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B-LEARNING IMPLEMENTATION STRATEGY IN TELECCOMUNICATION ENGINEERING, UNED COSTA RICA

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Abstract. The objective of the study was to develop a strategy for the implementation of the B-learning model in the Telecommunications Engineering program at UNED, Costa Rica. The study worked under a qualitative approach with an action-research design where three targeted samples were defined: graduates of the career, employers and academic managers. In addition, techniques such as surveys, review of case studies, literature review and documentary review of the AAPIA accreditation model were used to collect information. The information was processed through comparative techniques that allowed associating the topics of study with the competencies and methods of active learning. Among the results, it was found that in Costa Rica there are careers accredited with AAPIA but none has established the B-learning model as the basis of its learning process. The most valuable result is that four to six significant learning activities were incorporated per subject, about 300 academic and evaluation activities were proposed, with a range of 17 to 20 activities per subject. The work demonstrated that B-learning can be applied in engineering careers, and the strategy also provides the planning to achieve the AAPIA accreditation of CFIA, being an example framework, that other engineering careers can use.

Key words: Active learning, Telecommunications, Distance learning, Engineering.

ESTRATEGIA DE IMPLEMENTACIÓN DE *B-LEARNING* EN LA CARRERA DE INGENIERIA EN TELECOMUNICACIONES, UNED COSTA RICA

Resumen. El objetivo del estudio fue desarrollar una estrategia para la implementación del modelo *B-learning* en la carrera de Ingeniería en Telecomunicaciones de la UNED, Costa Rica. El estudio se trabajó bajo un enfoque cualitativo con un diseño de investigación – acción en donde se definieron tres muestras dirigidas: graduados de la carrera, empleadores y encargados académicos. Además, para la recolección de información se usaron técnicas como encuestas, revisión de casos de estudio, revisión bibliográfica y revisión documental del modelo de acreditación de AAPIA. El procesamiento de la información fue mediante técnicas comparativas que permitieron asociar las temáticas de estudio con las competencias y métodos del aprendizaje activo. Dentro de los resultados se encuentra que en Costa Rica hay carreras acreditadas con AAPIA pero ninguna ha establecido el modelo *B-learning* como base de su proceso de aprendizaje. El resultado de mayor valor es que se incorporaron de cuatro a seis aprendizajes significativos por asignatura, se propusieron alrededor de 300 actividades académicas y de evaluación, con un rango de entre 17 a 20 actividades por asignatura. Del trabajo se demostró que el *B-learning* se puede aplicar en carreras de ingeniería, además la estrategia da la planificación para alcanzar la acreditación AAPIA del CFIA, siendo un marco de ejemplo que otras carreras en ingeniería pueden utilizar.

Palabras clave: Aprendizaje activo, Telecomunicaciones, Enseñanza a distancia, Ingeniería.

Introduction

The Telecommunications Engineering program at UNED in Costa Rica began in 2016, with what is known in the country as a Bachelor's degree, which is not the initial degree of professional training, but an intermediate level. For the year 2021, with the approval of the National Council of Rectors (CONARE) to start the first degree of professional training, called Bachelor's Degree, the career must decide its learning model, since the Bachelor's Degree is totally virtual.

In engineering, virtual education is rejected as a valid model for teaching professional bases, even though studies such as that of López-Collazo (2020) point out that today's society requires engineers with the ability to respond to the demands of the environment. In addition, the career decides that, although there should be a continuity towards the Bachelor's degree education model, elements such as the students' access to the Internet and the need to acquire manual skills would not allow a 100% virtual implementation.

Bartolomé-Piña et al. (2018) indicate that a career can start with a high face-to-face percentage to evolve towards a virtual model. For this reason, the Telecommunications Engineering program establishes the *B-learning* model as the model that will allow this transition from the classroom to the virtual, and which, in turn, will allow students to acquire their engineering skills.

Another aspect considered by the race in its decision is that educational models evolve, and the digital transformation in the education sector becomes an obligation to adapt to the needs of the market and society. The concept of Society 5.0 implies that universities should train professionals with innate digital skills, with the ability to debate with intelligent agents, human or not (Cortés-Rico, 2020). Therefore, the digital competence required in engineers and professionals graduating from university careers should be based on the following dimensions: computer competence, information competence, generic cognitive competence, multiple literacies and digital citizenship (Terreni et al., 2019).

To achieve this goal, a strategy must be articulated because, as Arana (2020) points out, future professionals must have digital skills integrated into their competencies. Therefore, the Bachelor's Degree should allow students to acquire basic manual skills of an engineer, generate meaningful learning and provide training aligned to market trends, but they should also acquire digital skills such as interacting with non-human intelligent systems, working collaboratively using ICT, managing information and thus innovating, all this without departing from the UNED education model and the higher degree of Bachelor's Degree.

In addition, the career aims to achieve the accreditation model of the Accreditation Agency for Engineering and Architecture Programs (AAPIA) of the Federated College of Engineers and Architects (CFIA), so that graduates can choose to continue their studies in countries such as the United States and Canada (World Federation of Engineering Organization [WFEO], 2020). Within this model, a total of 12 attributes are worked on, which must be established at low, intermediate and high levels.

This accreditation model forces the engineering program to reformulate its teaching methods, because the intentionality is not only aimed at acquiring technical knowledge, but also to reach the levels of the declared attributes. In this way, academic activities, evaluated or not, have an additional intentionality of an attribute such as the development of written expression, relationship between engineering and society, among others.

From the literature review we worked with case studies from the Spanish American region and Costa Rica. From this study there is no similar work to this one in terms of the implementation of *B-learning* on a complete career, what are located are case studies that were raised for specific courses or subjects.

López-Collazo (2020) presents the implementation of the inverted classroom technique, which is part of the portfolio of *B-learning*techniques in the Telecommunications and Electronics Engineering course at the "José Antonio Echeverría" Technological University of Havana. In this implementation, the face-to-face teaching model was not varied, but a technique was incorporated that gives a twist to what is done in the classroom and what is done at home, the classroom is to answer doubts, interact and deepen. The home is where knowledge is acquired through self-learning. The results obtained were varied, because as well as positive evaluations, there were also negative opinions.

This case shows one of the reasons why a certain part of the students reject *B-learning,* and specifically the active learning technique. It is because by breaking the model of a teacher transferring knowledge, students must self-regulate and be self-taught. And, on the other hand, from the teachers themselves, because the active learning and combination of techniques proposed by *B-learning* require planning and preparation.

B-learning application models are based on a face-to-face/distance relationship and are measured by the achievement of significant learning. Hence the importance within *B-learning* of the pedagogical designs, methodology and techniques that are applied, adequate use of resources and intentionality with which they are used, degree of class planning and disposition and competencies of the teaching staff (García-Aretio, 2018).

There is also the case of García Chi et al. (2019), in the Simulation subject of the Computer Systems Engineering course of the Tecnológico Nacional de México (TecNM) where they implemented the mixed modality through the use of LMS platform, in this case Moodle is mentioned. The *B-learning* modality is implemented because classroom classes and laboratories are maintained, and the application of Moodle is for the solution of learning strategies. In this case, there is a combination between the face-to-face model and the *E-learning*model, hence it is considered a *B-learning*.

In other cases, the application of the *B-learning* model is directed to thematic units and not to the entire subject. This is the case of Corrales-Beltrán et al. (2018), where a micro-curricular design was developed for a specific topic and integrated the use of web 2.0 technologies as part of the teaching process. The results of the implementation were satisfactory, because they changed the negative perception of the students and improved their academic performance.

With respect to the case of Costa Rica, it was determined that no engineering career has this model as a basis. Similar to the region, there have been cases of implementation of specific strategies or in specific courses. Sandoval-Carvajal et al. (2017) mention of the integration of Problem-Based Learning (PBL) in the Systems Engineering career at the National University (UNA), being a specific technique. The same case of the Bachelor's Degree in Telecommunications Engineering where what is implemented is the 100% virtual model, but it is a higher degree, not at the Baccalaureate level (Santamaria-Sandoval and Chanto-Sanchez, 2020).

In another case, as a result of the emergency and modifications that had to be made due to the pandemic in 2020, the *B-leanirng* model arose as an emerging measure, where more than three thousand teachers were trained to provide continuity to the study programs at the University of Costa Rica (Oviedo and Alfaro, 2020), but it is not an implementation of a career as such.

Method

The study has a qualitative approach under an action-research design, where the researcher is an active part as one of those in charge of the program. The study was defined as qualitative because the result is for a given case, and the results are perceptions and assessments from the different populations to which the study is applied.

The following inductive categories, shown in Table 1, were established for the approach of the study:

Table 1
Research categories

Category	Definition	Operationalization	Research techniques
CFIA Attributes	Traits that graduates of university engineering programs must have in order to be accredited (WFEO, 2020)	Initial Intermediate Advanced	Bibliographic review Documentary review Surveys Expert Judgment
*B-learning*model	Education model that allows the integration of diverse strategies and methods giving flexibility and adaptability to the curricular designs of careers (García - Aretio, 2018)	Activities Significant learning Mediations	Bibliographic review Surveys Expert Judgment
ICT platforms for education and experimentation	ICT tools that enable learning management, experimentation or are the object of study (Hernández-Gómez, Carro-Pérez, & Martínez-Trejo, 2019).	Laboratories EVA in LMS	Bibliographic review Documentary review Review of platform logs Surveys Expert Judgment
Professional fields of Telecommunications Engineering	Areas in which a professional in Telecommunications Engineering can develop (Universidad Estatal a Distancia, 2021)	Career fields of study Themes by subject	Bibliographic review Documentary review Surveys Expert Judgment

The study participants were from three population groups: employers, graduates and academic peers. For all populations, targeted samples were established, because the objective is not to establish a trend, but rather the assessments that can be made by different stakeholder groups. Table 2 shows the research subjects.

Table 2
Research subjects

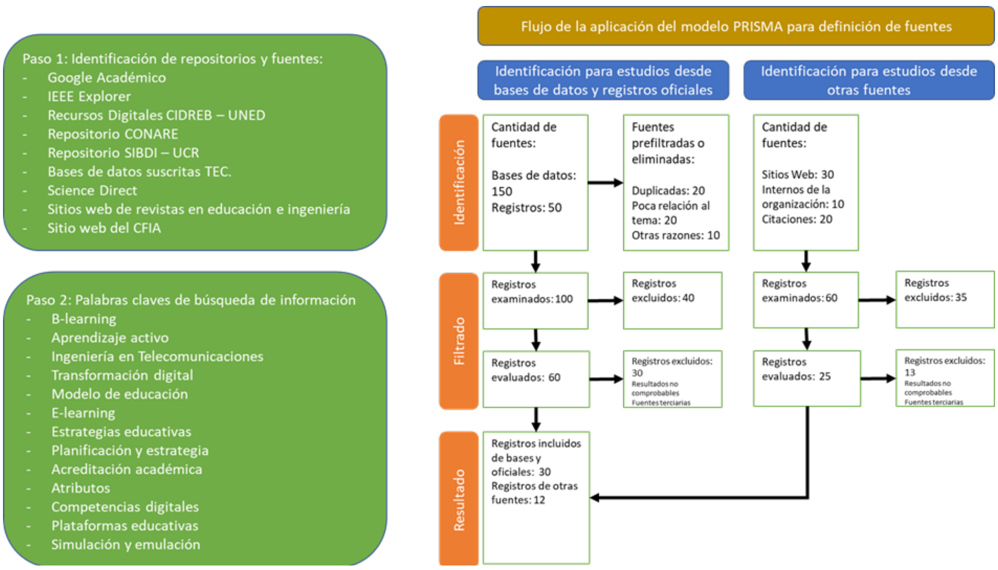
Subject or population group	Description	Quantity	Information

Program managers	Administrative and academic managers of the Telecommunication Engineering program	4	Perspective of *B-learning*implementation Evaluation of the teaching model Consideration of attribute levels Possible activities and their validation
Bachelor's Degree Graduates	Students graduating from the Bachelor's Degree in Telecommunications Engineering until 2021	13	Validation of the bachelor's degree graduate profile Assessment of the virtual education of the bachelor's degree Professional fields of the Telecommunications Engineer
Professionals in the field of telecommunications	Professionals working in the telecommunications field in Costa Rica.	40	Market need Professional fields of development of the Telecommunications Engineer Validation of the attributes of the career graduate Conceptualization of activities that can be carried out to approach the professional field

The techniques used included a literature review using the PRISMA method. Figure 1 shows the process carried out for the selection, classification and filtering of sources.

Figure 1

Application of the PRISMA model in the literature review methodology for state of the art constructions



Note. Elaborated from PRISMA. (2019). PRISMA TRANSPARENT REPORTING of SYSTEMATIC REVIEWS and META-ANALYSES. *http://prisma-statement.org/prismastatement/flowdiagram.aspx*

A second technique was the application of surveys to three previously defined population groups. This survey was administered between June and July 2021 through the Google Forms platform. The questionnaires for employers and graduates were 13 and 10 questions respectively. In the case of the graduates, the questions focused on the techniques and tools applied during the Bachelor's degree; for the employers, the questions focused on the skills that they consider future graduates should have.

A third survey was applied to the academic peers, where the emphasis was to obtain their perspective regarding the subjects, academic activities and teaching methods, being a technical and academic perspective.

Subsequently, the expert judgment technique was applied for data analysis in combination with the focus group. This allowed to generate validity and reliability to the data, since not only the understanding of the researcher-actor is raised, but also the vision of academic peers is contrasted. This activity is carried out at the end of July 2021 under an analysis guide.

Statistical analysis methods were applied in the processing stage. Although the results are not for quantitative analysis, descriptive statistical methods were used. These were used to obtain frequencies, modes and bar graphs to determine the amount of learning, the number of activities by type of activity, and the weight of the topics.

Thus, the method was divided into two phases: data collection and a second processing phase. Figure 2 shows the collection process and Figure 3 shows the processing process.

Figure 2

Data collection process of the study

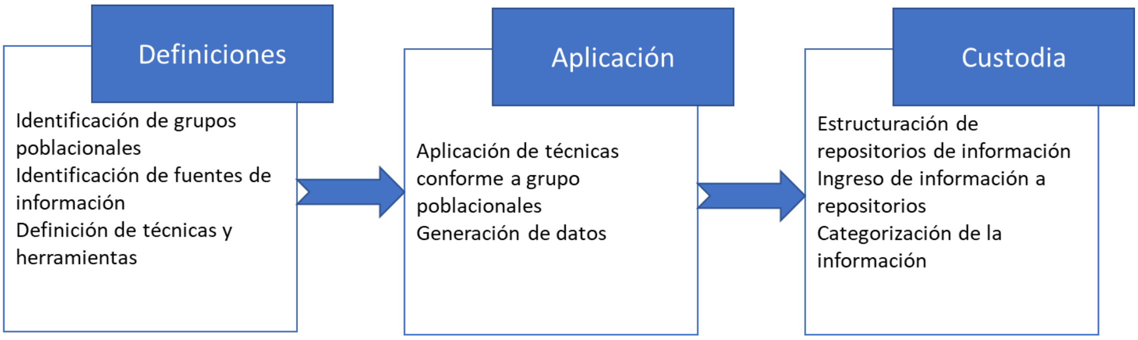


Figure 3

Stages of information processing of the study

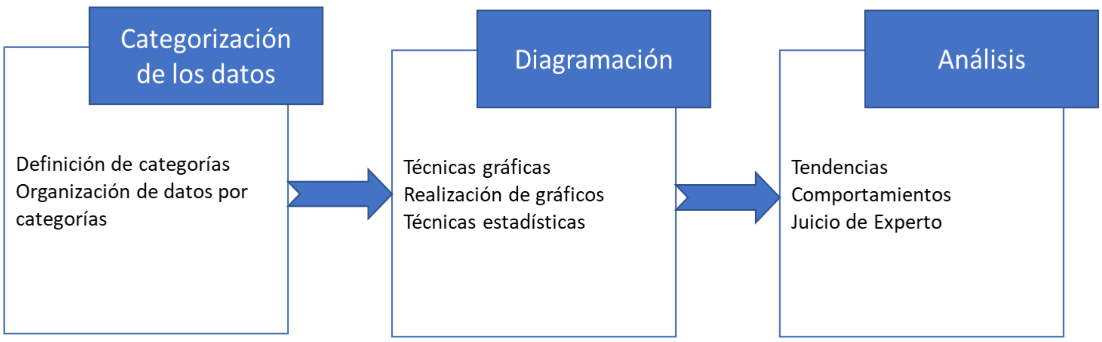


Table 3 shows the summary of the methodology applied in the project.

Table 3
Summary of applied research methodology

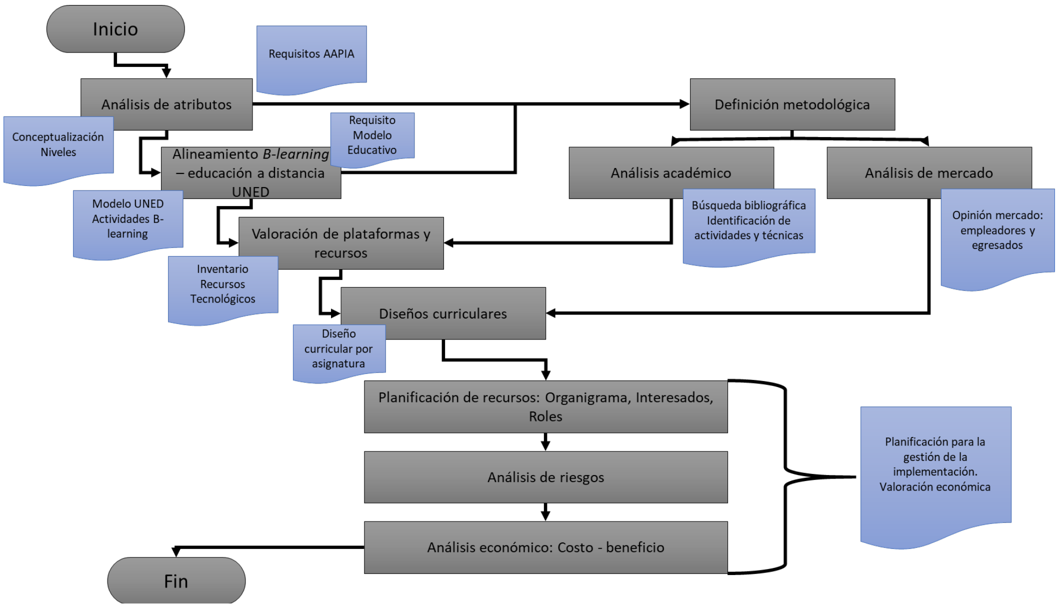
Research approach	Qualitative - professional study
Proposed methodology	Field work / Case study
Application environment	Telecommunications Engineering Career at UNED, Costa Rica Graduates and market employers
KPIs (Key Performance Indicators)	*B-learning* alignment with virtual distance education. Didactic activities by subject. Attributes by subject Significant learning by subject. Reuse of existing technological platforms at the University Project risk and importance Critical line of the project. Alignment of meaningful learning with the market. Curricular design of each subject
Study categories	CFIA Attributes *B-learning model* ICT platforms for education and experimentation Professional fields of Telecommunications Engineering.
Variables related to the categories	Attribute level by subject Number of attributes per subject Number of activities per subject Number of significant lessons learned per subject Number of laboratories proposed Level of application of virtuality in the degree program Number of activities related to professional practice per course Percentage of activities related to professional practice

Results

The main result obtained from the research was the construction of the strategy under a *top-down*model. The first step was to define the attributes of the AAPIA model, which were instrumentalized through meaningful learning and with them learning objectives and evaluative activities were determined.

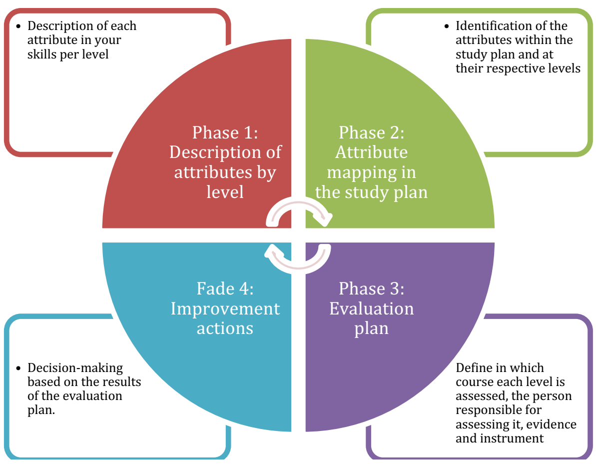
Figure 4 shows how the strategy was structured.

Figure 4
Structuring the proposed solution



The working model proposed by Meza-Badilla et al. was used to build the solution. (2017), where from four steps the attributes can be incorporated into academic programs. However, since it is defined as a strategy and not the implementation as such, it is defined as using only the first two phases of the model. The method is shown in Figure 5.

Figure 5
Steps for the incorporation of the 13 attributes of the AAPIA model in engineering careers



Note. Adapted from Meza-Badilla, E.C., Aguilar-Cordero, J.F., Quesada-Sanchez M.I. and Delgado-Montoya W. (2017). Attributes of graduation in engineering careers: Methodology of evaluation by results.

The first concrete result obtained from the research was the description of the attributes of graduation of the students of the Bachelor's Degree in a personalized way towards the Telecommunications Engineering career. The complete description by attribute is shown in Table 4, where these descriptions contemplate the knowledge of the graduate, the indications of the AAPIA model and the methodology of Meza-Badilla et al. (2017).

Table 4

Descriptions of the attributes of the AAPIA accreditation model for the Telecommunications Engineering program at UNED

Attribute	Level	Description
Engineering Knowledge (IC)	Av	The graduate: He integrates in his solutions to complex telecommunications engineering problems the theoretical and conceptual foundations of the discipline, and is able to explain their use. Designs, builds, implements and operates solutions applying telecommunications engineering principles and standards.
Problem analysis (PA)	Av	Apply and develop methods of analysis to the complex problems posed by the evolution of telecommunications technologies and services. Establishes, formulates and proposes schemes for the understanding of problems, by means of which the resolution of these is planned.
Design Solutions (DS)	Int	Design solutions to telecommunications engineering problems by applying existing methods. Infer possible solutions to a problem under conventional methods, professionally accepted standards and norms.
Research (IVT)	Int	Deduce possible results and trends from academic and professional research in the field of telecommunications engineering. Applies engineering and research methods to infer results from experiments and tests applied to telecommunications engineering technologies and solutions.
Modern engineering tools (HM)	Av	Evaluates and validates engineering tools applied to telecommunications infrastructure and solutions to demonstrate their usefulness. Suggests improvements, updates and new integrations of tools and technological platforms for the generation of value to the telecommunications engineering solutions.
Engineering and Society (IS)	Av	Contextualizes solutions to complex problems in telecommunications engineering with respect to the value they bring to society. Infer, synthesize and demonstrate the benefits to society from problem solving and solution development, as well as biases.
Environment and Sustainability (MAS)	Av	Evaluates the sustainability of telecommunications engineering solutions from an environmental perspective. Formulates and proposes engineering solutions in telecommunications that will provide benefits to the environment and the sustainability of ecosystems.
Ethics and equity (EE)	Av	Applies the code of ethics and current professional practice regulations in accordance with the telecommunications solutions to be developed. Decides actions and activities in which he/she participates and in which he/she does not participate in accordance with the ethical principles of the profession.
Individual and team work (TIE)	Av	Leads professional teams to develop solutions to complex problems in telecommunications engineering. Integrates high-performance work teams and fulfills individual responsibilities in a self-directed manner.
Communication (CM)	Av	Prepares concise, precise, clear and effective written communications on aspects of telecommunications engineering, projects in which he/she participates and his/her own work. Communicates orally and verbally through executive presentations the results of engineering work in telecommunications of their projects or work.
Project Management and Finance (APF)	Int	He customizes project management methods to the organizations where he works for the structuring, planning and execution of the development of telecommunications solutions. Influences and questions financial results to projects of the organizations related to telecommunications, as well as country project.
Life Long Learning (LLL)	Int	It recognizes the dynamism of telecommunications and the need for constant updating to generate valuable solutions. Applies new skills acquired in a continuous updating process in the development of solutions to complex problems in telecommunications engineering

With these definitions and considering the study topics, the relationships and levels per subject are proposed. It should be clarified that the ALV, APF, DS and IVT attributes are decided not to reach the advanced level. This is so because on the one hand, accreditation is only achieved when the student obtains the Bachelor's Degree and the Bachelor's Degree, and secondly, because within the Bachelor's Degree these attributes are deepened through the curriculum and study topics.

Table 5 shows the relationship between the bachelor's degree subjects, attributes and their levels.

Table 5
List of attributes and subjects for the bachelor's degree curriculum

Subject	Attributes (I - Initial, Int - Intermediate, Av - Advanced)											
	CI	AP	DS	IVT	HM	IS	MORE	EE	TIE	CM	APF	ALV
Level 4: Introduction to Engineering						Int	Int	Int				
Level 5: Signal Systems and Analysis	Int	I							I			
Level 5: Statistics I for engineering											I	
Level 5: Electrical Networks I	Int	I										
Level 6: Optical fiber	Int											
Level 6: General Electronics	Int	I										
Level 6: Graphic design for telecommunications networks			I								Int	Int
Level 6: Instrumentation systems I Laboratory	Int	I			I							
Level 6: Electrical Networks II	Int	Int					Int					
Level 6: Engineering Management						Int				Int	Int	
Level 7: Structured Cabling	Int				Int							Int
Level 7: Advanced Electronics	Int	Int										
Level 7: Computer Architecture	Int								Int			
Level 7: Instrumentation systems II Laboratory	Int				Int				Int			
Level 7: Electromagnetic Theory I	Int						Int					
Level 8: Radio and mobile link	Int		Int		Int							
Level 8: Electronic Communications Systems I		Int	Int									
Level 8: ICT Hardware and Software Infrastructure	Int		I		Int							
Level 8: Telecommunications Network Infrastructure			Int									Int
Level 8: Electromagnetic Theory II	Int											
Level 9: Fixed and mobile telephone systems			Av			Av						
Level 9: Electronic Communications Systems II	Av				Av							
Level 9: Internet network architecture and IoT technologies	Av				Av	Av						
Level 9: Telecommunication Network Systems			Av						Av			Int
Level 9: Unified Communications Systems					Av	Av						
Level 10: Research Methods and Techniques				Int			Av			Av		
Level 10: Television Systems	Av	Av										
Level 10: Telematic Networks and Routing Protocols	Int											Int
Level 10: Management and Monitoring of Telecommunications Networks		Av			Av				Av			
Level 10: Virtualization Systems	Av				Av							
Level 11: Supervised Practice			Int		Av	Av	Av	Av		Av		

The third step in the construction of the strategy was the assessment of techniques that can be associated with the B-learning teaching model. In the first instance, the evaluation components that UNED has in its distance education model were determined. These four components are (Jiménez Aragón, 2020):

- Test: Any evaluative activity not exceeding three hours. Its purpose is to evaluate the basic productive level of use of knowledge and skills to act on problems of the profession similar or equal to others already studied or solved in self-assessment exercises, previous activities. These activities include online, short or face-to-face written tests.
- Task: Its objective is exclusively to evaluate the reproduction of content; this component has no assignment within the cognitive plane of production. The activities considered as homework include album, portfolio, practice exercises, questionnaire, file, comparative table, glossary, concept map and mind map, among others.
- Professional Field: These are activities that can be carried out on site, remotely, simulated and, in the case of telecommunications, emulated activities. The objective is to evaluate the use of theoretical knowledge and skills to act in practical cases that recreate the profession. Reports, laboratory logs or reports, field work, systematization of experiences, field practices are included.
- Academic production: This is the component that evaluates the student's capacity of advanced productive domain, where he/she makes use of information sources, disciplinary knowledge and skills on which he/she applies scientific research logic. Among the activities are projects, proposals for scientific articles, documentary research, applied research, essays, theses, without being exhaustive.

This establishes a relationship between *B-learning strategies,* academic techniques, evaluative activities, their component and attributes, as shown in Table 6:

Table 6

Synthesis of evaluative and non-evaluative teaching strategies, techniques and activities for the Bachelor's Degree in Telecommunications Engineering

Strategy	Technique	Activities	Evaluative component	Attribute
Self-study	Individual Study Individual Tasks Individual laboratory Individual field work Projects Research	Testing tasks Summaries Testing Project reports Construction of electrical, electronic and telecommunications solutions Virtual laboratory practices Portfolio Construction of a reflective diary Self-assessment exercises Reading of individual material	Task Academic production	CI TIE ALV APF DS IVT HM CM
Interactive learning (includes active learning)	Master exhibitions Interviews Visits to specialized sites Conferences Inverted classroom Gamification of education Laboratories	Synchronous virtual tutoring Interactive questionnaires Discussion forums Visit reports Listening to conferences Mind and concept maps Game-based practices for testing Laboratory practices Development of wikis Interactive reviews	Professional field Tests	CI ALV IS DS HM CM
Collaborative learning	Troubleshooting Inverted classroom	Case studies Discussion forums Synchronous sessions Collaborative synthesis schemes	Professional field Task	CI TIE MORE AP EE CM
Cooperative learning	Teamwork Inverted classroom	Team tasks Team diagrams	Professional field Task	CI MORE EE CM

With the above, we work with each of the 32 subjects of the program, which are divided into three areas of knowledge: Electrical and Electronics, Information Systems and Telecommunications. A summary sheet similar to the one shown in Table 7 is created for each subject. This includes learning objectives, academic activities and significant learning.

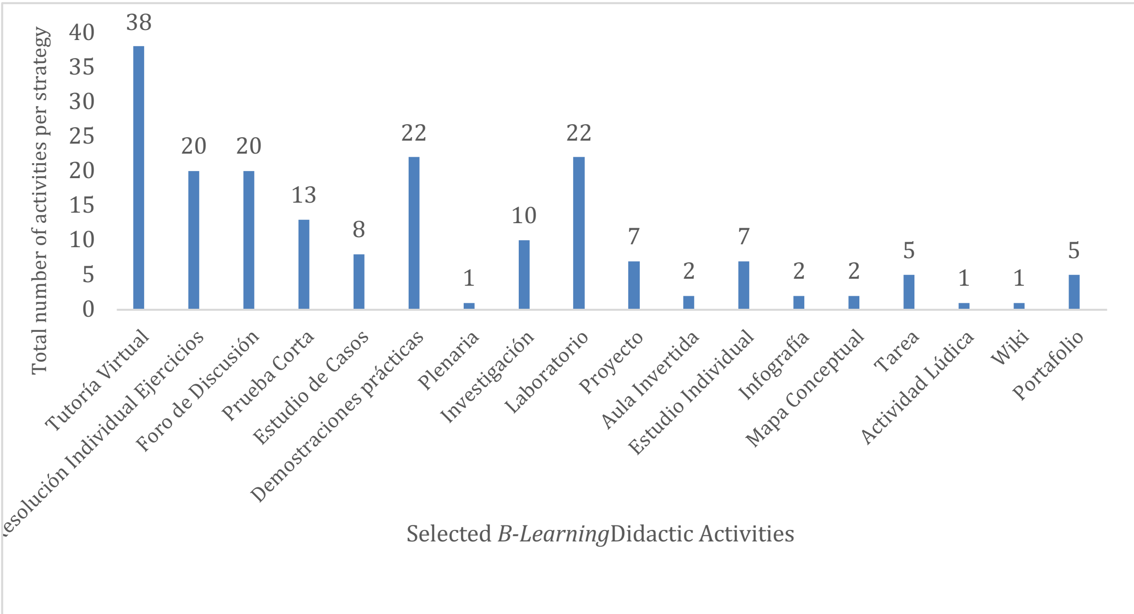
Table 7
Example summary sheet of the Virtualization Systems course

Name of subject	Virtualization Systems	
Description: In this course the student acquires knowledge of the different types of services for data networks in service virtualization. It also provides the knowledge for the technical skills of the different infrastructures of technologies such as Local Area Networks, Automatic Tranfer Mode, HyperServer, Virtual Desktop and Storage virtual networks. The student demonstrates configuration schemes and cases the competencies to maintain in operation the communications networks in an efficient way in order to increase creativity and innovation in telecommunications engineering at UNED. This will support you to mediate in different disciplinary fields leading groups and work teams. He is an expert in virtualization systems from the access, public or private network, operating system and storage. market applications. Students will make decisions to adjust the best technical decision that fits the solution posed in their service needs and the confidence to develop that achievement.		
General Objective: Assess the differences in virtualization services from their implementation in public or private networks considering the storage access components for different technologies and communication infrastructures.		
Subject	Learning objective	Didactic activity
1. Virtualization of LANs in communications networks	To propose the type of virtualization required in the data network considering the needs of the organization for the definition of the LAN operating model.	Practical synchronous tutorial on virtual network infrastructure configuration. Laboratory practice of virtualization of network elements from simulator or emulator applications. Individual study of methods and trends in network virtualization. Short research report on current methods of network virtualization.
2. Virtualization of services for public ATM networks	Deduce the virtualization applied in public ATM networks under mechanisms such as circuit emulation for the development and provision of services to end users.	Case studies on services provided from ATM networks and their current correspondence. Collaborative discussion forum on legacy ATM techniques in current telecommunications and convergent services.
3. Server virtualization	Implement virtualization tools in servers establishing their integration to the network for infrastructure optimization	Demonstrative synchronous tutorial on server virtualization with various operating systems and virtualization applications. Laboratory practice of network server virtualization from simulator or emulator applications. Start of virtualized data network design project - Progress 1 Virtualization of network elements.
4. Desktop virtualization (VDI).	Develop the configuration on servers and computational machines assessing the operational and organizational requirements for the deployment of virtualized desktops.	Laboratory practice of virtualization of desktops associated to a server from simulator or emulator applications. Continuation of virtualized data network design project - Progress 2 Server Virtualization
5. Storage Area Network (SAN) and VSAN networks	Establish the elements required for storage virtualization, defining the levels of response and availability of this infrastructure to meet performance indicators.	Completion of virtualized data network design project - Progress Final Desktop Virtualization Individual study of SAN virtualization tools. Practical simulation of database backup service configurations using SAN with high availability schemes.
Significant learning - Validates virtualization models and mechanisms in the different components and elements of a data network applying operation concepts and engineering criteria (CI.Av). - Suggests engineering tools and applications for the virtualization and integration of the elements to the telecommunications network (HM.Av).		

Thus, for the subjects in the area of Electrical and Electronics, a total of 186 activities are proposed, a total of 18.6 activities per subject and 18 types of academic activities are proposed. These activities range from those that are evaluated to those that are not evaluated but rather formative, of interaction and collective generation of knowledge through collective learning. Figure 6 shows the summary of the number of academic activities by type of activity for the 10 subjects of the Electrical and Electronics area.

Figure 6

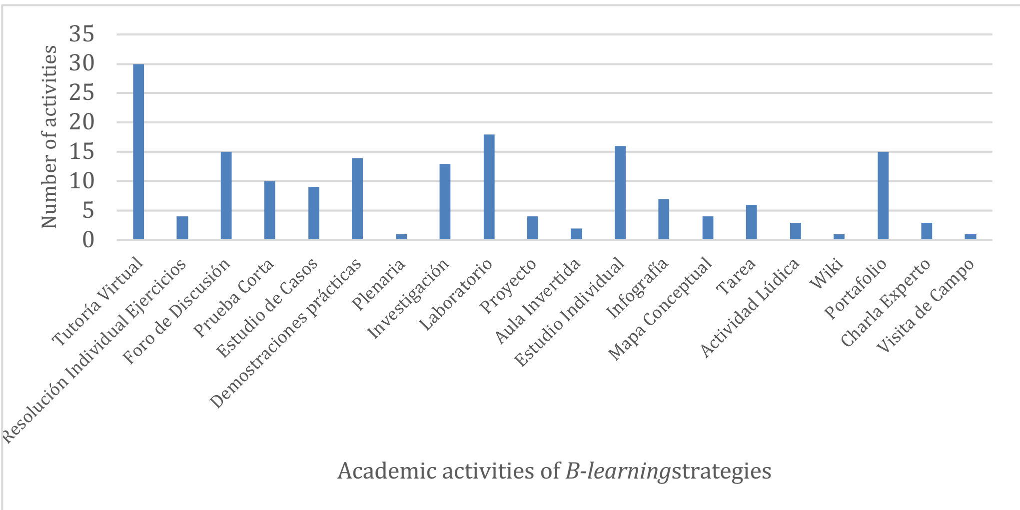
Summary of number of academic activities for the Electrical and Electronics area subjects



In the case of the subjects in the Information Systems area, a total of 176 activities were determined for an average of 19.55 per subject. Figure 7 shows the summary of activities proposed for the subjects of the Information Systems area.

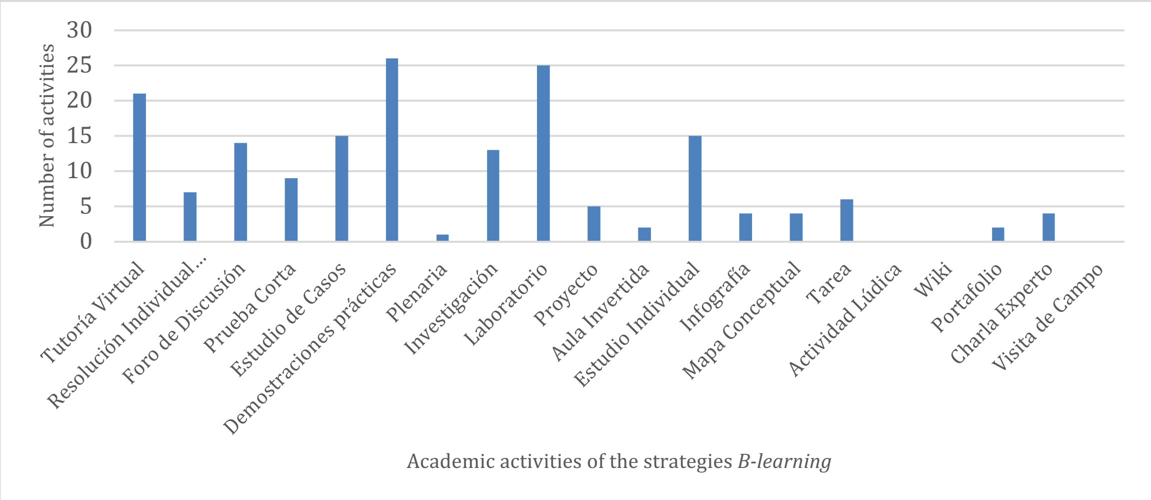
Figure 7

Summary of the number of academic activities for the subjects of the area of Information Systems



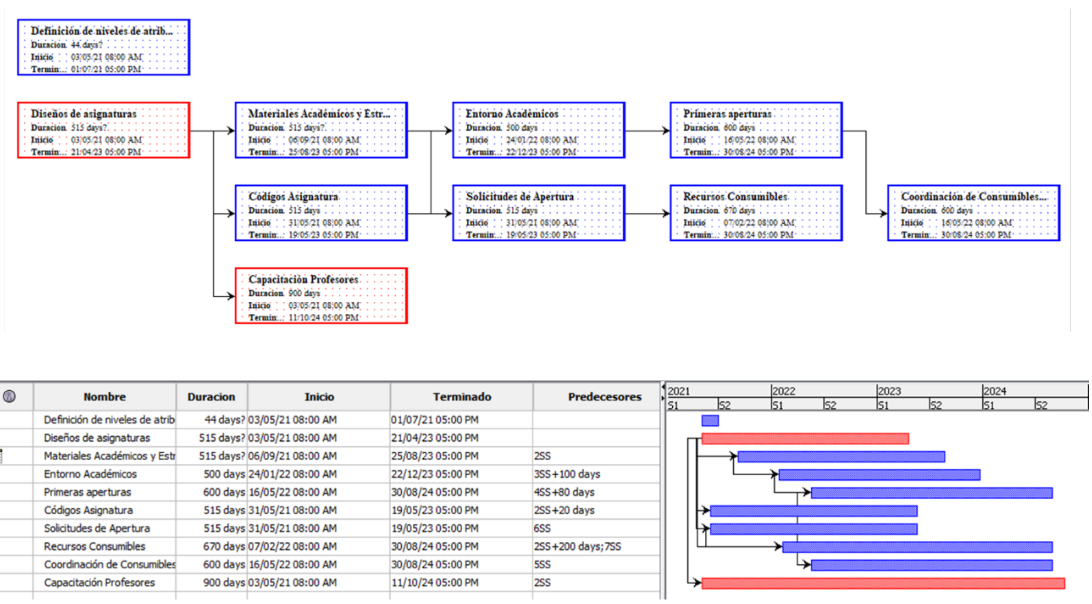
In the case of subjects related to the Telecommunications area, a total of 171 activities were determined, for an average of 17.1 activities per subject and a total of 18 different types of activities. Figure 8 shows the summary of the number of activities proposed by type for the subjects in the Telecommunications area.

Figure 8
Summary of the number of academic activities for the subjects of the Telecommunication area



Once this planning for the academic implementation of *B-learning* was done, we moved on to the operational planning of the process. Based on the above, it was established that each subject requires at least one year of planning, and therefore it was decided to work on the opening of the subjects in a gradual manner per quarter of each year. With this in mind, a work plan was drawn up for the period from 2021 to 2023, as shown in Figure 9.

Figure 9
Project Gantt Chart



		Nombre	Duracion	Inicio	Terminado	Predecesores
1		Definición de niveles de atrib	44 days?	03/05/21 08:00 AM	01/07/21 05:00 PM	
2		Diseños de asignaturas	515 days?	03/05/21 08:00 AM	21/04/23 05:00 PM	
3		Materiales Académicos y Estr	515 days?	06/09/21 08:00 AM	25/08/23 05:00 PM	2SS
4		Entorno Académicos	500 days	24/01/22 08:00 AM	22/12/23 05:00 PM	3SS+100 days
5		Primeras aperturas	600 days	16/05/22 08:00 AM	30/08/24 05:00 PM	4SS+80 days
6		Códigos Asignatura	515 days	31/05/21 08:00 AM	19/05/23 05:00 PM	2SS+20 days
7		Solicitudes de Apertura	515 days	31/05/21 08:00 AM	19/05/23 05:00 PM	6SS
8		Recursos Consumibles	670 days	07/02/22 08:00 AM	30/08/24 05:00 PM	2SS+200 days;7SS
9		Coordinación de Consumibles	600 days	16/05/22 08:00 AM	30/08/24 05:00 PM	5SS
10		Capacitación Profesores	900 days	03/05/21 08:00 AM	11/10/24 05:00 PM	2SS

To execute this strategy, a series of roles and responsibilities for the activities were established. This is a necessary result to avoid duplication of functions, to have clarity in the information to be collected and in the roles responsible for each step to be executed. This is shown in Table 8.

Table 8
RACI Matrix for the Implementation Strategy of the B-learning model in the Bachelor's Degree in Telecommunications Engineering

Activity	CC	CE	SA	RC	EE	TT	CR	DE	SP
Definition of attribute levels	RA	RA		C		CI	I	I	
Subject designs	R	RA		AC		A	I	RI	
Academic Materials and B-learning Strategies	R	RA			AC	A	I	I	
Academic Environment	R	RA				A	I	I	AC
First openings	RA	A				A	I	I	CI
Subject Codes	RA	RA	A	AI			I	RI	
Opening Requests	RA	RA	A			A	I	RI	AI
Consumable Resources	RA	RA	A			A	I	RI	
Student Consumables Coordination	RA	RA	A			A	I	I	
Teacher Training	RA	RA	A	C		A	I	I	
Definition of attribute levels	RA	RA		C			I	I	

Note: The RACI model is a responsibility assignment matrix and is used in project management for the following assignments: R is responsible, A is authority, C is consulted and I is informed. The A differs from the R role because it is the one who ultimately has the decision-making authority. When a double letter appears in table 8, it corresponds to the assignment of two roles.

Discussion and conclusions

From the work it is determined that the *B-learning* model is consistent with the distance education model of the university, which is necessary to generate the implementation proposal. The aspects of the role of the student, the teacher, mediation, educational strategies, didactic activities, educational platforms and curricular designs were evaluated.

In all aspects this coherence is demonstrated, for example, in the case of the teacher's role, he/she functions as a mediator rather than as a generator of knowledge, but is part of the group and applies collaborative strategies for such implementation. Table 9 shows the respective consistency analysis.

Table 9
Analysis of the coherence of the B-learning model with the distance education model

Parameter	*B-learning*	Distance education model	Consistency
Student	It is the center of the model. Self-learning and self-regulation	It is the center of the model. Self-learning and self-regulation	✓
Teacher	It provides information, but does not have the predominant role, but has a mixed profile. Is a mediator in the process, monitoring progress and interacting when required	Is a mediator in the process, monitoring progress and interacting when required	✓
Mediation	They are clear guidelines on the processes and procedures to be applied. A number of tools can be used that together provide guidance to the student	It has tools to guide the student: academic orientations, mediations for each activity, schedule of activities, didactic materials.	✓
Educational strategies	Self-study Interactive learning Cooperative and collaborative strategies	Self-study Interactive learning Cooperative and collaborative strategies	✓
Didactic activities	Activities oriented to experiences that allow the student's own interpretation and acquisition of knowledge, but combined with guided and collaborative accompaniment: Inverted classroom, forums, interactive activities, gamification, among others	Didactic and evaluative activities in four components: assignments, tests, professional field and academic production. Activities that encourage self-learning and collaborations among students	✓
Educational platforms	Both physical elements and ICT tools. It includes repositories, laboratory and learning mediation platforms.	Both physical elements and ICT tools. It includes repositories, laboratory and learning mediation platforms.	✓
Curricular designs	Consider learning objectives that favor self-learning and the achievement of significant learning.	Consider learning objectives that favor self-learning and the achievement of significant learning. Apply cognitive models and expected level of learning	✓
Significant learning	It is the final objective sought by the model, being the experiences, skills and competences acquired by the student to apply them in his/her professional life	It is the final objective sought by the model, being the experiences, skills and competences acquired by the student to apply them in his/her professional life	✓

The vision provided by the graduates was that the e-learning model of the Bachelor's Degree added value to their professional training. In addition, they pointed out that they respond to the needs requested by Society 5.0. This value is framed in the following aspects:

- Self-learning and self-motivation: The *B-learning* activities encourage self-learning in the professional that leads to self-motivation in future professionals, which is consistent with the attributes required by the accreditation models.
- Professional field: The activities of the model place the student in the normal actions that an engineer must face, thus generating experiential learning.
- Research and innovation: *B-learning* encourages professionals to continue researching in their field, to go deeper and, since the methods are mediated and not imposed, it generates professionals to propose innovations or to look for methods to solve these problems.
- Social and environmental awareness: The activities and their approach generate social awareness of the professional practice. Therefore, *B-learning* motivates

future professionals to apply what they have developed to society in a sustainable way.

- Soft skills: As *B-learning* applies collaborative and cooperative strategies, students develop their soft skills for teamwork, leadership, respect and tolerance, communication, decision making, factors that are highly valued in today's market

On the other hand, considering the proposed planning, it is demonstrated that the attributes of AAPIA can be achieved even under a *B-learning*model. As mentioned, it has been considered that engineering education can only be conducted under a face-to-face model. Thus, this planning determines that what is relevant is meaningful learning, and if the mediations of the activities are carried out in a concrete manner, such learning is achieved.

Moreover, the *B-learning* model forces the student to be more active in the learning process, not just a passive actor, so he/she is obliged to learn by doing. Under the proposed scheme of activities, where at least one or more activities must be carried out per week of the school period, the process is continuous and the fulfillment of the attributes is visualized.

In addition, considering that the levels of the attributes were not only based on expert judgment, but also by verifying the results of the surveys of employers and graduates, it is possible to determine with satisfaction that at least 80% of the attributes meet the requirements of the market. This detail is important, because while achieving accreditation is an important goal, it is also important that the profile is desired by the market.

While a career must comply with elements of academic quality such as accreditation, it must also satisfy the market. Today, students value both quality and employability, and in the telecommunications field competence will be determined by your skills, level of these and attributes, in addition to knowledge in the field. For this reason, the soft skills issue raised above should also be included, and under the *B-learning* model this is possible.

However, even though the strategy satisfies 80% of what the market expects, the results showed that there is a varied perception between graduates who are employed and what employers mention. Both groups noted the importance of the traits of the engineering person, but their levels vary by technical or business focus depending on the subject.

Finally, this strategy allowed for continuity between the Baccalaureate model and the Bachelor's degree model at the teaching level, which was another expected objective of this solution. Table 10 shows the assessment of the different results of the project as opposed to the indicators of this research.

Table 10

Assessment of the results of the strategy compared to the defined needs and KPI's

Need	Associated KPI	Deliverable	Result
Optimize the current resources of the career for its implementation. Validate the technological platforms and resources of the university and the career for the implementation of the baccalaureate level	Reuse of existing technological platforms at the University Project risk and importance Critical line of the project.	Inventory of university and career educational platforms Schedule Risk analysis Stakeholder study Project RACI matrix	100% reuse of current platforms EMONA TIMS, Labview, Satellite Trainer, GPS, Net Circuit. Project completion time 2 years. High risk project: 50% of major risks. 25% of stakeholders with power or interest in the project.
To propose and demonstrate that the educational model of the UNED allows the application of the *B-learning*model Integrate the *B-learning* model to the Baccalaureate aligned to the university, to the Bachelor's Degree and to the characteristics of the student profile and the expected graduate.	*B-learning* alignment with virtual distance education.	Study of the university model Definition of applicable methods of the university model in *B-learning* and vice versa Identification of attributes and learning at the bachelor's degree level	100% alignment between *B-learning* model and distance education. Total compatibility and integration of activities. Application of the 4 types of *B-learning* strategies in distance and virtual education.
Define significant learning: attributes, digital competencies and knowledge that the graduate must have to respond to market needs.	Significant learning by subject. Alignment of meaningful learning with the market.	Attribute description sheets with levels, learning objectives and significant learning. Definition of learning in the baccalaureate graduation profile	23 significant learning in the graduation profile. 3 to 4 significant learning per subject. 90% consistency between market requirements and what is incorporated in the solution.
Curricular designs of the subjects associated with the educational model of the university and the requirements of the career.	Curricular design of each subject	Curriculum design sheet for each subject	29 curricular designs developed.
Innovate with academic activities in the design of the subjects that make up the curriculum of the Bachelor's Degree.	Didactic activities by subject.	Proposed activities by subject	533 proposed activities, 18.37 activities on average. 24 different types of activities.
Adapt the significant learning of the career to the AAPIA and SINAES accreditation model, with AAPIA priority.	Attributes by subject	Definition of levels and number of attributes per subject	Between 1 and 3 attributes per subject at different levels. High level of compliance in the definition of attributes, activities and learning with respect to the AAPIA model

References

Arana, R. (2020). *Qué es la transformación digital y por qué es necesaria para cualquier negocio*. TTAMDEM digital studio. https://www.ttandem.com/blog/que-es-la-transformacion-digital-y-por-que-es-necesaria-para-cualquier-negocio/

Bartolomé-Piña, A., García-Ruiz, R. y Aguaded, I. (2018). Blended learning: panorama y perspectivas. *Revista Iberoamericana de Educación a Distancia, 21* (1), 33-56. http://dx.doi.org/10.5944/ried.21.1.18842

Corrales-Beltrán, S.H., Rodríguez-Barcénas, G. y Molina-Saenz, D.N. (2018). *B-learning* para la enseñanza del SQL Server en Ingeniería Informática de la Universidad Técnica de Cotopaxi. Informática y sistemas: *Revista de Tecnologías de la Informática y las Comunicaciones. 2* (1), 43-59. https://doi.org/10.33936/isrtic.v2i1.1131

Cortés-Rico, L. (2020). Hacia una sociedad superinteligente. *Sistemas.* (154), 8-12. https://doi.org/10.29236/sistemas.n154a2

García Aretio, L. (2018). Blended learning y la convergencia entre la educación presencial y a distancia. RIED. *Revista Iberoamericana de Educación a Distancia, 21*(1), 9-22. http://dx.doi.org/10.5944/ried.21.1.19683

García Chi, R.I.; Hernández, M.A.; Izaguirre Cárdenas, N.R.; Eguía Álvarez, A. (2019). El proceso *B-learning* en simulación incrementa el nivel de desempeño académico del estudiante de ingeniería. *Revista Teczapic, 5* (2), 8 - 18. https://www.eumed.net/rev/tectzapic/2019/02/proceso-B-learning.html

Hernández-Gómez, A. S., Carro-Pérez, E. H. y Martínez-Trejo, I. (2019). Plataformas digitales en la educación a distancia en México, una alternativa de estudio en comunicación. *Revista de Educación a Distancia (RED), 19*(60). DOI: http://dx.doi.org/10.6018/red/60/07

Jiménez Aragón, L. (2020). *Material guía para especialistas en contenido responsables del diseño curricular de asignatura. Modelo de evaluación de los aprendizajes de carácter sumativo: Componentes y aspectos orientadores*. Programa de Apoyo Curricular y de Evaluación de los Aprendizajes.

López-Collazo, Z. S. (2020). Implementación de la clase invertida en la formación pedagógica de ingenieros en Telecomunicaciones y Electrónica. *Revista Referencia Pedagógica, 8*(1), 147-166. https://rrp.cujae.edu.cu/index.php/rrp/article/view/208/230

Meza-Badilla, E.C., Aguilar-Cordero, J.F., Quesada-Sanchez M.I. y Delgado-Montoya W. (2017). *Atributos de egreso en carreras de Ingeniería: Metodología de evaluación por resultados*. Editorial Tecnológica de Costa Rica.

PRISMA. (2019). *PRISMA TRANSPARENT REPORTING of SYSTEMATIC REVIEWS and META-ANALYSES.* http://prisma-statement.org/prismastatement/flowdiagram.aspx

Oviedo, C y Alfaro, B. (2020, September 16). *UCR aplica plan inédito en el país para integrar la virtualidad.* Semanario Universidad. https://semanariouniversidad.com/universitarias/ucr-aplica-plan-inedito-en-el-pais-para-integrar-la-virtualidad/

Sandoval Carvajal, M.M., Cortés Chavarría, R., Porras Piedra E. y Lizano Madriz, F. (2017). Capítulo 3 ABP desde las trincheras: un caso de estudio en la enseñanza de la Ingeniería de Sistemas. En A. Guerra, F. Rodriguez-Mesa, F. A. González; M. C. Ramírez (Coords), *Aprendizaje basado en problemas y educación en ingeniería: Panorama latinoamericano*. Aalborg Universitetsforlag

Santamaria-Sandoval, J.R. y Chanto-Sánchez, E. (2020). Aplicación de la virtualidad en la enseñanza de la ingeniería: Caso de estudio Ingeniería en Telecomunicaciones en la UNED de Costa Rica. *Revista Technology Inside by CPIC, 5* (5), 96-113.

Terreni, L., Vilanova, G. y Varas, J. (2019). Desarrollo de competencias digitales en propuestas pedagógicas en ambientes mediados. Un caso en educación superior bajo modelo de aula extendida. *Informes científicos técnicos-UNPA. 11*(3), 61-87. http://doi.org/10.22305/ict-unpa.v11.n3.797

Universidad Estatal a Distancia. (2021). *Ingeniería en Telecomunicaciones*. Universidad Estatal a Distancia. https://www.uned.ac.cr/historia

World Federation of Engineering Organization. (2020, October 05). *CFIA Costa Rica becomes a Signatory of the International Engineering Alliance Washington Accord*. https://www.wfeo.org/cfia-costa-rica-becomes-a-signatory-at-the-international-engineering-alliance-washington-accord/

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