**International Symposium Industry and Energy**

**Assimilating digital educational technologies for higher education in the mechanical engineering area. A literature surveys**

***Asimilación de tecnologías educativas digitales para la enseñanza superior en el área de la ingeniería mecánica. Un estudio bibliográfico***

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**Abstract:**

Problem to deal with: Technology in its different configurations is a facilitator of educational changes. These changes are based on global trends that, if identified in a timely manner, allow educators to act and adapt effectively to the needs of the educational community. Methodology: In this context, through literature review techniques, some of the educational digital tools for higher education, useful for teaching mechanical engineering, are detailed so that students and teachers have access to the necessary educational material and can cooperate from anywhere. This requires customized educational technologies that facilitate the very demanding tasks required by the new educational roles of teacher and students. Digital competencies are considered a driver of educational innovation since their immediate result is the production of new digital media resources for teaching. Aims: the objective of this paper is to show the current state of educational digital technology for higher education in the area of mechanical engineering at the Central University "Marta Abreu" of Las Villas, in order to share this knowledge with all the actors involved in the teaching of mechanical engineering. Results and Discussion: the results of this study explain to what extent professors consider themselves skilled in the use of digital technological tools and digital resources. Conclusions: Most of the authors consulted agree that the use of these digital tools help to improve learning outcomes and student performance

***Keywords:*** Educational technology, Innovative teaching, Digital competencies, mechanical engineering

***Resumen***

Problemática: La tecnología en sus diferentes configuraciones es un facilitador de los cambios educativos. Estos cambios se basan en tendencias globales que, si se identifican oportunamente, permiten a los educadores actuar y adaptarse eficazmente a las necesidades de la comunidad educativa. Metodología: En este contexto, mediante técnicas de revisión bibliográfica, se detallan algunas de las herramientas digitales educativas para la educación superior, útiles para la enseñanza de la ingeniería mecánica, para que estudiantes y profesores tengan acceso al material educativo necesario y puedan cooperar desde cualquier lugar. Esto exige tecnologías educativas personalizadas que faciliten las tareas tan exigentes que requieren los nuevos roles educativos del profesor y de los estudiantes. Las competencias digitales se consideran un motor de la innovación educativa ya que su resultado inmediato es la producción de nuevos recursos mediáticos digitales para la enseñanza. Objetivo: El objetivo del presente trabajo es mostrar el estado actual de la tecnología digital educativa para la enseñanza superior en el área de la ingeniería mecánica en la Universidad Central "Marta Abreu" de Las Villas, para compartir este conocimiento con todos los actores involucrados en la enseñanza de la ingeniería mecánica. Resultados y discusión: Los resultados de este estudio explican en qué medida los profesores se consideran hábiles en el uso de las herramientas tecnológicas digitales y los recursos digitales. La mayoría de los autores consultados coinciden en que el uso de estas herramientas digitales herramientas ayudan a mejorar los resultados del aprendizaje y el rendimiento de los estudiantes

***Palabras Clave*:** Tecnología educativa, Enseñanza innovadora, Competencias digitales, ingeniería mecánica

**Nomenclature**

|  |  |
| --- | --- |
| Acronyms | |
| AOD | Asynchronous online discussions |
| CSCL | Computer Supported Collaborative Learning |
| DC | Digital Competence |
| DL | Digital Learning |
| DLO | Digital Learning Objects |
| EdTech | Educational Technology |
| ESD | Education for Sustainable Development |
| FIMI | Faculty of Mechanical and Industrial Engineering |
| F2F | Face to face |
| IoT | Internet of things |
| LORs | Learning Object Repositories |
| MES | Cuban Minister for Higher Education |
| Moodle | Modular Object-Oriented Dynamic Learning Environment |
| MOOCs | Massive Open Online Courses |
| cMOOCs | The connectivism MOOCs, based on connectivism distributed peer learning model |
| xMOOCs | Content-based MOOCs, delivered through proprietary learning management platforms of institutions or individual academics. |
| OER | Open Educational Resources |
| PEST | Political, Economic, Social and Technological factors |
| PBL | Project Based Learning |
| RQ | Research Questions |
| UCLV | Universidad Central "Marta Abreu" de Las Villas |
| FIMI | Facultad de Ingeniería Mecánica e Industrial |
| VLE | Virtual Learning Environmental |
| VR | Virtual Reality |
| XR | eXtended Reality |

**1. Introduction**

Digital teaching and learning embrace active pedagogy and learner-centered approaches. The basic assumption is that learners are unique and therefore learning should be personalized. As argued (Philippe et al., 2020), learner's centered activities value intrinsic motivation as well as metacognition for a more personalized and meaningful learning process. Today, at FIMI the fundamental contradiction is given by traditional education environment in opposition to dynamic environment.

Case study teaching increases student perception of learning gains related to fundamental course objectives but is not here frequently in relation to teaching engineering. Using a case-based approach engages students in discussion of specific scenarios that resemble or typically are real-world examples. This method is learner-centered with intense interaction between participants as they build their knowledge and work together as a group to examine the case. The instructor's role is that of a facilitator while the students collaboratively analyze and address problems and resolve questions that have no single right answer.

The notion that professors have about "Challenge-Driven Education" in the university is very poor. They do not know its inner workings and characteristics. It is possible to disseminate international experiences as well as presented in Challenge driven projects – five compelling examples (Marie Magnell & Anna-Karin Högfeldt, 2014)

Activities utilized within F2F flipped class included; case-based presentations, team-based discussions, panel discussions, expert led discussions, role-plays and student presentations, discussions and debates (Jacqueline O’Flaherty & Craig Phillips, 2015). Initiatives that try to radically change the usual rules of face-to-face training and require students to leave their comfort zone (e.g., flipped classroom models, gamification, project-based learning and telecollaboration), are not common in the career, but initiatives such as the international cooperation project "Europe-Brazil-Bolivia-Cuba capacity building through globally available digital learning modules", where faculty members participate, are focused on reversing this situation.

Massive open online courses (MOOCs) are one of the most prominent trends in higher education in recent years. It represents open access, global, free, video-based instructional content, problem sets and forums released through an online platform to high volume of participants aiming to take a course or to be educated. The most well-known xMOOCs are sites such as Coursera, edX, Udacity, Udemy, Khan Academy, FutureLearn and Venture Lab (Kesim & Altınpulluk, 2015). Although their structure and philosophy are very different, they all start from the fact of recreating a virtual environment that allows to carry out, with the highest quality, distance learning teaching processes. This is extremely useful for the current needs of universities, not only to carry out distance learning processes, but also to support traditional teaching, offering new tools that were unthinkable until recently. The Moodle platform at UCLV really offered courses that are produced by one teacher towards their own students.

The term Open Educational Resources (OER) was coined at UNESCO’s 2002 Forum on Open Courseware and designates teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions (UNESCO, 2012). The main types of OER typically used comprise course materials, software, videos, textbooks and other learning objects used in online teacher education programmer or F2F program. In the other hand, OER enable forms of collaborative learning and LORs of today can be considered as computer supported collaborative learning (CSCL) environments as they provide users tools for posting knowledge productions into a shared working space and providing tools for progressive discourse interaction between the users (Clements et al., 2015)

The notion that professors have about "Remote Lab", "video-sites", "digital examination sites", and "calculation exercise correction" in the university is very deficient. They do not know its inner workings and characteristics. So far has been used the Open access remote photovoltaics laboratory and associated open educational resources for online training and education from the University of West Attica Renewable Energy Resources Laboratory.

There is a small group of teachers in the career who have appropriate digital resources and a significant background of experience in this area; produced, for example, through academic exchanges, participation as guest lecturers, or participation in training programs or projects, which probably do not have great difficulties to ensure continuity. In the remaining cases of teachers, which are the majority, the simplest option consists of reproductively uploading their classes (lectures, seminars, practical classes) to the Moodle platform.

Basically, MOOCs courses based on areas of student engagement (Boris Kiselev & Vyacheslav Yakutenko, 2020) are:

* Video lectures: Video lectures in MOOCs have various presentation styles, from talking heads to lecturing instructors.
* Forums: Forums are where students post questions and other students replies, and are the main method of student interaction between course takers and instructors. Forums usually consist of general discussion, subject-specific discussion, course feedback, and technical feedback threads.
* Readings: Most MOOCs do not require students to buy books, and most readings are available online or provided by course instructors
* Activities: A range of instructional activities are offered, with the aim of allowing students to further test their understanding of the course concepts.

The use of remote labs, simulators and programming tools to facilitate the understanding of certain contents is not frequent here. We are thinking that the teacher and students will accept a remote lab. According to several papers,among which(Darrah et al., 2014)andthe recent study of(Vijesh J. Bhute et al., 2021),(Larriba et al., 2021) Important benefits are identified as a result of their use, such as the increase in student motivation and a more efficient deployment of pedagogical strategies. In addition, the acquisition of technical knowledge can be improved, and a wide range of competencies can be developed.

Garcia Acevedo (Jose Garcia-Acevedo et al., 2020) organized a survey to determine the primary indicator that measures the quality of e-learning systems considering the two main perspectives, pedagogical and technical. He used different criteria such as the learning environment, efficiency, performance, reliability, functionality, usability, interaction, services, customization, learning activities, access, cost, technology, content, among others. The educational package is constituted by three interactive software that studies the combustion processes, the second law of thermodynamics, and the energy balance applied to open systems. The average student grades in the three cases were higher when using the software than without using them. It indicates that the three software significantly improved the cognitive skills of the students.

The EUBBC-Digital project should be carried out through the appropriate use of technologies in different learning scenarios and technical aspects by offering infrastructures for better connectivity, more access points through the purchase of dedicated equipment, more advanced multimedia material to be made available on the platform, transfer of skills for the management of the platform, transfer of teaching methodologies and pedagogical approached in digital education. This project effectively facilitates the partner experiences exchange and transference in digital learning to UCLV. The EUBBC-Digital project will give the universities a unique possibility to, commonly and together with the EU-partners, establish a for the country’s unique methodology of digital learning, establish a Master program in a energy area with options to thereafter utilize the same methodology of digital learning towards other engineering subjects.

**2.**  **Materials and Methods**

A qualitative systematic review of the global literature was undertaken using an established methodology from the fields of education, health policy and practice according to (Sarah R. Lambert, 2020). The techniques and instruments used included observations, focus group discussions and semi-structured survey. A total of 11 teachers were considered, although for many reasons only 6 successfully completed the survey. The distribution by gender was 1 woman (16.6%) and 5 men (83.3%). All of participants teachers regularly teach face-to-face. A SWOT (Strengths, Weaknesses, Opportunities, Threats) matrix was made (see Appendix A 1)

FIMI professors are aware of the importance of introducing new tools, technologies and forms of learning such as the one established in the flipped classroom, Remote Lab, Case-Based teaching, Student-Centered Education, Challenge-Driven Education and so. Professors and students are motivated to have greater access to others and new repositories with learning materials on energy engineering. The use of new methods of instruction, accessing to knowledge through innovative learning platforms increases motivation of the students and teachers. Digital platforms make the educative process attractive and modern. We would like a sustainable transformation of the environments of teaching and learning,

The use of new methods of instruction, accessing to knowledge through innovative learning platforms increases motivation of the students and teachers. Digital platforms make the educative process attractive and modern. Geographical boundaries are no longer a problem, this promotes equity and equality of opportunities in educational spaces. To create a new, and for the partner countries, unique Open Challenge- and Digital-Based Educational Concept based upon a shareable “repository” global collaboration, with a high degree of student-centered and entrepreneurial learning towards 21st century digital skills, and implementing this in a pilot concept.

A review of the available technological tools that can be used in education was performed by (Hernandez-de-Menendez & Morales-Menendez, 2019). Examples and the benefits and results of their use in teaching and learning were presented. Virtual environments, digital games, web-based learning platforms, robots, virtual labs and simulations, mobile devices, social networks, the internet of things, text and content analytics, learning analytics, assessment and feedback tools are some of the technologies that have been adopted in education with interesting results. Recent research and reports were found in which an analysis of the effectiveness of these tools was done (Parra-González et al., 2021), (Bhute et al., 2021), and (Tuma, 2021)

In order to describe the state of OER as a possible tool for ESD at Faculty of Mechanical-Industrial Engineering at UCLV, it is necessary to look at the repositories that are established to provide teachers with materials additional to the classic textbooks with their restricted view on the teaching content and their media-inherent lack of representing current affairs. Moodle is the most popular repositories an UCLV.

LOR are multi-functional platforms which are designed to facilitate access to reusable learning objects in a variety of formats, so users can search for, find and make use of this content. The purpose of a repository is not simply safe storage and deliver resources, but allow their administration in terms of updating, identifying, utilizing, sharing and re-using them

Under the name of “Open Educational Resources” (OER), innumerable working sheets, curricular and teaching units have been developed and shared digitally under free commons licenses, connecting teachers and learners worldwide. Especially with regard to the UNESCO Education for Sustainable Development (ESD) Program, the concept has been allocated a pole position. However, challenges arise when it comes to matters of repository design, traceability, quality control and user acceptance (Roeder et al., 2017). OER, defined as ‘teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain. The main types of OER typically comprise course materials, software, videos, textbooks and other learning objects often used in online teacher education programmers (Littlejohn, A et al., 2008); however, a consensus about the types of materials that integrate OER has not yet been reached. Digital Competence (DC) is considered a driver for educational innovation since its immediate result is the production of new digital media resources for teaching such as Open Educational Resources (OER). Teachers’ DC is becoming a crucial element for the construction of useful pedagogical knowledge for practice and, consequently, improving students’ learning (Ramírez-Montoya et al., 2017).

**3. Results and Discussion**

In an era of technological explosion, the methods of providing education, especially engineering education, to present and future generations need to be changed dramatically to make engineering graduates ready to tackle the challenges posed by a world which promotes rapidly accelerating changes (Bhat et al., 2020). The literature tells us that one of the primary components of effective teaching is student engagement and that engagement is critical for learning.

MOOCs is the latest trend in the field of distance education which seems to go on for some time which indicate a significant need of research studies on it (Meltem Huri Baturay, 2015). A diverse set of open and proprietary technologies were found to deliver the programs, including for-profit and not-for-profit technology platforms, social-media based “cMOOCs”, as well as non-English and community-based MOOC platforms (Sarah R. Lambert, 2020). The frequency of different course delivery technologies is shown in Fig. 1 below. Multiple MOOCs was the most popular delivery choice, and 3 of the top 4 more frequent delivery choices involved more than one platform or tool.

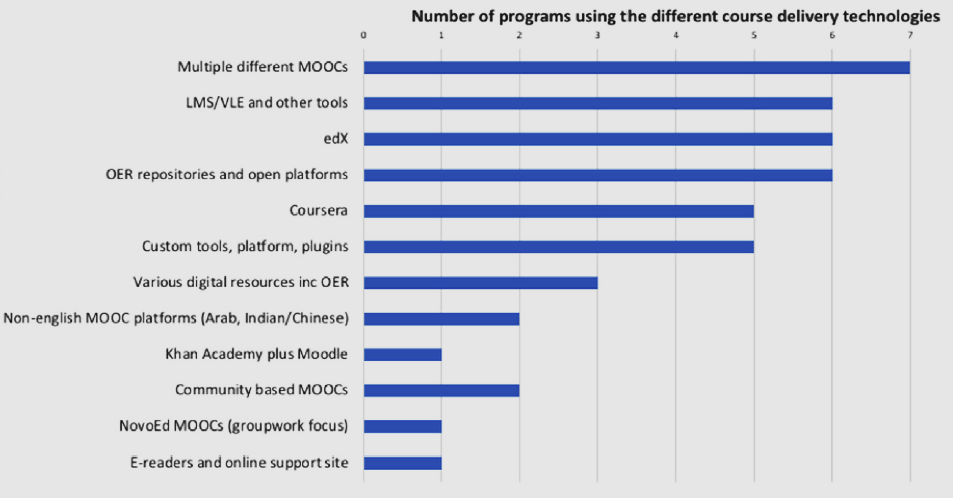


Figure 1. Frequency of the different course delivery technologies (N=45) (Sarah R. Lambert, 2020)

MOOCs have drawn attention and appealed to users previously unable to take courses from esteemed universities and their staff. This situation is not expected to be met enthusiastically by educational institutions and administrators providing face to face education. The development of thinking, creating, active individuals has become more important than diplomas and degrees. In this regard, even with the limitations carried, the emergence of MOOCs has brought a new page in education through offering high quality, open, and free courses. The most elite universities throughout the world are endeavoring to take part in this establishment, because such membership has become a symbol of the reputation and brand worth of institutions. The trend has become to reach more students at a lower cost. MOOCs appear to be the solution for the realization of this goal (Boris Kiselev & Vyacheslav Yakutenko, 2020) and (Joshua Littenberg-Tobias & Justin Reich, 2019).

The authors (Jacqueline O’Flaherty & Craig Phillips, 2015) and (Bhat et al., 2020) considered to establish how key aspects of the flipped class contribute to its effectiveness and to an improved student learning experience. These key aspects include: the design and conceptual framework of the flipped class, as well as the types and utilization of specific technologies to engage students. In addition, the authors wished to explore whether economic drivers as well as pedagogical acceptance by key stake holders were important factors effecting student flipped learning outcomes.

Result of survey on understand knowledge about flipper classroom among FIMI professors are presented in figure 2.

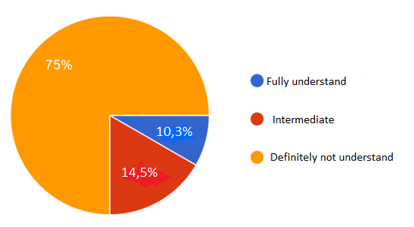


Figure 2 Result of survey on understand knowledge about flipper classroom among FIMI professors. On a scale from 1 to 3 (1=definitely not understand; 2 =intermediate; 3=Fully understand)

The flipped model has the potential to enable teachers to cultivate critical and independent thought in their students, building the capacity for lifelong learning and thus preparing future graduates for their workplace contexts. However, there is a danger that educators renewing their curriculum may not fully understand the pedagogy of how to effectively translate the flipped class into practice. From our findings it is evident that there is no single model for the flipped classroom to date but core features of the flipped learning approach include: content in advance (generally the pre-recorded lecture), educator awareness of students understanding, and higher order learning during class time. Outcomes of implementing a successful flipped class approach should consider effective student learning that facilitates critical thinking, and importantly improves student engagement, both within and outside the class. (O’Flaherty & Phillips, 2015) and (Bhanu Sharma & Archana Mantri, 2020).

Typically, the teachers associated with engineering education face two specific challenges while dealing with any course that they teach. The first challenge is to have a coverage of course content that is good enough for the students to prepare for the term-end examinations. Secondly, the teacher is also expected to make the classroom active enough so that the students could interact with their peers about the technical content learned and be able to apply their learning in the real world we (Zhiru Suna & Kui Xie, 2020) explored how students learn in the pre-class setting of an undergraduate flipped math course, investigated the relation of the pre-class learning behaviors with students' math performance over time, and examined the impact of achievement goals on the pre-class learning behaviors.

More than twenty competencies were identified (Hernandez-de-Menendez & Morales-Menendez, 2019) including Critical Thinking, Collaboration, Communication and Confidence. The use of technology in education promotes the development of specialized competencies such as Metacognitive, Spatial, Procedural Knowledge and Self-agency. Digital knowledge is also promoted among students and faculty. In answering research question of required competencies for teaching are presented in figure 2. We did observe a special preference for digital competences within the teacher.

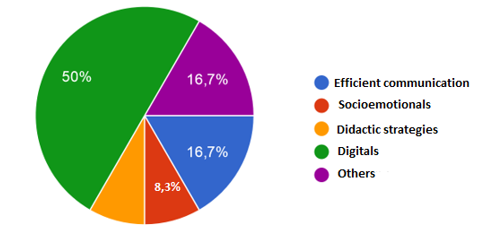


Figure 2. Result of survey on competencies were identified among FIMI professors

Finally, methods are changing the use of ICTs even in education; Internet of things (IoT) (Page, T, 2015), Data Analytics, Machine Learning and Artificial Intelligence, are promissory tendencies to use in engineering teaching. The “things” are any appliances, servers, devices, etc. that are connected to the internet and serve as autonomous tools useful in making teaching activities more attractive and efficient.

From survey as well as interview to teaches was also discovered that most teachers are interested in high- quality education and are eager to enhance their courses. At the same time, it is clear that there are many obstacles, for example, time and resource scarcity. Further obstacles arise from a conflict between balancing research and teaching activities. In order for pedagogical development to take place there is a need for things such as an active interest on behalf of management and also dialogue with colleagues on matters of education.

Today is very important imperative useful suggestions and guidelines for the renovation of educational buildings, in order to do University classrooms safe and sustainable indoor places, with respect to the 2020 SARS-CoV-2 global pandemic (Ascione et al., 2021). Cox (John Cox, 2021) outlined briefly some possible future implications of the global coronavirus crisis and highlights the importance for library operations and strategy of monitoring and understanding developments in higher education. Using the established PEST analysis methodology, the article foregrounds higher education throughout and finds major ongoing changes across all four dimensions globally, creating challenges and opportunities for libraries

**4. Conclusiones**

Based on literature review and interview analysis from which research findings and conclusion are derived:

* Sustainable development needs high quality ESD. At UCLV, the educational frameworks have been rewritten to include ESD implicitly by directing all educational efforts towards fostering competitions within the students.
* Virtual environments, digital games, flipped classroom, video-sites, digital examination site, calculation exercise correction, web-based learning platforms, robots, virtual labs and simulations, mobile devices, social networks, the internet of things, text and content analytics, learning analytics, assessment and feedback tools are some of the technologies that have been adopted in education with interesting results. Future research should investigate deeper in each technology, mainly to determine the educational effectiveness in particular contexts at UCLV. Also, it would be important to identify the challenges an organization could face when adopting these innovative technologies.
* Recent research and reports were found in which an analysis of the effectiveness of these tools was done. It was determined that they support the development of competencies in both students and professors. Also, they offer convenience as students and professors have a lot of flexibility when using them. Besides, aspects such as engagement, motivation, satisfaction and retention of students are improved. But the most interesting findings lie in the fact that these tools also aid in improving learning outcomes and the performance of the students.
* At present students use ICT as the main way for its self-preparation. The digital learning platforms Moodle and digital education is being promoted by the institution, although there are teachers who can handle this platform pretty well, there are many others who still stuck to classical teaching and learning models. Good communication with students and colleagues is often crucial to success.
* There is at UCLV an official Learning Management System (LMS) available in Moodle platform. Several postgraduate courses were taught with the purpose of train the teachers in the use of the LMS. Currently institutional publics repositories exist, e.g. <http://dspace.uclv.edu.cu> A department for educative technology and a virtual platform for education purposes exist, <https://moodle.uclv.edu.cu/>.
* Partners at FIMI-UCLV are powerfully convinced that aim of international collaboration in the field of renewable energy should be to inspire teachers, students and “challenge owners” to jointly develop solutions to technical, societal and sometimes very complex problems, in a way that incorporates demands on higher education quality.
* The results showed should be cautiously interpreted within the realm of personal teachers viewpoints; that is to say, they talk about the extent to which teachers consider themselves skillful in the use of technological tools and resources. Thus, more systematic research should be conducted in this direction to explore how teachers are implementing digital materials in their teaching and to confirm whether these actions align with their self-perceptions.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Appendixes**

**A 1. SWOT MATRIX ANALYSIS FOR MECHANICALS ENGINEERING MASTER PROGRAM AT UCLV**

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| **Strengths**   * UCLV play an important role in the country in the field of energy technologies. * Every year in average 50 student of mechanical engineering complete their engineer degree at the faculty and about 30 postgraduate courses are given * Specialist teachers in the area of knowledge with competences to develop digital education. * Socialized digital native students who interact commonly with new technologies, with new forms of communication and have access to information. * Programs designed by objectives for the development of skills and competences in the field of energy. * Strong management of educational digital content in the university. | **Weaknesses**   * Few educational practices in digital platforms. * Teaching competences in virtual/digital environments require improvement. * Old material and technological base. * Low motivation of the teachers since programs so far has been designed to face to face teaching. * Digital gap, and low interactivity through digital platforms, between teacher-students, teacher-teachers and student-students. * Low number of trained professionals with the necessary skills for the knowledge society and take advantage of the potential of digital technology for learning. * Most learners are digital natives more experienced teachers are not digital natives * Poor approach to the study of educational communication in the university faculties |
| **Opportunities**   * Transformation of the environments of teaching and learning. * Creation of virtual learning environments, with non-traditional methodological approaches. * Transit from individual to collaborative learning and teaching. * Evolution from the transmission to the construction of knowledge. * Advance in the development of digital learning competences to support changes in the social, economic and technological field in order to develop education in the knowledge society. * Improve the didactic nature of digital platforms as forms of communication and access to information. * Transversal nature of ICT in teaching and learning processes as an essential competence to improve the quality and effectiveness of the educational System in a critical manner. * Incorporation of new educational concepts to the regulations of the national board for engineering educational programs. | **Threats**   * Limited connectivity speed * Insufficient technological resources. * Traditional process of teaching and learning deeply established. * Limited access to high technology devices. * Some learners and teacher may have difficulties to afford a laptop, smartphone or tablet to study as they are expensive devises. |