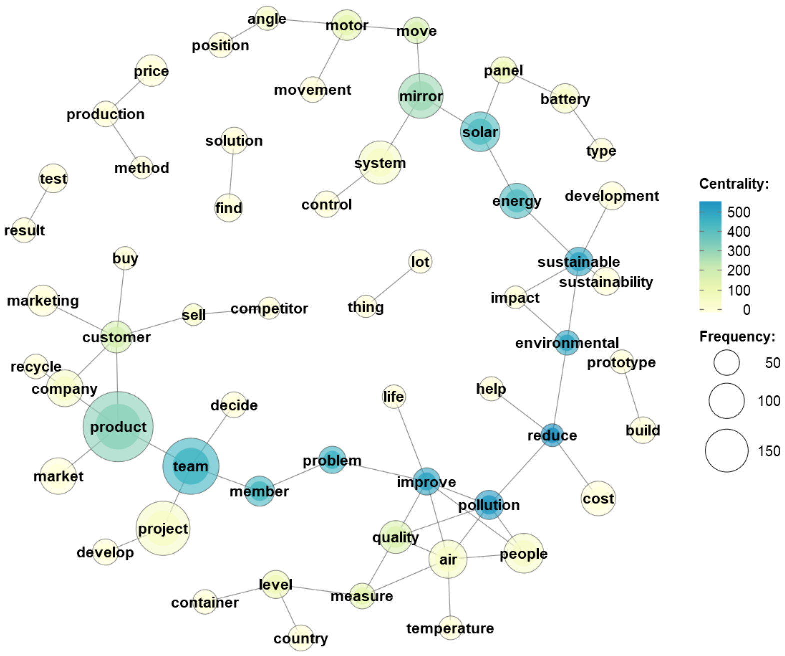

Fig. 6. Term frequency, centrality and co-occurrence network of the three reports

Term centrality is represented through colour, with the darker hue indicating terms with a central role and lighter hue terms with a peripheral role. The most central terms are *team*, *member*, *problem*, *improve*, *pollution*, *reduce*, *environmental*, *sustainable*, *energy* and *solar*, indicating that sustainability was a pervasive concern.

The students left also multiple testimonials concerning their EPS@ISEP learning experience in the reports. Below are some citations extracted from the final reports.

Wouter (Billy): "*The European Project Semester was really good experience to learn about multiple cultures and their way of working, (…) but also the different countries that your team members are from. Also, I loved to work on a project that is focussed on sustainable energy and materials while finding a solution for a problem that improves people's lives.*"

Damien (Billy): "*The European Project Semester at ISEP was a very rewarding experience. Although I am used to teamwork, it was the first time I worked with people from different countries and backgrounds in a global project where we have not only to design an object but also think about marketing, management and sustainabil-*

ity. We learned a lot from each other and about sustainability and project management. This project also made me grow up, I'm now more tolerant and I trust more easily my team mates."

José (SUNO): "*EPS is a program that has allowed me to improve different soft skills such as teamwork, communication, problem solving, etc. On the other hand, has made me realize that within a project is necessary to consider different ethical, marketing, sustainability and organization aspects for it to be successful. Therefore, I can say that this experience has allowed me to obtain a more realistic view of the world, while training for the scientific-technological challenges that may arise in the future. The work methodology, although the load of the same has been very high, has allowed us to devote many hours to the project itself, having total freedom to take decisions.*"

Raymond (SUNO): "*I found the EPS a greatly rewarding experience. The opportunity to enhance my team work, communication and interpersonal skills in an international environment will prove invaluable. EPS also forced me to think about the less technical aspects of engineering project work – Ethics, Sustainability and Marketing – issues that I don't often thoroughly consider during project work. It was also rewarding to take on board the ideas of others, as often decisions I disagreed about or was unsure about turned out to be good ideas after a group discussion.*"

The OiLevel team underlines the change in mentality, observed both at the individual and corporate level, the adoption of sustainable development strategies. "*People have started thinking about their future and how they can be more effective in terms of resource usage. By being effective, we mean not to spend too much energy, time and money for useless things. Even for companies, it is essential that products/services as a part of the environment to stay competitive. For a company, sustainability means to have no negative impact on the global or local environment, community, society, or economy*."

These testimonials show that, from the student perspective, the most relevant outcomes of EPS@ISEP were the acquisition of new:

- Sustainability-oriented design practices
- Ethics-oriented design practices
- Marketing-oriented design practices
- Teamwork skills
- Communication skills
- Project management skills

The ethical and sustainability concerns of EPS@ISEP staff (teachers and project advisers) are present at the syllabus level, by including dedicated project supportive modules, at the project brief level, by proposing SSC open-ended problems as suggested by [22], at the report level, by including dedicated chapters in the report template, and at the process level as recommend by [25]. Authentic involvement activities expose the student to real situations with totally open-ended projects, although the faculty may influence the selection of the situations and set performance criteria to assure that positive learning objectives are met [1]. The EPS@ISEP process ensures that the teams perform multiple studies covering the state of the art, marketing, sustainability, ethics and deontology to derive their project requirements. Another important aspect of the process is to keep the teams focussed and motivated. This means ensuring that, during the first half of the semester, the teams depart from an open-ended problem and converge to feasible designs and that, on the second half, they have the materials, components and skills required to build a working prototype. In this context, timely feedback is given during the scheduled activities. For example, in the project weekly meetings constant feedback is provided on the current status of the project, highlighting pending and upcoming tasks.

5 Conclusion

The problem of engineering education is mostly of a motivational nature. The challenges proposed by Smart Sustainable Cities are real and naturally open-ended, providing large design and innovation freedom. For a team of international multidisciplinary students, this is a rich learning context to develop a wide range of skills, including problem-solving, communication or project management, and adopt new design practices supported by ethics, marketing and sustainability analyses. On the one hand, the sustainability dimension motivates and attracts young people because it is complex and crucial to the survival of all life forms. On the other hand, the relevance of the ethical dimension of engineering is more visible on this type of project. Contrary to unrealistic projects done for academic purposes, a sustainability-oriented project implies previous and ulterior analyses of the problem and solution, both involving human beings. This is not the case in purely academic projects, where students receive and are assessed based on a set of abstract requisites, ignoring the human dimension of the engineering problems.

Based on the projects presented and on the analysis of the quantitative content analysis of the reports, it is safe to state that this learning framework provides students with a large degree of freedom in terms of marketing, sustainability and ethics-oriented design and reinforces their technical-scientific and personal skills.

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