The integration of Transversal Competences in Higher Education in Engineering through e-learning tools. The case of the ETSII at the UPV

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Abstract- One of the objectives of Higher Education, increasingly demanded by the labor market, is to guarantee the development of professional, social and ethical skills of students. Making the learning of these type of transversal competences (TC) compatible with the specific competences of the degree in the time frame of the studies, is not an easy task in particular of some of these competences, in engineering profile degrees. For this reason, at the Higher Technical School of Industrial Engineering (ETSII) of the Universitat Politècnica de València (UPV) it has been designed an e-learning platform by the teaching staff, students and employers, coordinated by the Sub-Directorate of Educational Innovation and within the framework of a Project of Innovation and Educational Improvement of the UPV. This platform allows students to train in TC at their own pace according to their needs and teachers to use methodologies appropriate to their subjects and domain level adapted to the engineering framework. In this way, the platform can be used as a vertical coordination axis between subjects, for the development of TC at the different levels of mastery throughout the ETSII students' studies.

Keywords: transversal competence, training, active learning, self-learning, e-learning, engineering

1. INTRODUCTION

The labor market demands more and more professional profiles capable of adapting successfully and quickly to the changing environment. In this context, one of the main objectives of Higher Education is to provide its students with knowledge and skills that allow them to successfully face their future professional life (Sá and Serpa, 2018) and that guarantee the development of social, ethical and professional skills at the same time. (Oksana, Galstyan-Sargsyan, López-Jiménez and Pérez-Sánchez, 2020).

A. On the need for training (also) in transversal skills

For this reason, there is a growing awareness of the responsibility to provide students not only with a solid scientific and technical training, but also to train them simultaneously in transversal competences (TC) transferable to any area of knowledge (Szafranski, Golinski and Simi, 2017). Additionally in the case of technical careers, many of the TCs are in line with the learning outcomes related to the practical application of

engineering and design and project required by international accreditation agencies such as ENAEE (European Network for Accreditation of Engineering Education) or ABET (Accreditation Board for Engineering and Technology; Baltimore, USA) (Alemany, Villanueva, Vallés-Lluch and García-Serra, 2020).

Faced with this situation, one of the most relevant actions carried out by the Universitat Politècnica de València (UPV) to adapt to the EHEA, the national and international accreditation agencies and the needs of the labor market, was the Transversal Competences Project (TC) within the framework of which 13 TC have been defined with two main objectives:

a) Establish a training strategy and systematic evaluation of transversal competences, defining where they are acquired and how they should be evaluated,
b) Prove the acquisition of said skills.

Certifying the acquisition of skills is not a trivial fact. For this reason, the UPV's institutional project proposes three ways to do so: the subjects of the degrees themselves, the Final Degree Project or Final Master Project and carrying out extracurricular activities (volunteering activities, sports activities, participation in projects, contests, etc.). In addition, it establishes three levels of mastery to progressively increase the degree of deepening of the students in each competence: Level I (1st and 2nd Graduate courses); Level II (3rd and 4th courses) and Level III (1st and 2nd Master's degree).

As a means for TC training, within the UPV's priority lines, the promotion of active learning methodologies has been identified, such as PBL (Learning Based on Projects or Problems). These methodologies include those methodological approaches that encompass both project-based learning, problems, or cases combined with the necessary ingredients of cooperative learning for the development of both specific and transversal skills (Alemany, Vallés, Villanueva and García-Serra, 2021). Therefore, they are complex methodologies close to reality, which favor learning experiences with high educational impact, the integration of knowledge, the transfer of what has been learned to professional reality, etc.

In this framework of action, it is necessary that previously knowledge related to both specific competences (SC) and TC have been worked on and evaluated that will later be developed, expanded and integrated together, using active learning methodologies. That is why these active learning methodologies are not incompatible, but rather must be complemented with activities that allow knowledge and training in TC and SC in a comprehensive manner. Therefore, it is necessary to continue training students not only in SC but also in these TCs jointly. In fact, and as Cano (2008) points out, one of the three features that characterize competences is that they are also learned: the fact of possessing certain intelligences innately is a good starting point, but it does not guarantee being competent. Competences must be developed with initial training, with ongoing training and with experience throughout life. That is, it is not enough for teachers to put the framework in their subjects for students to develop or enhance their TC, but training is also necessary, through methodologies with increasing complexity, in this type of competences to promote an adequate mastery of the same that guarantees them academic and professional success.

B. Not all transversal competences are the same ... some are "difficult"

The UPV Schools and Faculties are carrying out important coordination work to ensure that all competences are worked on at the different levels of mastery through three channels: subjects, Final Degree and Master's Projects and extracurricular activities. However, the experience accumulated during these years clearly shows that training and evaluation is not perceived by teachers with the same level of complexity for all TC. Specifically, the UPV's Higher Technical School of Industrial Engineers (ETSII) has found that 6 of the 13 UPV TC pose serious difficulties, not only from the teacher's point of view but also from the student body who has to work. This conclusion is derived from the follow-up meetings by the academic commissions of the different degrees after the implementation of the TC system at the UPV. The fact of distinguishing them by calling them "difficult" aims to highlight the greater complexity found when working on them and evaluating them in the context of engineering subjects, without depreciating the difficulties that it imposes, and the effort to be done to work and evaluate the other TC, with groups of students on many occasions quite large. On the other hand, these TC are among the most valued by Spanish companies in Engineers (Instituto de la Ingeniería de España-Asociación para el Progreso de la Direccion, 2017). These "difficult" TC are: Innovation, creativity and entrepreneurship; Teamwork and leadership; Ethical, environmental and professional responsibility; Knowledge of contemporary problems; Lifelong learning, and Planning and time management.

Given the lack of support, especially for students and even more so from an engineering point of view, the Subdirectorate of Educational Innovation of the ETSII of the UPV proposed the objective of facilitating the acquisition and evaluation of said competences with an effective model that would not be an additional burden for teachers, through the development of an e-learning platform. To this end, three educational innovation and improvement projects were launched (PIME/19-20/150, 151 and 152) with the aim of developing e-learning material in the six aforementioned TC. They have been working on this for more than 2 years with the collaboration of more than 70 participants between professors, students, graduates and employers. The result is an e-learning platform with generic and specific resources oriented to the engineering field that supports, facilitates and allows the integration of TC with SC. Additionally, this e-learning platform is aimed at achieving methodological coordination in the training and evaluation of said TC, since it is structured by mastery levels, indicating the most convenient methodologies according to the course in which the student is.

Thus, this article aims to show the e-learning platform in the six difficult TC and its usefulness when training and evaluating students in the field of higher education and more specifically engineering. The rest of the article is structured as follows. Section 2 establishes the starting point on which the current e-learning platform was built and whose development process is described in section 3. Section 4 describes the resulting e-learning platform as well as its different forms of use. Finally, section 5 establishes the conclusions and future lines of work. .

2. CONTEXT

Active learning methodologies are becoming increasingly important as a way of simultaneously working on the TC and SC of the degrees and as a means for students to face situations close to professional reality. The implementation of these methodologies will surely require a redistribution of classroom and seminar theory credits and even content review, which could require combining the PBL with the flipped teaching methodology. Flipped teaching, in turn, will require the preparation of material for autonomous work by the student, which can be written or audiovisual material through the network (e-learning) both of knowledge related to SC as well as TC. Rodrigues, Almeida, Figueiredo and Lopes (2019) define e-learning as an innovative web-based system supported by digital technologies and other forms of educational materials that support and improve learning processes. The advantages of e-learning systems are that it provides learning opportunities without the typical restrictions of place and time, and supports new approaches to teaching and learning that involve a mixture of traditional learning methods and e-learning (Alhabeeb and Rowley, 2018).

Although the UPV has a TC website and material for teachers on its online training platform, there is no space devoted to the training of students. On the other hand, there is no known initiative that uses an e-learning system as the axis of horizontal and especially vertical coordination between the subjects of a degree.

With the intention of contributing to fill the gap detected, from the ETSII's Subdirectorate for Educational Innovation, a collection of material available on other websites and in the UPV institutional repository was carried out as a first approach, which could serve as starting point for this project. The first version of the on-line training website in difficult CT was mainly nourished by material from the websites of other Universities (videos, texts, questionnaires, links, etc.), such as the University of Edinburgh, Sussex, Kent, or UNSW Sydney, but also free access videos through YouTube and Media UPV videos as well as links to in-depth texts on these TC. The learning and evaluation objects contained in the web were already of enormous value both for the students and for the teachers involved in these TC, being, therefore, the starting point of the Project that is presented here (Fig 1).

***Figure 1**. Starting point: analysis of initial support webs in difficult TC.*

As an example, the original version of the website for the Innovation, Creativity and Entrepreneurship TC can be consulted at the ETSII website (2019). The structure and approach adopted for the development of this website is described in detail in Alemany *et al.* (2021). Although these support websites for the six so-called difficult TC represented a substantial advance in the right direction, certain drawbacks were identified in the use of this "external" material:

i) The material was not structured by mastery levels, as would be desirable for students to access these contents.

ii) Specific examples or cases were raised, which in most cases do not refer to engineering applications, as would be desirable in order to integrate training in these competences with training in specific competences for Graduates or Masters in Engineering.

iii) The resources were quite heterogeneous: very visual and entertaining videos coexisted with other videos or much more arduous texts, and mostly in English.

iv) The specific experiences of students contained in this initial version of the websites are well understood in the context of other Universities, but they may be somewhat alien to our students and not be reflected in them.

In short, this first approximation showed a variety of resources of uneven quality and with a strong presence of external material. On the other hand, in many cases they had little engineering background and, consequently, little penetration capacity in the target students, thus identifying a great opportunity for improvement. For this reason, three institutional innovation and educational improvement projects were proposed (PIME/19-20/150, 151 and 152) that reflected the aforementioned spirit, each of them working on two of the previous difficult TC. To take advantage of this opportunity for improvement, it was thought that a fundamental part should consist of the participation of the teaching staff who had to work on the competences, the students towards whom the project was directed, and the employers who are the ones who most request this type of competences in their workforce template.

The main objective of the proposed PIME was to continue advancing in the development of the web, which will serve as a common thread for horizontal and especially vertical coordination in the subjects regarding the training and evaluation methodologies of difficult TC. It was proposed to structure the material by mastery levels, with examples and practical engineering cases, close and motivating for the students, with the involvement of the teachers and students of the ETSII. The following section shows the process carried out until reaching the e-learning platform.

3. DESCRIPTION OF THE METHODOLOGY FOR THE DEVELOPMENT OF THE CT E-LEARNING PLATFORM

The three institutional innovation and educational improvement projects (PIME/19-20/150, 151 and 152) were proposed as a means to achieve the following general objectives:

GO1. Contribute to the acquisition by students of six of the TC most valued by Spanish companies in Engineers perceived, in addition, by the teaching staff as difficult, thus improving the employment of graduates and facilitating the work of the teacher.

GO2. Define a methodological proposal for the training and evaluation of the six "difficult" TC, based on coordination by domain levels through the creation of web resources as a pivot element structured as an e-learning platform, by expanding and improving existing web resources, giving it a marked engineering character.

The work plan to achieve the above general objectives was similar for all TC. The different stages with their respective phases are detailed below, the execution of which was planned for a duration of two years.

Stage I) Incorporation to the PIME of the interested agents

Phase 1: Gather the participation of the agents involved in the different titles of the ETSII

In this previous phase, the participation of the greatest number of agents involved in the training and evaluation of TC was sought, so that the maximum possible number of degrees from between the 5 Degrees and 7 Master's degrees that are currently taught at the ETSII are covered. The objectives pursued were:

1. Get as much participation as possible from teachers, especially those who work and / or evaluate difficult TC, their students, as well as employers of graduates of ETSII degrees.
2. Achieve the widest possible variety of degrees and proficiency levels that would maximize the reach of the target audience.

For this, the proposal of the three aforementioned PIME was a strong stimulus, since it was possible to increase the sense of connection and belonging on the part of the agents involved and the generation of tangible and useful results for both students and teachers.

Stage II) Analysis of the initial CT-ETSII websites and improvement proposals

The main objective of this stage was the analysis of the original websites by the teachers involved, and also by certain students, as a first step towards improvement. For this, a questionnaire was designed to be completed by the different agents that evaluated both technical and content aspects of the initial TC websites. From this, relevant conclusions were drawn for their improvement. To achieve this, the following activities were established:

3. Review of the original websites for the six difficult TC by teachers and student groups.

4. Identification of gaps / opportunities for improvement of existing resources on the websites, identifying strengths and weaknesses.
5. Proposal by the teachers of each subject of their potential contribution to the improvement of the original websites, and identification of activities / methodologies either from the original websites or from other more suitable sources for their subjects.
6. Identification by those responsible for the PIME of CT-ETSII of possible contributions from the business world that complete the practical point of view of the competences.

Phase 2: Coordination and allocation of resources to be designed by each agent involved

Based on the responses obtained to the questionnaire posed in the previous phase, and through a process of interviews between the heads of the three CT PIME –ETSII with the agents involved by subjects and / or TC, the different contributions were defined and detailed to be carried out by each agent or group of agents: teacher videos, student videos, graduate videos, external videos, websites with useful material for training and evaluation in TC, good practice sheets with example of students, rubrics, new methodologies, etc. To carry out this assignment, the ETSII Educational Innovation team worked on assigning activities so that a broad exploration of the entire spectrum of possible activities, methodologies, and possible mastery levels was carried out, in such a way that there would be a varied representation of each one of them. Once coordinated, we proceeded to assign specific tasks to each of the participants based on their availability, always offering the support required by the teaching innovation team. After the identification period, we proceeded to assign specific tasks that would focus the work of each participant. The activities carried out can be summarized as:

7. Analysis by those responsible for the three PIME of the responses obtained to the questionnaire launched in Stage II.
8. Coordination of activities / methodologies between subjects by proficiency levels and potential contributions to the improvement of the web.
9. Assignment of the contributions of each agent to the different activities / methodologies and the web resource to be improved.

Stage III) Design of the e-learning platform in difficult TC

Phase 3: Designo f the contributions of each agent

After assigning the contribution to be made for each agent, we proceeded to the design phase of each of them. Any application had to be documented in detail in its formal aspect for possible follow-up by other students / teachers. The tasks consisted of:

10. Preparation of the contribution or web resource assigned to each agent.
11. Design an application example and document the TC and SC integration activity / methodology carried out, so that it can be replicated by other teachers.

Phase 4: Definition of the structure of the e-learning platform in difficult TC and integration of the contributions

During this phase, the existing websites were redesigned with the aim of turning them into a true e-learning platform in

"difficult" TC. For this, it was necessary to redesign the initial websites, integrating them into a single website, structuring the different contributions by domain levels. Thus, the main task of this phase consisted of:

12. Redesign the original TC websites with the contributions received and the suggestions for improvement obtained with the Stage I questionnaire.

4. RESULT: E-LEARNING CT ETSII PLATAFORM

As a result of the previous process, a single e-learning platform was obtained for the six so-called "difficult" TC (accessible in the ETSII Transversal Competences Blog, 2020): a more modern, simplified and friendly space in which they are integrated and similarly structured various learning objects targeting each of the difficult TC. New contributions have been incorporated into this platform, although existing resources have also been maintained, as well as varied application examples consisting mainly of videos on methodologies and their application, testimonial videos from various agents, questionnaires, self-evaluation activities, activities carried out in ETSII subjects for the training and evaluation of these TC, support websites and other learning objects.

The new platform is structured in several pages. The first one, called "Welcome", is designed for new students for whom TC is a totally unknown concept. This page is characterized by a cover that defines the transversal competences as understood in the UPV and values them in the student's curriculum both at an academic, personal and / or work level, with examples of the relevance that these TC have for some reference companies in their sector (Fig. 2).
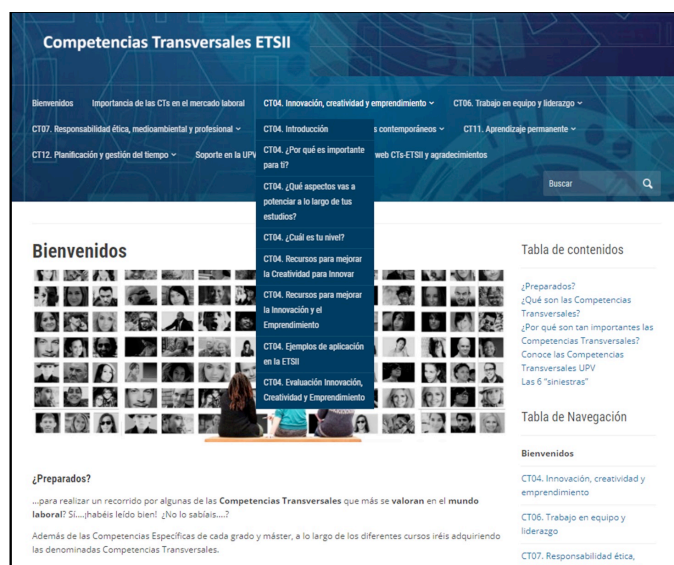

***Figure 2**. Welcome page of the CT ETSII-UPV e-learning platform. The drop-down menu shows the page structure of each TC.*

Subsequently, a page is included on the "Importance of TC in the labor market" with testimonies from different executives of leading companies in their sector to value TC and most of whom have graduated from the ETSII. Next, the platform dedicates a page to each of the six TC which, due to their difficulty or complexity when working, are colloquially referred to as the "sinister six": Innovation, creativity and entrepreneurship; Teamwork and leadership; Ethical,

professional and environmental responsibility; Knowledge of contemporary problems; Lifelong Learning and Planning and Time Management.

The development of these competences maintains a common and consensual structure that covers different concepts and areas through the following sections (Fig. 3):

- **Introduction:** where the TC is defined.

- **Why is it important to you?:** where it is intended to make the student understand the importance of also training in these TC, for which, in certain cases, learning objects made by students, graduates and / or employers are included.

- **What aspects are you going to enhance throughout your studies?:** which includes the learning outcomes that students are expected to acquire at the three levels as they progress through the different courses of the degree.

- **What's your level?:** showing self-assessment tools that can help students get a preliminary idea about their current proficiency level in the corresponding CT.

- **Resources to improve:** where different learning objects about methodologies and tools are included, organized by mastery levels so that students can improve such CT. These objects combine certain external material, but mostly made at UPV and made within the framework of the three PIME of CT.

- **Examples of application in the ETSII:** where the activities carried out by different subjects in the ETSII are shown through videos and sheets of good practices, organized by mastery levels, titles and subjects.

- **CT evaluation:** where the student is told that the evaluation of each CT can be carried out by the teacher, the student (self-evaluation), or his / her classmates (co-evaluation), and various instruments and examples are shown in ETSII subjects, some of which use rubrics.

Figure 3. *Common structure of material available about each of the "difficult" TC.*

As an example, and to give an idea of the size of the project and the amount of ETSII's own staff resources, section CT04. Innovation, creativity and entrepreneurship, has a video of a student of the ETSII and two of former entrepreneur students recounting their experience regarding this TC, two tests or self-assessment exercises on the level of development -one of them own resources-, 28 videos with techniques and resources to improve -12 of them own-, and 11 application examples (good practices) -all of them own-.

The e-learning platform obtained for the six difficult TC offers the possibility of being used in multiple ways. One of them is that students use it completely autonomously, which allows them to expand access to different types of educational resources according to their level. It would be a self-organized learning, understood as a learning method that students undertake independently, without following the prescribed curricular requirements or without depending on teachers (Ponti, 2014). In addition, the e-learning platform offers students valuable resources and learning objects to put these TC into practice throughout the tasks assigned in the course, and helps teachers to train and evaluate the corresponding TC. It is about teachers directing their students to specific objects and sections of the platform so that they can train and work autonomously prior to classes where they will be applied in an integrated way with the SC, either through classroom activities and / or academic works, with the substantial savings in time that this entails. Another alternative is for teachers to use the platform's resources to level the capacities of their students at the beginning of the academic year (Cuenca *et al.*, 2018). Finally, the platform has also been conceived as a tool for the vertical coordination of methodologies between subjects of the same degree by proficiency levels. In fact, this is one of the current lines of work in the ETSII of the UPV.

5. CONCLUSIONS AND FUTURE LINES OF INVESTIGATION

This article describes the work carried out over the last three years, first by the ETSII Educational Innovation team and then by more than 70 agents linked to said school under the protection of the ETSII Directorate, the Vice-Rector's Office for Studies, Quality and Accreditation (VECA) and the Institute of Education Sciences (ICE) of the UPV. As a result of the identification of the difficulty detected on how to work and evaluate certain TC in an integrated way with the SC in the TC control point subjects, the ETSII Educational Innovation team started a project, first of its own, and then under the format of three Educational Innovation and Improvement Projects (PIME) that covered the six difficult TC. The aim of these projects was to provide support to students and teachers when training, working and evaluating said TC, so as to minimize teaching resources already committed in the classroom, allocating them to a deeper learning of implementation.

The resources generated have been of great variety in terms of subjects of different levels of mastery and titles of the ETSII. In addition to the e-learning platform itself, it has deepened in providing content according to the objectives pursued, achieving a self-learning platform with a consistent structure, "user friendly" and with a common thread that facilitates understanding, and acquisition of competences through different proposals that work on them, and a variety of examples that illustrate their application in various contexts. Through this platform, support is provided to students who, independently or following the instructions of the teaching staff, wish to train in these TC in a more applied way, closer to Engineering and with examples more aligned with their future professional work.

After a first stage of design and implementation, the work team is now evaluating the results in terms of achieving improvement in the domain of the aforementioned TC and satisfaction with the products generated. During this process, a pre and post-use study of the platform is being investigated to observe possible changes in the perception and assimilation by students of the work carried out in the development of these TC. For the moment, the students have welcomed the initiative in a positive way and the fact of participating in the making of videos and learning objects has been a motivating element for them. Finally, it remains to carry out a global analysis and by subject to be able to draw conclusions about the impact that the e-learning platform has had on the competence level of the students.

REFERENCES

Alemany M. M. E., Villanueva J. F., Vallés-Lluch A. and García-Serra J. (2020). Web based on e-learning objects as support to the development of transversal competences for engineering students. *INTED2020 Proceedings*, pp. 2227-2235.

Alemany M. M. E., Vallés A., Villanueva J. F. and García-Serra J. (2021). E-learning in "innovation, creativity and entrepreneurship": Exploring the new opportunities and challenges of technologies. *Journal of Small Business Strategy*, 31(1), 39-50.

Alhabeeb A. and Rowley, J. (2018). E-learning critical success factors: Comparing perspectives from academic staff and students. *Computers and Education*, 127, 1–12.

Cano M. E. (2008). La evaluación por competencias en la educación superior. *Profesorado. Revista de currículum y formación del profesorado*,12, 1-16.

Escuela Técnica Superior de Ingeniería Industrial (2019). Web for the CT of Innovation, creativity and entrepreneurship. Available at https://www.etsii.upv.es/competencias/innovacion.php.

Escuela Técnica Superior de Ingeniería Industrial (2020). Blog for the ETSII Transversal Competences. Available at https://ctetsii.blogs.upv.es.

Instituto de la Ingeniería de España-Asociación para el Progreso de la Dirección. (2017) *Informe sobre competencias adicionales requeridas a los ingenieros por las empresas españolas*. Available at: https://www.iies.es/single-post/2018/02/20/APD-IIE-encuestacompetencias-ingenieros

Oksana P., Galstyan-Sargsyan R., López-Jiménez P. A. and Pérez-Sánchez M. (2020) Transversal Competences in Engineering Degrees: Integrating Content and Foreign Language Teaching. *Education Sciences*, 10(11): 296. doi: 10.3390/educsci1011029.

Rodrigues, H., Almeida, F., Figueiredo, V and Lopes, S. L. (2019). Tracking e-learning through published papers: A systematic review. *Computers and Education*, 136, 87–98. doi: 10.1016/j.compedu.2019.03.007.

Sá M. J. and Serpa S. (2018) Transversal Competences: Their Importance and Learning Processes by Higher Education Students. *Education Sciences*, 8(3):126. doi: 10.3390/educsci8030126.

Szafranski, M., Golinski, M. and Simi, H. (2017) *The Acceleration of Development of Transversal Competences*. Centria University of Applied Sciences: Kokkola, Finland, ISBN 978-952-7173-26-8.

Universitat Politècnica de València. (2015). Institutional Project of Transversal Competences. https://www.upv.es/entidades/ICE/info/Proyecto_Institucional_CT.pdf.