

# Can learning methodologies contribute to develop Digital Competences in telecommunication engineering education?

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**Abstract—** Digital Transformation has revolutionized the job market. New digital profiles emerge to exercise new professions. However, the gap between the Digital Competences required by companies and the skills developed by the young graduates is large. Current engineer curriculums for masters and bachelor degrees have recently been adapted to the European Higher Education Area (EHEA) and it is early to proceed new deep changes. Nevertheless, learning methodologies may contribute to develop new Digital Competences. In this study, two experiences have been analyzed in the context of a course of the MSc in Telecommunication Engineering at the Universidad Politécnica de Madrid. Results show positive effects in developing Digital Competences using gamification and mobile quizzes to promote an active learning. Millennials have a different mindset and getting them engaged requires new pedagogical techniques that can match their expectations.

**Keywords-** engineer education; digital competences; telecommunication engineer

## I. INTRODUCTION

Digital Transformation is deeply affecting the economy, while forcing companies to transform and adopt new competition drivers [1]. In most sectors, the value chain and the traditional relationships between companies are suffering deep structural modifications [2]. This new paradigm may become an opportunity to promote innovation and create value. However, these changes incur additional costs and risks, often unpredictable, and not everybody is ready to face them [3]. The companies that adequately manage digital

technology can expect added benefits in one or more of the following three areas: i) better customer experiences and engagement, ii) streamlined operations, and iii) new lines of business or business models. Nevertheless, despite the growing awareness of the need for Digital Transformation, most companies lack both the management temperament and relevant experience to know how to effectively drive such transformation through technology [4].

Therefore, Digital Transformation should not be considered as a new department or a new team in the organization. Instead, Digital Transformation implies a new way of thinking about business models, customer relationships and organization's processes [5]. According to the results showed in the report entitled “The Future Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution” of the World Economic Forum, a high percentage of professionals has not developed the Digital Competences needed to face the new emerging roles. One of the recommendations of the report is the need to rethink the education systems and encourage the joint work across businesses and education institutions to figure out what a true 21st century curriculum should look like [6].

Over the last few years, Higher Education curriculums have been reviewed and adapted within the European Higher Education Area (EHEA). The professionals trained in these degrees are now entering the labor market. It appears to be soon to introduce new deep changes in the curriculums, but Digital Competences may be included in other ways, such as leveraging on learning methodologies. The rest of the paper is structured as follows. Section II briefly describes the challenges to develop Digital Competences in engineering

education. Section III explains the methodology used and describes the experiences. Section IV reports the results obtained and the discussions. Finally, some conclusions are presented in Section V.

## II. CHALLENGES TO DEVELOPE DIGITAL COMPETENCES IN ENGINEERING EDUCATION

The European Union, through the EU Science Hub (the European Commission's science and knowledge service), has recently published the "DigComp 2.0 Digital Competence Framework for Citizens" describing 21 Digital Competences grouped into 5 areas [7]. Previously, DigComp 1.0 was published in 2013 and became the reference for many Digital Competences initiatives at both European and Member State levels [8]. DigCom 2.0 updates the framework in DigCom 1.0 with new vocabulary and descriptors, although the 5 areas remain equal, and gives examples of how DigComp is used in Europe. The new competences areas are the next:

- Information and data literacy. Competences of this area are centered in browsing, searching and filtering data, information and digital content; evaluating and managing digital content.
- Communication and collaboration. These competences focus in interacting, sharing and collaborating through digital technologies. They include recommendations to manage the digital self-identity and participate in society through digital services.
- Digital content creation. It is necessary to program and to understand copyright and licenses to develop digital contents, because in most of the cases new digital contents emerge from the modification, refinery, improvement and integration of existing information and content.
- Safety. Digital contents, devices, personal data, privacy, health and the environment are new strategic values and must be protected. It is important to understand how to avoid risks and to perform a sustainable use of technology.
- Problem solving. The competences of this area consist on the identification of needs and technological responses to reduce the digital gap with creativity and innovation using digital technologies.

Recent studies have analyzed the use of DigComp in teaching and learning strategies [9]. Results show how some authors conclude that schools and higher education institutions are not getting a fully assessing and amplification of the students' Digital Competences [10]. Other studies point to the lack of Digital Competences training in the professors as one of the principal barriers in the development of Digital Competences. Professors need to be familiar with digital environments, new pedagogical techniques and collaborative networks to enable such competences in others [11]. They are considered a key factor in the broadcasting of Digital Competences. We need a novel teachers' orientation towards an innovative, proactive, collaborative and critical learning of technology that empowers student in an adequate

use of Information and Communications Technologies (ICT) [12]. Finally, the literature suggests to promote the use of content management tools in both student-student and student-teacher interactions to contribute to the development of the Digital Competences [13].

In higher education, the students in their final years are radically different to students from a decade ago. They are the first generation brought up with Internet, videogames or smartphone, and their mindset is different from their predecessors [14-15]. There are different designations for these new students: digital natives, millennials, digital learners, google generation or i-Generation [16]. According some authors, the current curriculum and methodology is not designed for them, and the students' expectations are fully opposite to what the professors' offer [17]. The findings of Erstad [18] show four key areas to promote digital literacy: i) encouraging the participation and sharing of information in social media, ii) accessing and researching digital information iii) promoting new communicative skills online iv) creating digital contents contributing to the contents on the Internet, using digital tools and understanding the rules for re-use and copyright.

In engineering education, some challenges emerge as a result of these new environment. Students who have finished a degree are ready to enter the job market. Nevertheless, some studies show that the self-perception of the students about their Digital Competences is substantially different from the employers' perception [19]. Master degrees should contribute to reduce this gap in more dynamic ways than through the academic curriculum. Besides, while doing a master, most of the students combine their studies with an internship in a company. This fact complicates their availability and, in consequence, the possibility to develop a correct ongoing assessment. In education, engagement has been identified as a valuable indicator of students' academic accomplishments [20]. New methodologies may contribute to solve this problem and promote the development of Digital Competences without complex changes in the curriculum. Active methodologies, like gamification, have the potential to engage students in learning activities, as engagement has been proved as positively correlated with students' success, including satisfaction, persistence, and academic achievements [21-23]. Developing Digital Competences is also positively correlated with student success, [24]. Against this background, it is important to analyze whether the new learning methodologies can contribute to develop Digital Competences, as we do in the present paper.

## III. METHOD

The aim of this paper is to analyze whether learning methodologies can contribute to develop Digital Competences in telecommunication engineering education. Particularly, the study analyzes the results obtained in two experiences in a course of the MSc in Telecommunication Engineering at the Universidad Politécnica de Madrid. The course is entitled "Strategic vision of technologies and systems integration in the ICT sector" is a 3 ECTS course taught during the first semester of the first academic year of

the Master. The course has been developed three times since the creation of the degree and in the last two editions, two experiences with innovative methodologies have been developed. The methodology of the course has been similar throughout all the years. Students can choose between a final exam and an ongoing assessment. The lectures combine a master class with the resolution of two case studies within each topic of the course program. The differences between the two experiences developed are shown below.

#### A. Description of experiences

1) *Gamification*. In the academic year 2015/16, the assessment of the course was split in three parts: an assignment weighted 20%, an exam with a practical case which represents 20% of the final grade and a more theoretical exam weighted 60 percent. The assignment was gamified to promote the participation of the students. The assignment consisted in developing digital content choosing between a video and an essay about digital economy. All these contents joined to a competition sponsored by the “*Cátedra Telefónica Economía Digital*” with five awards in each of the two categories of the assignment. In the video category, students could develop their assignments in groups, but the essays had to be individual. Both videos and essays had to be developed to be published in the blog of the sponsor. Videos had to be complemented with a short description and for the essays, it was recommended that they included images, hyperlinks and other multimedia contents. The assignments were assessed by the professors and after finishing the course, an event was organized to grant the awards. The jury panel was composed by three professors and two professionals from the sponsor. Finally, all contents developed were published in the blog of the “*Cátedra Telefónica Economía Digital*” [25].

2) *Online quizzes*. In the academic year 2016/17, the assessment of the course was split in three parts: a group assignment weighted 10%, short online quizzes representing a 20% and a final exam weighted 70 percent. The assignment consisted in a group work about the different topics of the course, contributing to elaborate or update notes for future students. The quizzes had to be undertaken at the beginning and at the end of the class. The students could access the materials available in Moodle beforehand to get prepared for the quizzes. First questionnaires analyzed if students had read the materials, and the ones at the end of the class analyzed if they had followed the lecture. During the lecture questions were taken to clarify doubts. The quizzes were available in Moodle and students could answer using their smartphones.

#### B. Participants

The MSc in Telecommunication Engineering, in which the course of study is framed, enables graduates to practice regulated Telecommunications Engineering activities. Therefore, students have curricula with a previous degree in telecommunications, electronic or telematics engineer. The study collects data from two different academic years. Table I shows the distribution of gender and number of students by academic year.

TABLE I. GENDER DISTRIBUTION BY ACADEMIC YEAR

<i>Academic year</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>
2015/16	103 (67.3%)	50 (32.7%)	153
2016/17	98 (76.6%)	30 (23.4%)	128

#### C. Data collection of the study

To analyze the results of the study different data were collected in each experience. In the Gamification experience video and essays evidences were classified according to the author to compare with their final grades. In the Online Quizzes experience all grades of different questionnaires were registered in the Moodle, and final grades were collected to analyze them. An anonymous survey about the experience was taken at the end of the course in both Gamification and Questionnaires experiences. These surveys were in 5-point Likert scale (1 minimum to 5 maximum). Surveys are structured in five items: motivation, usefulness, learning, research and satisfaction, with several questions by item.

## IV. RESULTS

#### A. Gamification experience

In this experience students developed their assignments in two categories: videos and essays. Table II shows a summary of the participation results. Most of students worked on essays with a 73.2 %. However, the assignment grades in video category were significantly higher than essay with p-value <0.001. In the case of the final grade, no significant differences were founded.

TABLE II. GAMIFICATION EXPERIENCE RESULTS BY CATEGORY

<i>Category</i>	<i>N° students</i>	<i>Assignment Grade (Mean/SD)</i>	<i>Final Grade (Mean/SD)</i>
Video	41 (36.6%)	4.51 (0.53)***	7.56 (0.97)
Essay	112 (73.2%)	3.73 (1.01)	7.26 (0.99)
Total	153	3.92 (0.97)	7.33 (0.99)

\*\*\* Significant difference p-value<0.001

Final survey of the experience was collected before the awards ceremony, a sample of 105 was processed (68.63% of the students). Table III shows the results of the different items by category. All of them are above 3 points of 5. In the items about the motivation of the experience, usefulness and research, no significant differences were found. However, in the items about learning and satisfaction, students from the video category perceived a learning and satisfaction with the course significant higher than essay category.

TABLE III. GAMIFICATION EXPERIENCE SURVEY RESULTS BY CATEGORY

Item	Category	(Mean/SD)	p-value
Motivation	video	3.52 (1.12)	p=0.708 p>0.05
	essay	3.11 (1.20)	
	Total	3.23 (1.18)	-
Utility	video	3.58 (0.85)	p=0.246 p>0.05
	essay	3.31 (1.03)	
	Total	3.39 (0.98)	-
Learning	video	4.08 (0.86)	p=0.031 * p<0.05
	essay	3.27 (1.09)	
	Total	3.51 (1.09)	-
Research	video	3.68 (1.07)	p=0.489 p>0.05
	essay	3.23 (1.16)	
	Total	3.36 (1.15)	-
Satisfaction	video	3.94 (0.98)	p=0.0036 ** p<0.005
	essay	3.46 (1.10)	
	Total	3.60 (1.90)	-

\* Significant difference p-value<0.05 \*\* Significant difference p-value<0.001

### B. Online quizzes experience

In this experience, students answered the questionnaires at the beginning and at the end of each class. This experience was accomplished in both master classes and practical classes. Table IV shows the results of questionnaires by class type.

TABLE IV. MOBILE QUESTIONNAIRES RESULTS BY CLASS TYPE

Class type	Beginning questionnaires	Ending questionnaires	p-value
Master Class	2.33 (1.39)	4.08 (0.70)	p=0.000 *** p<0.001
Practical Class	1.86 (1.19)	3.39 (1.20)	p=0.000 *** p<0.001

\*\*\* Significant difference p-value<0.001

A final survey of the experience was collected before the final exam, a sample of 55 was processed (42.97% of the students). Table V shows the results of the different items. All of them are above 3 points of 5. The item best valued is the satisfaction with the questionnaire experience, followed by the perceived usefulness and the increase of motivation. The lowest valued items are the perception of the learning with the experience and the improvement in the research capability.

TABLE V. MOBILE QUESTIONNAIRES EXPERIENCE SURVEY RESULTS

Item	(Mean/SD)
Motivation	3.55 (1.08)
Utility	3.69 (0.94)
Learning	3.22 (1.18)
Research	3.07 (1.23)
Satisfaction	3.89 (1.00)

## V. DISCUSSION AND CONCLUSION

Both the Gamification experience and the Online Quizzes experience are strongly associated with some of the areas of the Digital Competences defined in the framework of the European Union [7-8]. In the case of Gamification, students' assignment consisted on the elaboration of digital content about Digital Economy. This experience promoted the development of competences in the following areas: Digital content creation, Information and data literacy, and Communication and collaboration. The self-perception was positive in both video and essays categories. However, in the video category the self-perception was higher than in the essay one in all items. Particularly, the differences were significant in the learning and satisfaction self-perception. Video creation requires the use of more Digital Competences than essay writing. It is important to note that academic performance of the students was significant higher in the video category too. This effect is not significant in the final grades, but this is congruent with the findings of Hatlevik et al. [24], who showed that students with the higher development of Digital Competences get better academic results. Students quickly understood the assignment and elaborated their videos and essays to be published in the sponsor's blog. The satisfaction with the experience was good, maybe because this assignment was more aligned with the expectations of the students and according to their new mindset [17].

In the Mobile Questionnaires experience, competences about Information and data literacy, Communication and collaboration, and Problem solving were developed. All items were positively valued, however satisfaction, usefulness and motivation stood out more than the others. This experience was more interactive because in all the lectures students got some feedback and had the chance to raise their doubts. Students' participation was encouraged according to the Erstad recommendations [18]. Results showed that the grades of the beginning quizzes were substantially worse than those of the quizzes at the end of the lecture. Students perceived the quizzes as a learning measure, this explains that the perception of learning was not one of the most valued, opposite to the usefulness. However, professors found here a very useful tool. When students answered the questionnaires at the beginning and at the end of the class, their names got registered in the system, so it was not necessary an attendance control. Traditionally,

students have perceived the attendance control as an invasive technique, but attendance is important to accomplish a correct ongoing assessment.

In conclusion, the challenges to develop new Digital Competences may be faced including new learning methodologies in the course. Millennials have a different mindset and getting them engaged requires new pedagogical techniques able to meet their expectations. New innovative education models emerge with encouraging results: Flipped Classroom, Gamification, Learning-Service, Augmented reality, lifelong learning and more. Education must not be at the end of the Digital Transformation process, it must be at the front so as to train the future leaders to understand the new digital paradigm.

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