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Bridging the Gaps between Technology and Engineering Education*

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The great technological development in which we are immersed has changed the scenarios, tools and forms of learning. In the light of those challenges, engineers must be able to develop new skills and abilities to face them, through planned technical pedagogical training that allows them to link technology with engineering education. As a result of previous research, the need for a link between technology and education in engineering was evident, as was the need for training in platforms for the creation of virtual learning spaces. To this end, the proposal was applied to a case study involving a group of engineering educators from the Escuela Politécnica Nacional de Quito. This research aims to present the results of the implementation of a training programme for engineering educators to improve their competence in new technologies and the teaching design methodologies applied to the design of online learning environments for engineering. To achieve this goal, the training included a framework based on pedagogical foundations, instructional and learning strategies, online learning technologies and good practices of engineering design activities, as well as a Learning Management System (LMS) platform adopted by the institution. The results of the implementation of this pedagogical technical training strategy show that 92% of engineering educators confirmed that the proposed framework helped them to develop online courses. In addition, 83% of engineering educators confirmed that the training course in the LMS tool was useful. Additionally, it was confirmed, with an acceptance of more than 90%, that the inclusion of the recommendations for the design of the engineering activities was relevant. These results confirm the adaptability of engineering teachers to the application of new technologies and methodologies, and will enable the production of better qualified engineers to pursue this profession and face future challenges.

Keywords: training; teachers; engineering; virtual learning; e-learning; virtual education

1. Introduction

At present, the use of technology is evidence of quality in education [1, 2]. Teachers increasingly face challenges that involve the development of new skills and the ability to use technology appropriately to support their work. In such a context, the need for a lifelong learning programme for teachers that enables them to be continuously updated in order to play their role more effectively and appropriately is evident [3]. Institutional problems, such as lack of budget, excessive workload for teachers, and training programmes that are not tailored to the needs of engineering educators, are barriers that discourage teachers and result in their postponing training for continuing professional development. Large virtual learning initiatives such as OpenCourseWare, Massive Open Online Courses (MOOCs) and the increasing availability of Open Educational Resources (OER) have become a global trend, facilitating access to virtual learning that eliminates barriers of time and space, and requirements often linked to formal education [4]. This trend is also apparent in Latin American countries, including Ecuador, where the regulation of higher education institutions has democratized learning platforms for education, enabling the diffusion of knowledge as a public good [5].

To face these new challenges, teachers require training in virtual environments. However, exclusive training in the use of technological tools does not constitute a satisfactory solution to the problem. As Nuñez and colleagues claimed [2, p. 2], "we must not forget the importance of the official academic value of these new experiences, to guarantee the quality and educational value of the training through the Internet." This is supported by Diaz and colleagues [3] who explained that pedagogical activities will serve to improve the curriculum by promoting the possibility of personalization and providing a greater flexible response to the formative demands of the students. A comprehensive training proposal is required that involves knowledge of the technology linked with didactic and

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pedagogical complements, in order to generate a transformation in the teaching-learning processes, evolving from a basic process of instruction towards the construction of relevant learning experiences. Virtual learning environments are a practice that is increasingly widespread in higher education institutions (HEIs). A European Union (EU) report shows that 91% of HEIs are incorporating the use of b-learning, making it the most used option in virtual learning, in comparison to 50% of HEIs that are incorporating e-learning [6]. Also, in the United States (US), the use of virtual learning is a modality used by more than 63% of public HEIs [7].

In this research, the Escuela Politecnica Nacional (EPN) of Ecuador, the premier institution in the country in engineering education, is presented as a case study of the application of a training plan to engineering teachers. As a result of previous research [8, 9], 91% of teachers expressed support for b-learning as the appropriate modality for the support of engineering education [10]. In addition, it was evidenced that 87% of teachers required training in Learning Management System (LMS) platforms for the creation of virtual learning spaces. Studies carried out with the institution's teachers determined that the main barrier to the adoption of technology in the classroom was the additional time that would be taken by the construction of the virtual classroom. This time increased due to the lack of knowledge of the tool and the lack of a framework for the development of virtual classrooms for engineering. Consequently, this research aims to present the results of the implementation of a training programme for engineering educators. This programme was intended to improve their competence in new technologies and the instructional design methodologies applied to the design of online learning environments for engineering. To achieve this objective, the training included the LMS tool adopted at the institution, as well as a framework based on pedagogical foundations and good engineering practices. The framework is presented in this research and addresses planning, elaboration, monitoring, and evaluation to build resources and online learning activities for engineering education.

The results of the implementation of this pedagogical technical training strategy show a high acceptance of the programme by engineering educators. Those who took the training confirmed the helpfulness of the proposed framework for the development of online courses. They not only reported that the training course in using the LMS tool was useful, but also the inclusion of the recommendations for engineering learning activities design was helpful.

The document is organized as follows. Section 2 presents a theoretical framework for the research topics of this work. Section 3 presents the proposal based on the Plan, Elaborate, Monitor, and Evaluate (PEME) framework for instructional design. Section 4 deals with the materials and methods used during this research. Section 5 describes and discusses the main results of surveys answered by engineering educators. Finally, Section 6 closes this document with the main conclusions and future work.

2. Theoretical framework

2.1 Virtual education

Virtual education is the result of merging education with technology. It revolutionizes the traditional paradigms of teaching towards new approaches focused on students, and promotes active learning and teamwork, where students are responsible for their learning [4, 11]. Virtual education practices are evolving, with the mutual influence of platforms for the implementation of virtual education and pedagogical models. Today, the wide penetration and consolidation of e-learning is advancing and new possibilities are arising. The future of virtual education encompasses the use of Internet technologies for formal and informal learning, taking advantage of different services and applications, and correctly selecting and using technologies primarily to meet the needs of communication [12].

This evolution has been possible thanks to the development of technology, such as platforms that support virtual education. These platforms, known as LMS, are the frameworks used to manage, in a coherent and consistent manner, all the elements involved in the process of virtual education [12]. An LMS is an infrastructure that administers and manages educational content, identifies and evaluates organizational or training learning, tracks progress towards the goals, and collects and presents data to support the learning process [13].

For those students born in the digital age, the use of these online platforms and digital learning formats does not represent a problem, because they are proficient in the use of technologies, particularly technologies for communication and collaboration. In addition, they also routinely engage in social interaction and collaborative learning and have strong interpersonal and communication skills. On the other hand, for the teachers who must respond to these challenges, this is often a challenging task, in particular for those teachers with little experience of technological tools. For teachers, it is a major challenge to provide an education that meets all of these individual and global requirements, due to a greater diversity of student profiles [3].

2.2 Elements of virtual education

Curriculum design in higher education is not a common activity [14]. There is limited support for formal improvement of the academic skills required to improve the design of courses, modules, resources, activities and other elements in the learning process. The results of some studies [6, 15] suggest that the harmonization of environments is required, not only in relation to media and technologies, but also to the approaches to design.

The use of Information and Communication Technologies (ICT) in online environments enables teachers to arouse their students' interest, to manage time and course activities in a flexible way, save time for course activities, track student progress with ease, and engage in extensive interaction, collaboration and communication with students [15]. Hence, the course activities should be designed with the intention of improving communication, collaboration, interaction and technical aspects. The quality of learning environments must be based on the principles of instruction that are derived from solid and multiple learning theories. Pedagogical approaches are derived from learning theories that provide principles for the design of specific instructional and learning strategies. These are the mechanisms for linking theory with practice. Instructional strategies are developed by instructors, instructional designers, to create and facilitate student learning. According to [13], there are three key components that work collectively to foster meaningful learning and interaction in virtual learning environments:

- Pedagogical models.
- Instruction and learning strategies.
- Pedagogical tools or online learning technologies.

2.2.1 Pedagogical models

According to [16], the pedagogy of e-learning can be classified into four categories:

1. Associative: a traditional form of education delivery. The emphasis is placed on the transmission of theoretical units of information learning as a structured task activity, where the focus is on the individual, with learning through association and reinforcement.
2. Cognitive/constructivist: knowledge is seen as more dynamic and expanding rather than objective and static. The main tasks here are to process and sub-process information permanently, making sense of the surrounding world. Learning is often task oriented.
3. Situational: learning is seen as a social practice and learning occurs through interaction in context. The student has a clear responsibility for his own learning. This approach is therefore student-centred.
4. Connectivist: learning is through a networked environment. The theory advocates a learning organization in which there is no body of knowledge to be transferred from the educator to the student and where the learning is not carried out in a single environment. Instead, it is distributed through the Web and people's commitment to it constitutes learning.

The evolution of the learning process dates from cognitivism, where e-learning consisted basically of the mere transmission of content, to the emergence of today's process of connectivism, developed by Siemens [17]. This involves new concepts of learning communities, identical to those who generate networks of knowledge, but with an emphasis on communication where interaction is a priority. The concepts of constructivism and constructionism have diminished [13].

Connectivism [17] and constructivism [18] transform the teaching-learning process into an active process that encourages continuous learning, self-learning, decision-making and knowledge-seeking. Learning in networks of knowledge is the essence of connectivism. It is based on self-knowledge, either individually or through interdisciplinary learning networks, and accepting challenges, where the ability to know is more important than what is currently known. Connectivism builds meaningful learning strategies that include communication and collaboration in learning communities [19], creating cooperation and cooperative work. All these are substantial elements that should be the focus of a new model of teaching and learning, especially when the process is mediated by technology.

The framework for the construction of learning spaces for virtual education is derived from the traditional teaching-learning models augmented by the use of technology. Likewise, the framework for the construction of virtual spaces is subject to the selection and appropriation of the pedagogical models adopted that are based on the teaching-learning processes. The new trend in learning styles is known as "learner-centred" or "student-centred". It is the placement of the control of learning in the hands of the student. This style of learning is characterized not only by greater autonomy for the student, but also by a greater emphasis on active learning, with creation, communication, and participation playing key roles. There are changing roles for the teacher and student, with the teacher guiding the student's learning and the student as the principal actor of learning [2]. Therefore, selecting a pedagogical approach is critical to the design of the course. This determines and specifies the approaches and instructional strategies that will be used, determines the roles of the student and tutor, and also signifies its presence in the motivation, interaction, communication and cooperation in the course. Therefore, deciding on the best pedagogical approach to meet the specific needs of the study group, considering its modality, is a fundamental task.

2.2.2 Instruction and learning strategies

The common framework for the construction of these learning spaces is Instructional Design (ID) [20], as mentioned in [19, 21, 22] which define the ID as an iterative process of planning, effective selection of teaching and learning strategies, technologies, identification of educational media and, ultimately, performance. However, while there is a great deal of information about ID in general, there is little information regarding ID for virtual education, as mentioned in [19]. As mentioned in [4], quality in a virtual learning environment begins with a good instructional design.

The definition of the instructional techniques described below corresponds with a selection of the best recommendations for the instructional design of resources and learning activities. Therefore, Merril's five principles of instructional design [23] were considered, as described below:

- Learning is promoted when learners are engaged in solving real-world problems.
- Learning is promoted when existing knowledge is activated as a foundation for new knowledge.
- Learning is promoted when new knowledge is demonstrated to the learner.
- Learning is promoted when new knowledge is applied by the learner.
- Learning is promoted when new knowledge is integrated into the learner's world.

According to the requirements of instructional design for higher education, problem-based learning (PBL) can be considered to be a proven technique of learning that improves retention, development of high-level intellectual skills such as forming judgements, decision-making and an ability to analyse and synthesise [16, 24, 25].

In addition, since this research is a contribution to higher education in engineering, listed below are some teaching strategies for engineering based on [24, 26, 27]. These examples demonstrate the particular focus of this research in the area of higher education in engineering:

- Design practical and concrete activities contextualized with reality.
- Establish the relevance of course material and teach inductively. Motivate learning by relating the new material to the previous, as the experience of the students is essential.
- Balancing concrete and abstract information in each course, using visual examples and demonstrations of course-related material as much as possible.
- Promote active learning in the classroom. Active, student-centred learning is superior to passive teaching where instruction is teacher-centred and encyclopaedic. People acquire knowledge and skills through practice and reflection, not by seeing and hearing others telling them how to do something.
- Use cooperative learning. This is a teaching method in which students work in teams in a structured learning task, promoting teamwork, individual responsibility and learning from others.
- Balance material that emphasizes practical problem-solving methods with material that emphasizes understanding the theory.
- Provide the overall picture or goal of a lesson before presenting the steps, doing as much as possible to establish the context and relevance of the subject and relating it to the students' experience. Students should be free to devise their own methods of solving problems rather than being forced to adopt the teacher's strategy.
- Provide only enough information for the period, to facilitate learning, encourage retention and avoid confusion.

According to [26], most students in technical education are visual, sensory, inductive and active, and some of the most creative students are global. The majority of technical education is auditory, abstract (intuitive), deductive, passive and sequential. These mismatches may lead to poor student performance, professional frustration, and a loss to society of many skilled potential engineers, if one does not consider the contradictions between the ways in which students learn and the type of learning that is appropriate for them.

The mental schema with which students learn in higher education is characterized by the concrete, precise and schematic way of solving problems. Therefore, if the best results of the teaching-learning process in the classroom are to be obtained, it is necessary to establish a proposal for the design, construction, execution and evaluation of virtual courses for higher education as tools to support face-to-face learning that considers these elemental needs.

2.2.3 Online learning technologies

As mentioned in [13], the development of learning technologies show that the past has been characterized by the automation that led to the development of e-learning platforms. The present is dominated by integration and interoperability. The future challenge is to connect and relate the different tools and services that will be available to manage knowledge and learning processes.

The main infrastructure that is supporting virtual education today is the LMS. The LMS platforms are oriented for distribution, communication, interaction, and course administration [12]. On the other hand, Learning Content Management Systems (LCMS) are a direct evolution from the LMS. The LCMS are different from the LMS in that, in addition to all the functionalities that the latter present, the LCMS are also focused on the creation and administration of content.

The LMS is the piece of software that has become almost ubiquitous in learning environments. Various LMS platforms such as Blackboard, Absorb, Moodle, Schoology, D2L and BrightSpace [28], have been installed at thousands of universities and colleges, and these platforms are used by hundreds of thousands of instructors and students. The benefits of these LMS are that they take learning content and organize it in a standard way. A course is divided into modules and lessons, supported by a range of resources and learning activities, such as quizzes, tests, and discussions that integrate today with the student information systems in HEIs.

Many technological innovations enter the market with great fury and disappear [29]. However, this is not the case with LMS, which have been, and will remain, the key to integrating technology as an educational support. In this scenario, new proposals such as OER, MOOCs, and gamification, seek to supplant their space. However, the LMS does not yield to this intrusion, but rather complements it. There is an evolution towards technological ecosystems [30], which, in addition to providing the services of a traditional LMS, offer information support and knowledge management in heterogeneous contexts of integration and interoperability.

3. Framework of work

In the EPN of Ecuador, previous research [8–10] has shown that 91% of teachers expressed support for b-learning as the appropriate modality for the support of engineering education. However, it has not been applied due to problems with the inclusion of technology generated by the engineering professors. These problems were evidenced by issues such as the fact that 87% of teachers required training in LMS platforms for the creation of virtual learning spaces. In addition, studies carried out with the institution's teachers determined that the main impediment to the adoption of technology in the classroom was the additional time that would be taken by the construction of the virtual classroom, due to their lack of knowledge of the tool and the lack of a framework for the development of virtual classrooms for engineering.

To meet these needs, this case study aimed to plan and implement a training programme for a group of teachers of an HEI, as a proposal for the pedagogical technical training of teachers in engineering. While the use of virtual learning environments and learning platforms online is not a new topic, the particularity of this research is its approach to engineering and the fact that if successful results were obtained they should be spread widely.

The basis for the training programme proposed a framework for the design of virtual environments. This framework included the following components [13]: pedagogical, instructional and learning strategies, as well as technologies for online learning. The framework proposed for execution addressed the four stages of PEME as a guide [31].

3.1 Pedagogical component

Learning how to build virtual learning spaces would be simply a process of instruction as a means of delivering content, if not complemented by an educational framework based on the learning theories that support it. This framework should be aligned with the changing needs of the digital age, involving a pedagogical change to develop new skills and competencies [32, 33] in the construction of learning spaces, supported by ICT, in line with the new millennium.

Due to the diversity of students it was inappropriate to apply only one pedagogical theory. In particular, it was important to consider, when designing learning environments, the students' individual needs according to their particularities and the context in which the learning is to be performed [15]. For educators in engineering [33], this proposal had to allow them to incorporate educational theories, such as constructivism [34] and connectivism [17] for the design of learning, but without neglecting situated learning, i.e. that learning must be adapted to the learning context, because this will promote better learning for engineering.

Since the proposal was to be applied to teaching in engineering, it was designed taking into consideration four main dimensions: the basic sciences, social sciences, design and practical implementation. This would enable the engineer to be viewed as a professional with an integral formation, who combines, in varying proportions, the qualities of a scientist, sociologist, designer, and maker [35].

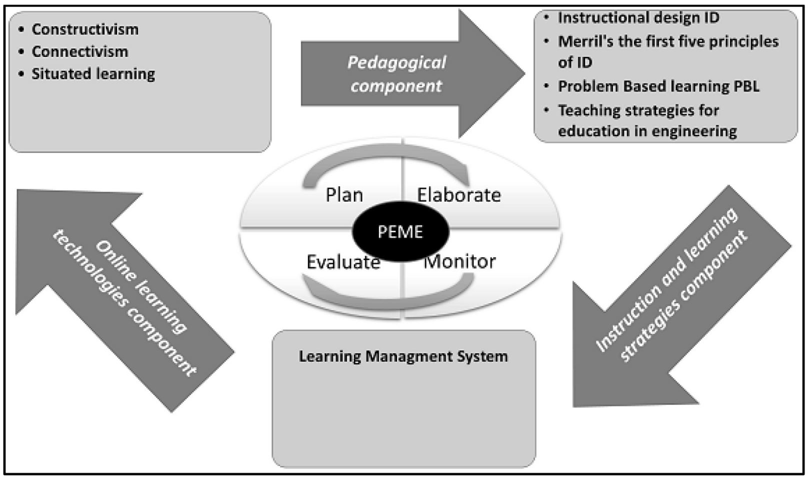

Fig. 1. PEME Framework for the construction of virtual learning spaces in engineering.

3.2 Instruction and learning strategies component

The proposed model established a framework with clearly defined phases. These were selected based on the review of the literature [22, 36, 37]. The phases of the construction of virtual learning spaces represent a simplification based on the practice of the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model [22] of ID that defines the process of online education. The PEME framework proposal envisaged the use of phases of continuous feedback, as seen in Fig. 1. The ADDIE model was considered appropriate because its use has been widely validated for designing virtual education spaces, although it was born as a model of design software [37].

3.2.1 Phase I: Plan (P)

An essential aspect of the design of a learning environment is the planning and analysis of the course context [25]. Planning should be aligned with the group's work and directly influence the overall learning outcome to be achieved from the course. When initiating strategic planning for e-learning, the following recommendations can be broadly considered: always start with the needs assessment, reflect on the planner's own strengths, identify unique opportunities, be realistic within the resources and try to move towards something new and innovative.

Planning enables the consistent organization of the learning sequence necessary to obtain the planned learning outcomes for the course. Based on the instructional design model known as ASSURE [38], this phase should specifically include:

- Identify the characteristics of the student or the group for which the learning space will be designed.
- Establish learning objectives, determining the desired learning outcomes of students.
- Establish temporary planning.
- Select strategies, technologies, resources, and materials.
- Organize the learning stage.

3.2.2 Phase II: Elaborate (E)

This phase corresponds to the merger of two phases of ADDIE, Design and Development, which in the PEME framework corresponds to Elaborate. This fusion is given by design practice, which demonstrates that the design process must go hand-in-hand with development complementing the cycle. This phase is within a cycle of permanent feedback in which resources and activities for learning are designed and built. Thematic units and subunits can be created in each one of them. Based on the desired learning result, resources and activities are developed for the students with the objective of obtaining the desired learning outcomes, as described in [18]. At this stage, the proposed engineering teaching strategies should be considered for the design of learning activities and resources.

3.2.3 Phase III: Monitor (M)

This phase is undoubtedly one of the most important in the proposed model, since here the process of follow-up and accompaniment of the student by the course tutor is performed, so that the classroom is not merely a space for the transmission of information. The classroom becomes a learning environment in an active space [39], where the students become the builders of their learning, that is to say they are responsible for it, while the teacher becomes their guide and tutor. Both parties strengthen their participation in the classroom—the teacher as a learning guide and the student as the centre of the teaching-learning process and builder of their own knowledge.

In this phase, building a solid communication base is essential. A good relationship between teacher and student leads to success or failure of this learning model [40]. The objective of this phase is to promote cooperative, collaborative work, taking advantage of the combined reality to achieve commitment and interactivity with stakeholders in the teaching-learning process, with the aim of promoting teamwork, for this, current and future technologies [10].

Therefore, it is useful to encourage communication with new ICT [41, 42]. The objective is to inspire the participation, interaction, and cohesion in the virtual classroom with the support of the teacher [43]. Providing formative, timely and individualized feedback has also been identified as a major challenge in the online learning environment. Online learning should provide students with a balanced learning experience that includes both synchronous and asynchronous opportunities, as well as the opportunity to explore, investigate and create [12], encouraging student participation through active involvement and cooperative strategies. Structured online asynchronous discussions should be considered to support student collaboration and support learning where student performance is the result of pedagogically rich strategies that include engaging the instructor, interacting with students, and facilitating student collaboration, as well as monitoring and moderating discussions.

3.2.4 Phase IV: Evaluate (E)

This phase of the process evaluates the product obtained and the results. To evaluate the process, it is important to determine the clarity and consistency in the processes established for the course design, with the aim of continuous improvement and feedback. It is recommended that feedback is provided by students in order to evaluate the products obtained. Furthermore, peer-evaluation of the products is recommended, involving students and based on clear rubrics [4]. Finally, to evaluate the outcomes of learning evidenced by students, and ascertain whether learning objectives have been met, a formative assessment will promote significant learning and continuous learning [44]. A summative assessment is also necessary, even in current education systems, to establish compliance and learning achievements.

3.3 Online learning technologies component

Technological support is required in order to apply the model and to provide the physical infrastructure within which the proposal can exist. As previously mentioned, the LMS provides the technical characteristics necessary for the implementation of virtual classrooms, adjusted for the proposed model.

For this case study, the EPN chose Moodle due to its recognized advantages. Moodle is an open source software with a General Public License (GPL). It primarily supports teaching based on social constructivism and it is a great learning community [45]. The ease of use of online management courses and the availability of a variety of resources and activities that are continuously updated (such as mobile devices), makes it the most popular platform worldwide [24]. The EPN has already used several versions; the version currently used in undergraduate courses is 2.9.

Moodle provides a variety of learning resources and activities that can be used in the classroom, as well as several communication tools for participants. Although Moodle is not considered to be a vital element in the learning process, it is an essential component in the educational process mediated by technology [42]. To validate the proposed training for engineering teachers in the design of virtual learning spaces, a detailed case study is presented below.

4. Materials and method

This case study involved the training of a group of teachers of the HEI to develop their knowledge of the PEME framework, and also of the Moodle tool, in order to check the validity of the proposal. As instruments of this research, two questionnaires were designed: the pre-test and post-test. The pre-test questionnaire was applied in the initial phase of this research and consisted of a survey of 32 questions. The post-test instrument was also applied in the final phase of this research and consisted of a survey of 40 questions. Both the pre-test and the post-test questionnaires used the Likert scale and included open questions, which were the source for this case study.

4.1 Initial stage

Sixty-four teachers of engineering took a twenty-hour course in face-to-face modality. The course was named "Web Tools for Teaching" and was offered on the institution campus by expert instructors. Course plans included a detailed curriculum to develop teachers' knowledge on the PEME framework and the Moodle tool. The aim of this training was to provide engineering teachers with the necessary skills to create virtual classrooms for their courses.

The course "Web Tools for Teaching" included the following themes:

- Conceptual framework for the implementation of the PEME framework for the construction of virtual learning spaces in engineering.
- Application of the methodology using Moodle as a tool in each of its phases as mentioned below:
  – Planning phase included the basic structure of a course in Moodle and its administration by reviewing topics such as configuration, appearance, roles, and blocks.
  – Elaboration phase focused on the management of the Moodle editor, management of resources and activities such as books, folder, pages, tasks, and lessons.
  – Monitoring phase addressed the feedback on a Moodle course by reviewing topics such as forums, chat, messages and other communication activities.
  – Evaluation phase provided the ability to configure assessment instruments under Moodle by reviewing topics such as the configuration of categories, report card, formulas, and reports.

The course was held before the start of the academic term. The teachers participated actively in the study and created virtual classrooms for their courses. The first survey was taken upon completion of course training and was used as pre-test is the Annex 4-a [46].

4.2 Final stage

After two months of training, the post-test survey was undertaken is the Annex 4-b [46]. The instruments used for this research consisted of questionnaires with open and closed questions. Only the questions that made a contribution to this research were evaluated. A group of sixty-four teachers was trained, but only fifty-four teachers participated in the second phase of the research and completed the survey.

Although the initial phase of this training was face-to-face, the dropout rate for the final phase was 16%. This dropout percentage is relatively low in comparison with the usual desertion percentage of online training courses. For example, for MOOCs, as cited in [47], 87% of learners leave the course. However, it is important to identify the barriers faced by engineering teachers for the inclusion of technology in their teaching practice in engineering. To support this goal, Section 5.4 analyses in detail the results of the evaluation of the open question "39. Indicate your main problems or obstacles for the construction and execution of your virtual classroom within the teaching-learning process".

During the implementation process of the course development, the teachers were supported by a methodological guide for virtual classrooms under Moodle [48], designed to support the training proposed. To complete and evaluate this research, open questions were assessed using a combined methodology for analysis of the text and sentiment.

4.3 Method

As explained, the online survey launched to the case study participants used closed questions based on the Likert scale and open questions or opinion. Closed questions were assessed by using traditional quantitative methods.

The aim of evaluating the open questions or opinion questions using data mining techniques, despite the amount of data not being representative for an analysis of this nature, is to obtain more genuine results without the biases generated by a qualitative evaluation by humans. The methodology used for evaluation of the open questions of opinion used a combination of two data mining techniques: Text Analysis (TA) and Sentiment Analysis (SA), abbreviated as TSA. Fig. 2 shows the phases and steps of this methodology. Educational Data Mining (EDM) models and techniques were applied to extract knowledge from the context, specifically within the educational context [49].

The main goal of text mining is to extract interesting and important behaviour patterns and to

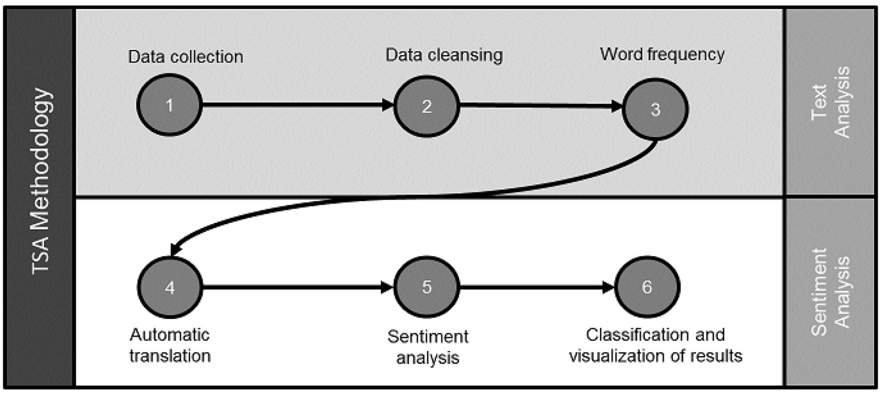

Fig. 2. TSA Methodology to analyse text strings.

explore knowledge within the textual data from semi-structured or unstructured text, with or without supervision.

Among the notable text mining tasks are: information retrieval; concept extraction; categorization; sentiment analysis; content management; and ontology management. Sentiment analysis, also called opinion mining [50], aims to determine the attitude of the user or text analysed by establishing a polarity value in a range of positive to negative through neutral. This method enables the researcher to ascertain the views which are more relevant and within them to verify the positive or negative polarity from the comments made in the survey. This enables the acceptance or rejection of the proposal presented in the research to be established.

5. Results

5.1 Results of the initial stage pre-test

Sixty-four teachers who took the training course answered the pre-test. It was applied in September 2015 when the training course for the PEME framework was completed and at the commencement of the academic semester. The pre-test consisted of a questionnaire of 32 questions in [46]. The objective was to determine the participants' knowledge about the platform and about resources, activities, administration and monitoring by teachers. The results of the main questions related to this study are analysed below.

Question 7. Have you had any previous experience with the use of virtual classrooms in your teaching? 57% of teachers stated that they did not have previous experience with virtual classrooms in their teaching work, which is a high percentage and ratifies the need for training.

Question 13. Do you consider that using this tool would require a greater dedication of your time? and Question 15. Is willing to spend more time based on the benefit obtained? 81% of teachers were aware that the use of this tool implies they would need to dedicate more time. But, according to the benefit obtained, 98% stated in question 15 that they were willing to spend more time.

Question 16. What do you consider to be your level of general knowledge in ICT management? 37% of teachers expressed that they had a low level of knowledge of ICT and 41% expressed they had an acceptable level. Only 19% considered they had a good knowledge of the use of ICT.

Question 21. Do you consider that the Plan, Elaborate, Monitor and Evaluate (PEME) framework is a necessary phase for the development of the virtual classroom for your subject? The results show that 100% of teachers considered that the proposal for the PEME framework was an appropriate framework for the implementation of virtual classrooms.

Question 22. Do you consider that the training received for the application of the PEME framework using Moodle will allow you to develop your classroom and manage it appropriately? 98% affirmed the relevance of the training received for the purpose described.

5.2 Results of the final stage pre-test with TSA

The results obtained by applying the TSA methodology are described below. After analysis of the data sample, it was found that there were some hidden patterns in the responses that the teachers gave to the questions. The first pattern was found in the data from the single open question which asked:

Question 32. We invite you to give us your suggestions and recommendations. The polarity distribution is shown in Fig. 3, which shows a majority of the values around 0, additionally positive and negative values of polarity are visualized using the TSA methodology.

The correlation between the polarity values of Question 32: *We invite you to give us your suggestions and recommendations* and Question 3: *Select the number of years of teaching* were then analysed. Although only 24 teachers responded to the open-ended questions, the polarity of their responses was correlated by the number of years of teaching experience in Fig. 3. It is apparent that the neutral

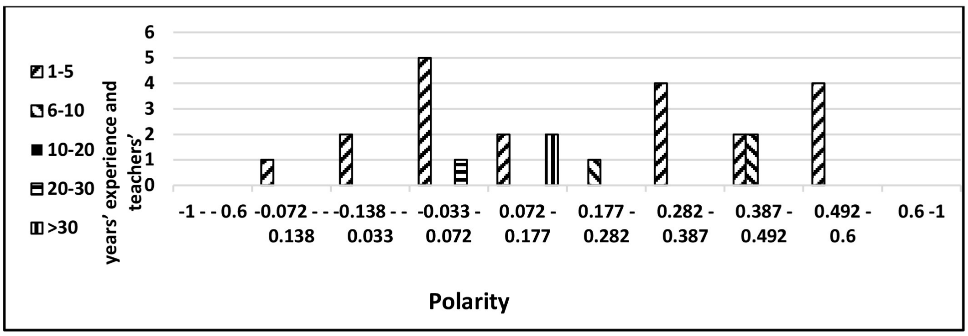

Fig. 3. Question 32: We invite you to give us your suggestions and recommendations and Question 3: Select the number of years of teaching

and negative values were related to answers given by teachers with experience of between one and five years. Another interesting pattern is that there were no complaints from teachers with more than ten years of experience. This leads the researchers to confirm that there is no relationship between the years of experience of the teacher and their willingness to be involved in improvement plans to include technology in teaching practice that is in the interest of all engineering teachers of this HEI. In addition, from the previous results it was concluded that all teachers supported the use of the PEME framework at 98%, since the complaints (negative values) were very low relative to the positive values.

Evaluation of the pre-test revealed that the results gave neutral values, as well as negative values. This proves that using the TSA methodology, the results were not always positive, and even more so in the initial phase of the case study where problems and complaints could be found.

5.3 Results of the initial stage post-test

Out of sixty-four teachers who took the training course and answered the pre-test, only fifty-seven teachers answered the post-test. The post-test was applied four months after the training course in January 2016, when the academic semester was ending. The results were obtained after applying the PEME framework training so that the design of virtual learning spaces in engineering could be evaluated. The post-test consisted of a questionnaire of 40 questions in [46]. The objective was to determine the participants' views about the training regarding the proposal for the PEME framework, time, materials used, and the tool and its potentialities. The results of the main questions related to this study are analysed below.

Question 4. How many virtual classrooms did you handle before the training? And *Question 5. How many virtual classrooms do you handle nowadays?* In Fig. 4, it is important to appreciate the variation that exists between the number of classrooms before the training, compared to the number of classrooms after the training. The results show a clear increase in the number of virtual classrooms.

Question 16. The Planning Phase of the virtual classroom development model is one that makes it possible to think coherently about the learning outcomes that students want to achieve. Considering that it involves temporary planning of resources and learning activities depending on the training group, as well as the presentation of the course, describe the level of importance from your perspective. The results show that 94% of teachers consider the planning phase as relevant and contextualized for their function.

Question 17. The Elaboration Phase for the building of a virtual classroom is the very concretion of the process of making virtual classrooms, since here the resources and learning activities are developed based on the learning outcomes proposed with pedagogical foundations. Describe the level of importance from your perspective. 91% of teachers considered the elaborate phase as appropriate within the proposal.

Question 18. The Monitoring Phase of the development model of virtual classrooms is one that converts virtual space into a living learning space, for which communication is fundamental. Describe the level of importance from your perspective. 90% of teachers validated this phase as the most relevant within the model.

Question 19. The Evaluation Phase of the virtual classroom development methodology becomes the process of continuous improvement with the use of the different types of evaluation by means of which the results obtained are checked against those proposed. Describe the level of importance from your perspective. This phase starts the process of continuous improvement, with 89% importance placed upon it on the part of teachers.

Question 20. Do you consider that the Plan, Elaborate, Monitor and Evaluate (PEME) phases reflect the major stages in the construction of the virtual classroom?

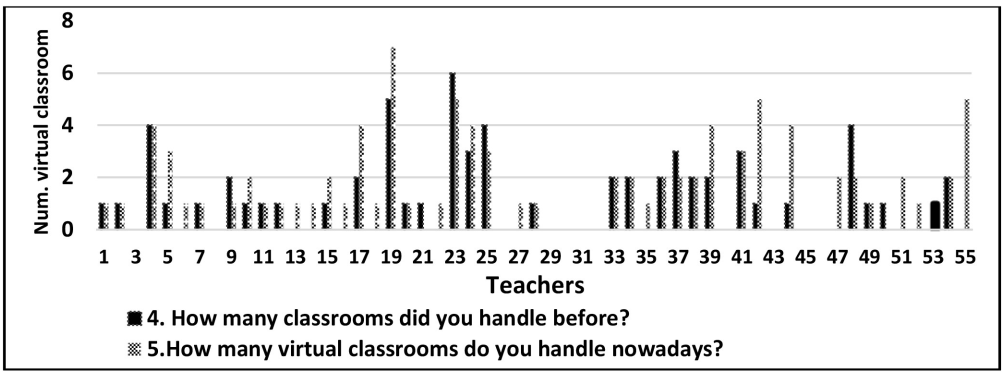

Fig. 4. Question 4: How many virtual classrooms did you handle before the training and Question 5: How many virtual classrooms do you handle nowadays.

Table 1. Teaching-learning activities for engineering education [24, 26]

	Designing practical and concrete activities	**Linking new and existing knowledge**	**Balancing concrete information from the abstract**	**Promoting active learning**	**Using teamwork**	**Applying evaluations with headings**	**Offering feedback and gratification**
A lot	48%	52%	42%	48%	52%	40%	50%
Frequently	42%	44%	48%	48%	40%	48%	40%
A little	10%	4%	10%	4%	8%	12%	10%
Never	0%	0%	0%	0%	0%	0%	0%
Did not answer	0%	0%	0%	0%	0%	0%	0%

The initial approval of the PEME framework was 100%. After the execution of the model, this percentage decreased to 92%. Nevertheless, it is a high range of approval.

Question 23. Do you consider that the training you received was helpful in the construction of your classroom and allowed you to develop and manage the classroom appropriately? This question, which was also evaluated in the initial stage of this study with a 98% acceptance, in this final stage obtained an 83% acceptance, which is understandable since the teachers now had to apply the knowledge of the training received. However, the acceptance value is high and sufficient to validate the proposal.

Question 25. Were the recommendations useful for designing teaching-learning activities for engineering education? With 90%, teachers valued the recommendations of learning activities and learning resources as positive.

Question 26. Which recommendations for the design of teaching-learning activities were useful? In Table 1 it is important to appreciate that all of the 'designing teaching-learning activities for engineering' were accepted with an approval rate of more than 88%; the teachers considered that all the proposed activities were relevant to improve the learning process in engineering.

Question 35. Was the guide designed for the creation of virtual spaces delivered to you in the training course useful? Some 98% of the teachers affirmed that the material provided in addition to the classroom course was useful to them.

Question 37. Did the time for training seem appropriate? 59% considered the time spent in the face-to-face training course to be appropriate. This value was not very satisfactory and important comments were made about how to improve it, such as to increase the duration of the training course, or to divide the material into two courses.

5.4 Results of the final stage post-test with TSA

In the post-test, the open questions of the questionnaire, in which the TSA methodology was applied, were evaluated. The methodology allowed a value of polarity that determined a negative, neutral or positive sentiment value in relation to the data analysed to be obtained.

Question 39: Indicate your main problems or obstacles encountered for the construction and execution of your virtual classroom within the teaching-learning process. It can be concluded that the problems encountered by teachers in relation to the application of technology in the classroom were related to the word "time". This obtained the highest frequency with 36%, followed by other words such as "limit", "platform", "material", "much," and "virtual". These received 8.3% frequency, a percentage that differs greatly to that of the word time, however, they must also be considered.

In relation to the word time, the polarity was mostly neutral as can be seen in Fig. 5, which is an

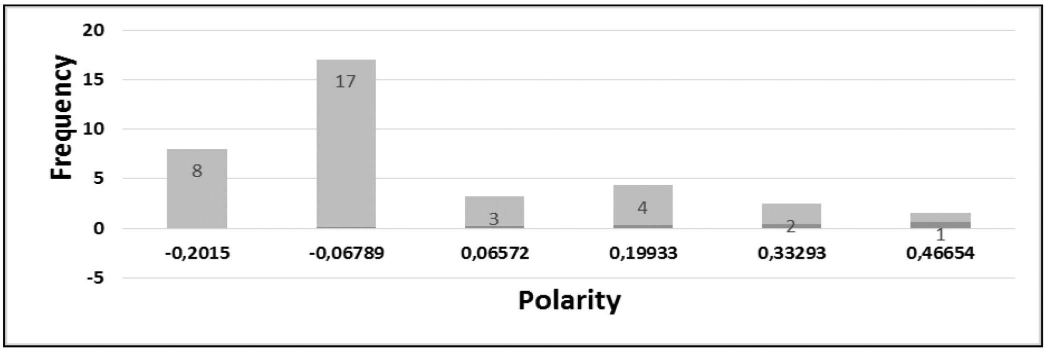

Fig. 5. Question 39: Indicate your main problems or obstacles encountered for the construction and execution of your virtual classroom within the teaching-learning process.

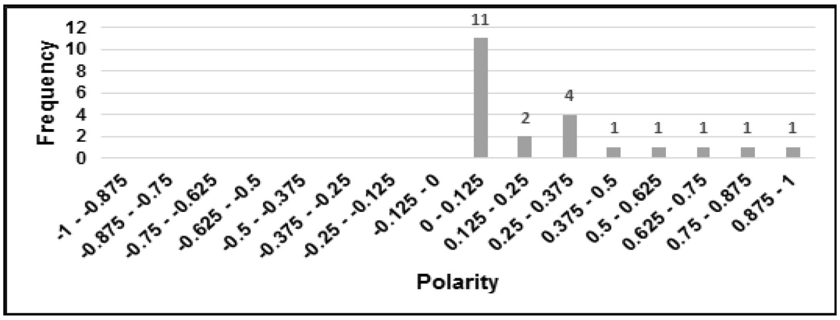

Fig. 6. Question 40: We invite you to give us your suggestions and recommendations regarding outstanding issues.

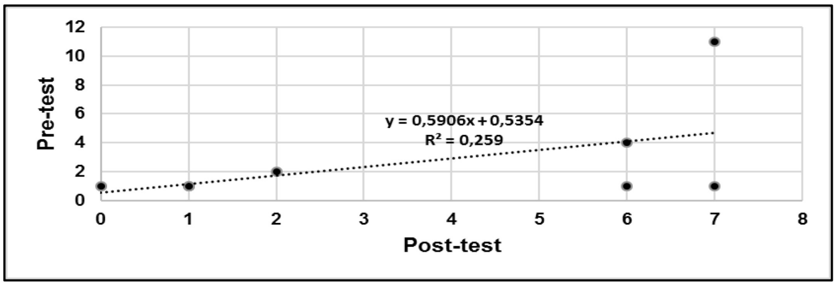

Fig. 7. Results of polarity show that the teachers changed their opinions between the pre-test and the post-test and their opinions improved.

indicator that this was not a major problem because, in questions 13 and 15, the teachers indicated that the extra time they would need to use technology would be repaid by the benefit obtained.

Question 40. We invite you to give us your suggestions and recommendations regarding outstanding issues. Neutral and positive values were obtained as a result of the polarity analysis, as shown in Fig. 6. This determines that the opinions of the teachers were positive with respect to the evaluated model.

In addition, a correlation was made between the polarity values of the post-test versus the polarity of the pre-test, after using the TSA methodology. A low value, $R^2 = 0.25901$, was obtained due to the fact that there was no similarity in values. This was because, in the post-test, no negative values were obtained. This low correlation value indicates that there is no direct relationship between the values of the pre-test and the post-test. The results show that the post-test contains positive values, which is desirable for this work, as shown in Fig. 7.

6. Discussion

The use of virtual learning environments is not a new topic. Over time, some generic models have been proposed that allow the construction of virtual learning spaces. Gagne and Briggs made their first proposal in 1974 [51], and this has evolved towards a proposal according to current needs [52]. Likewise, both Branch and fellow researchers [53] and Bourne and colleagues [54] introduced some guidelines for instructional design that still remain valid today. Researchers such as Díaz Lantada et al. [3], Núñez et al. [4], Gros et al. [13], and Felder and Silverman [26] have made significant contributions in relation to teaching methods and the skills and competencies that engineering professors require to face the current challenges. Nevertheless, no recent proposal has been found to address virtual education in engineering teaching. Therefore, this research proposed a comprehensive framework for the inclusion of technology in engineering education.

This framework considered elements such as pedagogical models, instruction and learning strategies, and pedagogical tools for online learning technologies, under the guidelines of the PEME framework for the construction of virtual learning spaces in engineering. Given the particularities of this group of study, the PEME framework was based on ADDIE. However, this was not a model in itself, but rather it was born as a development paradigm [53]. ADDIE defines five phases: Analysis, Design, Development, Implementation, and Evaluation. Similarly, the PEME framework defines four phases: Planning, Elaboration, Monitoring, and Evaluation. Each phase focuses on the objective to be achieved; for example, the Monitoring phase provides a permanent accompaniment to the student. Therefore, this phase is essential, and its inclusion in the model makes a difference regarding other proposals considered relevant [53, 54].

The proposal was validated by testing it in a case study that involved the training of a group of engineering teachers. The training included the application of the PEME framework in the implementation of virtual learning environments for their students. The case study concluded with an evaluation of the results obtained from the application of the framework. These showed that the professors revised their opinions between the pre-test and the post-test and that their opinions had improved, thus corroborating the validity of the proposal. The 83% of the teachers who confirmed that the training course had been useful fulfilled one of the objectives of this research, which was to validate the training and the material designed for this investigation. By virtue of the results obtained, it is possible to confirm that the framework proposed to link engineering teachers with technology has had satisfactory results with an acceptance of 92%.

Regarding the results obtained from the questions that asked about the phases of the PEME framework, the results reflect a high individual acceptance rate in the phases of Plan 94%, Elaborate 91%, Monitor 90%, and Evaluate 89%.

The evaluation results were obtained by using a pre-test and a post-test questionnaire applied to the participating engineering teachers. The main results of the pre-test evidenced that most teachers had a low level of knowledge of the Moodle tool. However, this lack of knowledge was overcome at the end of the first training phase, which implied that the training met the objective. Also, a positive result was obtained for the application of the PEME framework as a guide to conduct the development of the learning environments. Additionally, the open questions of the pre-test were evaluated by applying a TSA methodology that used data mining techniques such as text analysis and sentiment analysis. The results demonstrated that teachers, independently of their age, showed a positive attitude toward the inclusion of ICT in their teaching practice.

The main results of the post-test were framed in the validation of each of the phases of the PEME framework. The results validated the proposal. Additionally, the recommendations for the design of teaching-learning activities in engineering were also corroborated, as was the material designed to support the construction and monitoring of these virtual learning spaces for engineering, constructed by using Moodle.

Regarding the evaluation of the open questions of this phase, by means of the TSA methodology, it was possible to identify that the "time restriction" was the main barrier faced by engineering teachers. The academic responsibilities of teachers, and the demands they must meet that are linked to evidence of quality in education through accrediting bodies, limits the time that teachers are able to devote to preparing their teaching activities. The additional time that teachers must dedicate to the inclusion of technology in their teaching practice is often not recognized by public higher education institutions that have increasingly limited budgets [3] due to state policies. It is for this reason that the inclusion of technology in the classroom, on many occasions, becomes a personal challenge to engineering teachers, as their contribution to reduce the gaps between education and technology.

Engineering training activities with a value greater than 90% were classified as relevant for the design of teaching-learning activities, of these the following are notable: the use of teamwork, the design of practical and concrete activities, the linkage of new and existing knowledge.

Some of the suggestions mentioned by teachers in this phase were: "the course needs more time to work patiently"; "the correct configuration and organization of content require time"; "more training and more diffusion"; "training continuing" and, "I think it is necessary to have support after the course".

It is important to emphasize the evolution of the polarity values obtained from the pre-test, which demonstrated negative to neutral polarity, to the post-test, which showed neutral to positive polarity. This is clear evidence of the contribution of this research, which could reduce the gap between engineering teachers and technology, based on adequate training. Although this case study was not carried out with a large amount of data, the TSA methodology can be applied to large volumes of data given the generality of the techniques applied. Finally, this study is a solid contribution to this research field, in which there was previously an absence of a framework for the design of virtual learning environments in engineering education. Thus, it has responded to the shortcoming that was evident in previous investigations [8–10].

7. Conclusions and future work

Although the benefits of LMS environments have been widely studied, in this paper we have presented a good study case with detailed information about the training of engineering educators under the PEME framework based on the ADDIE model. This case study focused on an innovative approach to new technologies and online environments, as well as the evaluation of data provided by these environments. Hence, the contribution of this paper can be considered for application in other cases of engineering studies.

The teachers agreed with the use of the PEME framework to design virtual spaces for learning, with a high degree of acceptance, as shown in previous section. However, the most important concern expressed by teachers was about the evaluation phase, regarding the evaluation of the learning outcomes of the students. Teachers agreed that the most suitable evaluation of the products obtained in the learning process can be carried out by means of the application of the peer evaluation methodology among the same students by using clear rubrics.

This research has shown that technology may be a limiting factor for teachers who were not born in the digital age. However, as demonstrated, a clear and well-defined framework, as well as adequate training, is sufficient to establish bridges between teachers of engineering and technology. Other important information obtained from the higher education engineering teachers who took part in this study is the adaptability of teachers in the application of new technologies and methodologies in order to improve the instructional design that is applied in virtual learning environments. This will be a contribution to obtaining better qualified engineers to develop and guide the technological advances that generate change in the present, and to face the future challenges mentioned in their practice fields.

As an additional contribution, this paper tested a practical application of the analysis of sentiment for the evaluation of open questions or opinion, which enabled relevant information on the acceptance or rejection of the proposal to be obtained. Interesting results were obtained. However, due to the limitations of the data, which allowed the researchers to determine the acceptance of the educators in engineering on the proposed framework of work, there may be future potential to explore data from online platforms within the educational field using data mining techniques, such as text analysis and sentiment analysis.

As future work, it is proposed to re-evaluate the proposal, applying it to other institutions and other groups of engineering teachers, with a view to obtaining feedback and improving the proposal. In addition, it is important that the academic authorities make the decision to take concrete action that will support this type of initiative in their institutions, with incentives for teachers to become actively involved. According to the engineering teachers' requirements, it is necessary to extend the proposal to consider activities, methods, and evaluation resources, and to consider the requirements for new training plans that contemplate the opinions of those involved.

References

1. G. G. Conole, MOOCs as disruptive technologies: strategies for enhancing the learner experience and quality of MOOCs, *Revista de Educación a Distancia*, **39**, 2015, pp.1–17.
2. J. L M. Núñez, E. T. Caro, J. S. López and P. M. García, Education quality enhancement through open education adaptation, *Frontiers in Education Conference (FIE 2014)*, Madrid, Spain, 2014, pp. 1–4.
3. A. Díaz Lantada, J. M. Muñoz Guijosa, E. Chacón Tanarro, J. Echávarri Otero and J. L. Muñoz Sanz, Engineering Education for All: Strategies and Challenges, *International Journal of Engineering Education*, **32**(5B), 2016, pp. 2255–2271.
4. J. L. M. Núñez, E. Tovar Caro and J. R. Hilera González, From Higher Education to Open Education: Challenges in the Transformation of an Online Traditional Course, *IEEE Transactions on Education*, **60**(2), 2017, pp. 134–142,
5. Consejo de Educación Superior, Reglamento de Régimen Académico, http://www.ces.gob.ec/index.php?option=com_phocadownload&view=category&id=12&Itemid=303, Accessed 03 June 2017.
6. M. Gaebel, V. Kupriyanova, R. Morais and E. Colucci, E-learning in European Higher Education Institutions: Results of a mapping survey conducted in October–December, *European University Association Publications*, Brussels, 2014.
7. T Maddison and M. Kumaran, Eds. *Distributed Learning: Pedagogy and Technology in Online Information Literacy Instruction*, Chandos Publishing, 2016.
8. M. Peñafiel, S. Lujan-Mora, L. M. Vintimilla and P. Pozo, Analysis of the usage of virtual classrooms in the National Polytechnic School of Ecuador: Teachers' perception, *Information Technology Based Higher Education and Training Conference (ITHET)*, Lisbon, Portugal, 2015, pp. 1–6.
9. M. Peñafiel, S. Vásquez and S. Lujan-Mora, Use of Virtual Classroom: Summarized Opinion of the Stakeholders in the Learning-Teaching Process, *Information Technology Based Higher Education and Training Conference (CSEDU)*, Rome, Italy, 2016, pp. 314–320.
10. M. Peñafiel, R. Navarrete, S. Vásquez and S. Luján-Mora. Moodle as a Support Tool in Higher Education. Academic Authorities Opinion, *The Ninth International Conference on Advances in Computer-Human Interactions (ACHI)*, Venice, Italy, 2016, pp. 98–04.
11. S. Y. Wong, W. J. Tee and P. V. Lim, Design Model for Integrating Learning Activity Management System (LAMS), Massive Open Online Courses (MOOC) and Flipped Classroom in Taylor's Integrated Moodle e-Learning System (TIMES), *Taylor's 7th Teaching and Learning Conference 2014 Proceedings Springer*, Singapore, 2014, pp. 379–387.
12. William R. Watson and Sunnie Lee Watson, An argument for clarity: what are learning management systems, what are they not, and what should they become? *TechTrends, Springer Verlag*, **51**(2), 2007, pp. 28–34.
13. B. Gros and F. J. García-Peñalvo, Future trends in the design strategies and technological affordances of e-learning, *Learning, Design, and Technology*, *International Compendium of Theory, Research, Practice, and Policy*, 2016, pp. 1–23.
14. C. Young and N. Perović, Rapid and creative course design: as easy as ABC? *Procedia-Social and Behavioral Sciences*, **228**, 2016, pp. 390–395.
15. N. Gedik, E. Kiraz and M. Y. Ozden, Design of a blended learning environment: Considerations and implementation issues, *Australasian Journal of Educational Technology*, **29**(1), 2014.
16. T. Mayes and S. de Freitas, *Learning and e-learning. Rethinking pedagogy for a digital age*, Routledge, 2007, pp. 3–25.
17. G. Siemens, Connectivism: A learning theory for the digital age, *International Journal of Instructional Technology and Distance Learning (ITDL)*, 2005.
18. S. A. Reese, Online learning environments in higher education: Connectivism vs. dissociation, *Education and Information Technologies*, **20**(3), 2015, pp. 579–588.

19. R. A. Ellis and P. Goodyear, Models of learning space: integrating research on space, place and learning in higher education, *Review of Education*, **4**(2), 2016 pp. 149–191.
20. C. M. Reigeluth, *Instructional Design Theories and Models: An Overview of Their Current Status*, Routledge, 2013.
21. R. A. Reiser and J. V. Dempsey, *Trends and Issues in Instructional Design and Technology*, Boston, MA: Pearson, 2012.
22. R. M Branch and T. J. Kopcha, *Instructional Design Models. Handbook of Research on Educational Communications and Technology*, New York: Springer, 2011, pp. 77–87.
23. M. D. Merrill, First principles of instruction, *Educational Technology Research and Development*, **50**(3), 2002, pp. 43–59.
24. A. Díaz Lantada, P. Lafont Morgado, J. L. Muñoz Sanz, J. M. Muñoz Guijosa, J. Echávarri Otero, E. Chacón Tanarro and E. De la Guerra Ochoa, Towards successful project based teaching-learning experiences in Engineering Education, *International Journal of Engineering Education*, **29**(2), 2013, pp. 1–15.
25. G. Conole, *Learning Design: A Practical Approach*, Routledge, 2014.
26. R. M. Felder and L. Silverman, Learning and teaching styles in engineering education, *International Journal of Engineering Education*, **78**(7), 1988, pp. 674–681.
27. R. M. Felder, D. R. Woods, J. E. Stice and A. Rugarcia, The future of engineering education II. Teaching methods that work, *Chemical Engineering Education*, **34**(1), 2000, pp. 26–39.
28. W. Fenton, The Best LMS (Learning Management Systems) of 2017. https://goo.gl/OxNdAN, accessed 03 June 2017.
29. N. Cavus and T. Zabadi, A comparison of open source learning management systems *Procedia—Social and Behavioral Sciences*, **143**, 2014, pp. 521–526.
30. S. Sanchez-Gordon and S. Luján-Mora, An ecosystem for corporate training with accessible MOOCs and OERs, *Proceedings of the IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education (MITE 2015)*, Amritsar, India, 2015, pp. 123–128.
31. K. Park, Instructional Design Models for Blended Learning in Engineering Education, *International Journal of Engineering Education*, **31**(2), 2015, pp. 476–485.
32. C. M. Gray, C. Dagli, M. Demiral-Uzan, F. Ergulec, V. Tan, A. A. Altuwaijri and E. Boling, Judgment and instructional design: How ID practitioners work in practice, *Performance Improvement Quarterly*, **28**(3), 2015, pp. 25–49.
33. C. L. Dym, A. M. Agogino, O. Eris, D. D. Frey and L. J. Leifer, Engineering design thinking, teaching, and learning, *Journal of Engineering Education*, **94**(1), 2005, pp. 103–120.
34. F. Alonso, D. Manrique, L. Martínez and J. M. Viñes, Study of the influence of social relationships among students on knowledge building using a moderately constructivist learning model, in *Journal of Educational Computing Research*, **51**(4), 2015, pp. 417–439.
35. A. D. Figueiredo, Toward and Epistemology of Engineering, *Proceedings Workshop on Philosophy & Engineering (WPE 2008)*, Royal Engineering Academy, London, 2008, pp. 94-95.
36. A. Hervás, F. B. Garcia and F. J. G. Peñalvo, A method of assessing academic learning experiences in virtual learning environments, *IEEE Latin America Transactions*, **12**(2), 2014, pp. 219–226.
37. R. C. Clark and R. E. Mayer, *E-learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*, John Wiley & Sons, 2016, pp. 98–104.
38. R. Heinich, M. Molenda, J. D. Russell and S. E Smaldino, *Instructional Technology and Media for Learning*, New Jersey, Columbus. Multimedia Pembelajaran, 2005.
39. J. E. Pérez Martínez, J. García Martín, I. Muñoz Fernández and A. Sierra Alonso, Active learning and generic competences in an operating systems course, *International Journal of Engineering Education*, **26**(6), 2010, pp. 1484–1492.
40. C. Romero, P. G. Espejo, A. Zafra, J. R. Romero and S. Ventura, Web usage mining for predicting final marks of students that use Moodle courses, *Computer Applications in Engineering Education*, **21**(1), 2013, pp. 135–146.
41. T. I. Aldosemani, C. E. Shepherd, I. Gashim and T. Dousay, Developing third places to foster sense of community in online instruction, *British Journal of Educational Technology*, **47**(6), 2016, pp. 1020–1031.
42. C. H. Ikpeze, Teaching Across Cultures, *Teaching across Cultures*, Sense Publishers, 2015, pp. 179–192.
43. P. Tsiotakis and A. Jimoyiannis, Critical factors towards analysing teachers' presence in on-line learning communities, *The Internet and Higher Education*, **28**, 2016, pp. 45–58.
44. P. Pamplona, S. Medinilla and P. Flores, Assessment for Learning: A Case Study of an Online Course in Operating Systems, *International Journal of Engineering Education*, **31**(2), 2015, pp. 541–552.
45. A. Sife, E. Lwoga and C. Sanga, New technologies for teaching and learning: Challenges for higher learning institutions in developing countries, *International Journal of Education and Development Using ICT*, **3**(2), 2007.
46. M. Peñafiel and S. Luján-Mora, Cuestionarios para el análisis del uso de las tecnologías de la información y la comunicación en la Escuela Politécnica Nacional, URL: http://hdl.handle.net/10045/71490, accessed 28 November 2017.
47. S. Sanchez-Gordon, T. Calle-Jimenez and S. Luján-Mora, Relevance of MOOCs for training of public sector employees, *Information Technology Based Higher Education and Training Conference (ITHET)*, Lisbon, Portugal, 2015, pp. 1–5.
48. M. Peñafiel, C. Ruilova and P. Acosta, *Guía metodológica para aulas virtuales bajo Moodle*, http://rua.ua.es/dspace/handle/, accessed 03 June 2017.
49. L. D. Miller, L. K. Soh, A. Samal, K. Kupzyk and G. Nugent, A Comparison of Educational Statistics and Data Mining Approaches to Identify Characteristics that Impact Online Learning, *Journal of Educational Data Mining*, **7**(3), 2015, pp. 117–150.
50. B. Liu, *Sentiment Analysis and Opinion Mining: Synthesis Lectures on Human Language Technologies*, San Rafael: Morgan & Claypool Publishers, **5**(1), 2012, pp. 1–167.
51. R. M. Gagne and L. J. Briggs, *Principles of Instructional Design*, Holt, Rinehart & Winston. 1974.
52. R. M. Gagne, W. W. Wager, K. C. Golas, J. M. Kellera and J. D. Russell, Principles of instructional design, Performance Improvement, **44**(2), 2005, pp.44–46.
53. R. M. Branch, *Instructional design: The ADDIE approach*, 722, Springer Science & Business Media, 2009, pp. 165–168.
54. J. Bourne, D. Harris and F. Mayadas, Online engineering education: Learning anywhere, anytime, *Journal of Engineering Education*, **94**(1), 2005, pp. 131–146.

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