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Proposal about Challenge-Based Learning and competition in final degree projects

Propuesta de Aprendizaje Basado en Retos en proyectos de finalización de carrera

Proposta de Aprendizagem Baseada em Desafios em projetos de conclusão de carreira

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ABSTRACT
Challenge-Based Learning is presented as an active strategy that contributes to employability, since students in their environment must identify and solve a problem in reality. The objective of the article is a learning proposal based on the challenges and competencies of the students who carry out their final degree projects in Computer Science discipline. From the methodological point of view, the competencies defined for the profile of the Systems Engineer according to Federal Council of Deans of Engineering were analyzed and the one called "Identify, formulate and solve Engineering problems" was selected, and it was adapted to the profile of the Graduate in Information Systems. The active Challenge-Based Learning methodology was analyzed and a proposal was designed in line with the professional competencies for the graduate's profile. This active challenge-based proposal consists of a didactic sequence and its corresponding evaluation rubric. The proposal was validated in the 2020 school year. A descriptive research was developed. In the context of Social, Preventive, and Compulsory Isolation, final projects of twelve students were approved, 3 were defended in December 2020, 2 in the first quarter of 2021 and 2 students are in the defense process. Finally, it is concluded that this learning promotes the solution of problems in the context, contributing to development from the university to the environment and innovating with processes and products mediated by ICT, while ensuring that students finish their careers.

Keywords: Challenge-Based Learning; professional competencies; Computer discipline competencies; degree completion projects.

RESUMEN
El Aprendizaje Basado en Retos se presenta como una estrategia activa que aporta a la

empleabilidad, dado que los estudiantes en su entorno deben identificar y solucionar un problema de la realidad. El objetivo del artículo es presentar una propuesta de aprendizaje basada en retos y competencias de los estudiantes que realizan sus proyectos de finalización de carrera en la disciplina Informática. Desde lo metodológico se analizaron las competencias definidas para el perfil del Ingeniero en Sistemas, según el Consejo Federal de Decanos de Ingeniería; se seleccionó la denominada "Identificar, formular y resolver problemas de Ingeniería", y se adaptó al perfil del Licenciado en Sistemas de Información. Se analizó la metodología activa Aprendizaje Basado en Retos y se diseñó una propuesta en consonancia con las competencias profesionales para el perfil del egresado. Esta propuesta activa basada en retos consiste en una secuencia didáctica y su correspondiente rúbrica de evaluación. Se desarrolló una investigación descriptiva. La propuesta se validó en el ciclo lectivo 2020. En el contexto de Aislamiento Social, Preventivo y Obligatorio se aprobaron los proyectos de finalización de carrera de 12 estudiantes, de los cuales tres se defendieron en diciembre de 2020, dos en el primer trimestre de 2021, y dos en proceso de defensa. Se concluye que esta modalidad de aprendizaje fomenta la solución de problemas del contexto, aportando al desarrollo desde la universidad al medio e innovando con procesos y productos mediados por las Tecnologías de la Información y las Comunicaciones, al tiempo que logra que los estudiantes finalicen sus carreras.

Palabras clave: Aprendizaje Basado en Retos; competencias profesionales; competencias de la disciplina Informática; proyectos de finalización de carrera.

RESUMO

A Aprendizagem Baseada em Desafios apresenta-se como uma estratégia ativa que contribui para a empregabilidade, uma vez que os alunos em seu ambiente devem identificar e resolver um problema na realidade. O objetivo do artigo é apresentar uma proposta de aprendizagem baseada nos desafios e competências dos alunos que realizam seus projetos de conclusão de curso na disciplina de Ciência da Computação. Do ponto de vista metodológico, foram analisadas as competências definidas para o perfil do Engenheiro de Sistemas, segundo o Conselho Federal de Reitores de Engenharia; A chamada "Identificar, formular e resolver problemas de Engenharia" foi selecionada, e foi adaptada ao perfil do Graduado em Sistemas de Informação. Foi analisada a metodologia ativa de Aprendizagem Baseada em Desafios e desenhada uma proposta alinhada às competências profissionais para o perfil do egresso. Esta proposta ativa baseada em desafios consiste em uma sequência didática e sua correspondente rubrica de avaliação. Foi desenvolvida uma investigação descritiva. A proposta foi validada no ano letivo de 2020. No âmbito do Isolamento Social, Preventivo e Compulsório, foram aprovados os projetos de conclusão de 12 alunos, dos quais três defendidos em dezembro de 2020, dois no primeiro trimestre de 2021, e dois em o processo de defesa. Conclui-se que essa modalidade de aprendizagem estimula a solução de problemas do contexto, contribuindo para o desenvolvimento da universidade para o meio ambiente e inovando com processos e produtos mediados pelas Tecnologias da Informação e Comunicação, ao mesmo tempo em que garante que os alunos finalizem suas carreiras.

Palavras-chave: Aprendizagem Baseada em Desafios; habilidades profissionais; Competências da disciplina de informática; projetos de conclusão de curso.

INTRODUCTION

Higher Education spaces continually present challenges to face innovations that reflect the requirements of the context, the development of competencies in the training of professionals inserted in an increasingly complex and dynamic economy of knowledge. This article explains Challenge-Based Learning (CBL) in a context of professional competencies defined and illustrated in the subject Final Degree Project (FDP) of the Bachelor's Degree in Information Systems (DIS), whose objective is the definition and realization of a final degree project or PFC, which represents the dissertation. Some authors who treat challenges as an active methodology are: Icaza (2015), Gaskins *et al.* (2015) and Olmos (2015), Probert (2015), Gibert Delgado *et al.* (2018), Demuth & Sánchez (2019), Rodríguez Borges *et al.* (2021). Rowe & Klein-Gardner (2007) describes the STAR Legacy cycle recovered in ABR.

Contextualization

The proposal is located in the subject of degree Final Degree Project. Its course regime is annual and corresponds to the fifth year of the Bachelor's Degree in Information Systems, Study Plan 2009. This subject integrates numerous concepts and methods oriented towards the specification, design and development of computer solutions for organizations or R&D projects. 1 +D contributing to the generation or transfer of knowledge in the field of Computer Science (LSI Career Study Plan, 2009). This establishes the requirement of the final project required for the degree, which for its approval must be defended before an evaluating court. This space completes the training of the Bachelor of Information Systems addressing professional and social issues inherent to professional performance. To defend their final project, students must have all approved subjects (LSI Career Study Plan, 2009).

Therefore, the design and development of this completion project constitutes a pedagogical practice of professional activity approachable from a model based on competencies sustained in understanding and meaningful learning. Some ideas developed in each PFC are based on the model supported by the understanding proposed by Pozo and Pérez Echeverría (2009), such as: avoiding questions and tasks that allow reproductive responses; favor the use of materials in the evaluation; apply continuous evaluation; assess the personal ideas of students and admit different solutions to a problem. Thus, the advanced student must put into play a competent behavior since his being and doing is involved with respect to a subject of study (Gibert Delgado *et al.,* 2018).

In addition, the development of this final degree project implies designing and building a solution to a real problem, and thus the integration of previous knowledge with those required by emerging technologies.

The competences model in the Final Degree Project

The subject Final Degree Project illustrates a special case of the competency model established by Miller (1990), which promotes different levels of competencies in the student nearing graduation. Some examples are presented; it should be noted that each level includes others.

From *knowing how to be:*

- Solidly argue the opinions when making decisions about the different stages of the development of the PFC project, respecting different positions raised individually or in groups to solve similar challenges.

- Integrate ethics and social responsibility in the proposed projects.

From *know-how:*

- Integrate disciplinary knowledge acquired in previous subjects and emerging topics to develop the project, effectively and correctly applying concepts, methods, techniques and tools for problem solving.
- Apply principles, methodologies and life cycles of the discipline for the solution of abstractions of real problems innovating in the socio-economic-cultural environment.
- Design ICT artifacts using methods and tools of the discipline for the solution of abstractions of real problems that integrate ethical and social aspects.

In the complex knowledge society, it is necessary to attend to the context in which students operate as future professionals. Some learning strategies that contribute to the achievement of the objectives are:

- Provide a clear and understandable vision of the learning objectives, allowing students to identify where their activities are heading and achieve greater understanding when the teacher or their peers give them feedback and point out their strengths and weaknesses. An instance that also provides elements for self-evaluation. In addition, the PFC regulations and program are proposed, which include the preparation of the Project Plan (Appendix II) and the Final Report (Annex III), documents integrated into the regulations. These synthesize the integration of previous knowledge, new knowledge and know-how that is reflected in the writing, according to the Introduction, Method, Results and Discussion (IMRD) format.
- Feedback from a formative assessment approach helps students respond where am I now? To promote learning, up to three versions of the project are monitored, making a personalized and a general return. Activity that is repeated in the advances of the technological product derived from the project and in the final report.
- Give prominence to the student in the evaluation, in order to improve learning. It implies its precise and frequent transformation, as a motivator, by recognizing what it can do and promoting the adoption of alternative actions.

These strategies are related, being progressive their implementation. That is, the teacher offers a clear and understandable vision of the learning objectives, the project is gradually modeled, the students are involved in self-reflection, monitoring and exchange of learning with their peers and teachers (Coordination of Curricular Development and Management of Quality, 2018) and thus it is oriented to the development of competencies and continuous evaluation in the teaching process to achieve significant learning that contributes to their professional training.

The evaluation system is formative, continuous and globalized, based on the e-portfolio. The PFC product is an artifact proposed through a project (intervention project, implemented intervention, design and development of an ICT product). Therefore, this product integrates specific knowledge of an area of the discipline, the "knowing how", since an artifact is planned or designed; These competences are reflected in a technological product that solves a problem in the context of the social, economic, cultural, educational

order or delves into subjects of the Computer Science discipline. These subjects object of disciplinary specialization is applied for the development of a technological product that also solves a situation and generates innovations in that context.

The evaluation system adopts an e-portfolio modality based on the progress of the different versions of the project, and in which teachers suggest, indicate, analyze and monitor to address the issue. In the proposal, the e-portfolio is represented in the virtual classroom space assigned to the delivery and return of Annex II. This is how an authentic evaluation is developed, according to Tardiff (1993) (cited in Demuth & Sánchez, 2019) implies "… necessarily an evaluation of the competence. The real problems to solve, tests, research projects, simulations, laboratory activities, etc. they are situations of authentic evaluation" (p. 3).

Aschbacher & Winters (1992) (cited in Demuth & Sánchez, 2019) argue that "it demands that students actively solve complex and authentic tasks while using their previous knowledge, recent learning and skills relevant to solving real problems" (p. two).

In this case, the e-portfolio is made up of different versions of the project with their corresponding revisions, in which the guidance teacher and PFC teachers intervene, the demonstrations of their technological products, the feedback that arises from the constant self-criticism between what is projected and what is feasible to build, also incorporating the vision of the guidance teacher and the subject.

Therefore, the objective of the article is a proposal for learning based on challenges from the competence *Identify, formulate and solve engineering problems* aimed at students, who carry out their final degree projects.

A problem that supports this inquiry is due to the fact that many students work before graduating, as well as the need for a greater number of human resources in the IT industry. For this reason, Challenge-Based Learning in the subject Final Career Project is presented as a strategy that links the academy with its context.

MATERIALS AND METHODS

A descriptive and cross-sectional investigation was developed, located in a real context such as the Final Degree Project subject. The study population included students who attended 2020 in the context of Preventive and Compulsory Social Isolation. Different online instruments were designed and applied to record the data generated: attendance sheet, activities in the virtual classroom, participation in synchronous classes, direct synchronous observations. The collected data were processed and analyzed in order to argue how Challenge-Based Learning in relation to the generic graduation competence "Identify, formulate and solve Engineering problems" is addressed in the subject Final Degree Project.

The design of the challenge-based learning proposal integrating the competence model was based on what was stated in Mariño & Alfonzo (2020) and Demuth & Sánchez (2019), which implied:

- Review of the guidelines defined by the Red Book (Federal Council of Engineering Deans, 2018) regarding the competencies of the IT professional.
- Definition of professional competencies, focusing on those inherent to the profile of the Bachelor's degree in Information Systems, adapting them from the profile of Systems Engineer according

to the Red Book (Federal Council of Engineering Deans, 2018).

- Selection of the competence "Identify, formulate and solve Engineering problems", considering that the project and product generated in the PFC responds to them integrally.
- Study and deepening of active methodologies, in particular, from Challenge-Based Learning.
- Selection of contents of this subject, object of analysis and treatment from the focus focused on challenges.
- Elaboration of a didactic sequence with a view to making explicit the development carried out from the subject.
- Preparation of evaluation elements. A rubric was built to evaluate the final degree project. In addition, a variety of alternative assessment tools were integrated. The decision was based on favoring the strengthening of previous learning, the acquisition of new knowledge, integrating disciplinary questions for the resolution of the selected real situations.

Among the evaluation tools promoted to facilitate and document authentic learning experiences are e-portfolios, also called electronic or virtual portfolios. In this case, the e-portfolio is built as a digital collection of evidence, which includes the different versions of the project and the product that constitutes the solution to the challenge posed in the framework of the PFC. In addition, a detailed record of the issues indicated for substantive improvement was made.

For this reason, as an alternative resource to evaluation, the e-portfolio allows: recording learning progress, evidencing achievements, documenting self-evaluations, exploring the construction of knowledge that is reflected in the project and product as a solution to the problem. With this resource it is possible to build a more comprehensive evaluation that includes both disciplinary and transversal competences.

The feedback received from the external actor offers a learning experience for the students. In this sense, the university-environment link should be considered, reflected in the solution of real problems that are evaluated by entities outside the academic field. The evaluation of implementations with this approach frequently turns to experts in the discipline, critics, juries, clients, industry, government or civil society.

Additionally, the resolution of challenges can be evaluated through contests and competitions among students. Examples include study completion scholarships, research initiation scholarships, participation in entrepreneurial programs at the provincial level, Agential calls, among others generated from this subject.

Total development time. The selected competition was developed in three months, approximately five hours per week, 20 hours per month, amounting to a total of 60 hours. In addition, the student allocated the same number of hours for independent work in order to advance, fulfill the planned goals and finish his project within the framework of the PFC.

Necessary physical spaces. The proposal involved the definition of virtual, face-to-face or hybrid spaces considering the new situation caused by the COVID-19 pandemic. In particular, the virtual synchronous and asynchronous modality was chosen. These activities included expert lectures and demonstrations of ICT solutions. In face-to-face instances, prior to 2020, the virtual classroom complemented the activities, as well as email.

Material resources. Time was allotted between activities for students to learn to use

resources in such a way that they contribute to the achievement of objectives. The human resources involved in the project are the teachers of the subject Final Degree Project. The guidance teachers, who are chosen by the students at the beginning of the PFC, are also involved; In general, it coincides that these professionals are specialists in the disciplinary area from which the solution to the problem defined as a challenge arises. Other implicitly involved human resources may be the subjects of the context, those who pose a problem and the recipients of the product that will derive from the execution of the PFC project. Among some resources are mentioned: projector, computers, and repositories, sources of information, regulations or standards related from the conceptual or empirical point of view in the development of the PFC.

RESULTS

The results address the definition and development of the experience in the year 2020 in the subject, in the midst of Preventive and Compulsory Social Isolation. The experience considers the selected competency, Challenge Based Learning as a teaching and learning strategy and assessment strategies.

Identification of competencies associated with the profile of the Bachelor of Systems

Competences imply being, knowing and knowing how to do. This last aspect was evidenced in the PFCs that integrate being and knowing. The "knowing how to do" refers to practical skills, that is, the development of skills necessary for the development of skills that allow to achieve the objectives proposed in the subject and thus specify the student's graduation.

To determine the contributions of the subject in the formation of the competencies listed in the Red Book (Federal Council of Deans of Engineering, 2018), considering the Professional Profile of the future graduate, point 23 was selected: Engineer in Information Systems / Computer Science. The analysis allows us to affirm that there is evidence of a high degree of link between the Generic and Specific Competences specified by CONFEDI and the strategies and actions defined by the subject.

In this proposal, the Generic Graduate Competence was chosen: "Identify, formulate and solve Engineering problems" (Federal Council of Engineering Deans, 2018, p. 21). This competence was adapted to the subject in order for the student to identify, formulate and solve a real problem by designing and building a technological solution oriented to its context.

As specific competences are:

- Elaboration of a technological project of applied research, experimental development and innovation R + D + I that proposes a solution to the socio-economic-cultural context in which topics 1, 2, 3 of the programs are included.
- Situation in which the student demonstrates his achievement (evaluative activity). In process, elaboration of the technological product, of annex II and annex III, which respond to the regulations of this subject
- Assessment mode in process, with feedback to the student and the guidance teacher. Systematization of information in the field of the subject.

Table 1 shows the contents selected following the PFC subject Program and that pertain to the preparation of the proposal.

Table 1- Contents of the PFC subject under study

Contents	Description
Conceptual	Topic 1. Introduction to the PFC. Importance and scope of the PFC in undergraduate degrees. The PFC regulation. Orientation and monitoring of the PFC. Roles of the Coordinating Teacher and the Guiding Teacher. Relevant lines of work within the framework of the Bachelor's Degree in Information Systems. Topic 2. Notions of research methodology in Computer Science. Fundamentals of Research Methodology. Usual research methods in the field of Computer Science. Unit 3. Elaboration of the PFC: introduction to the elaboration of projects. Bibliographic review. Open access content. Component sections of the PFC. The presentation of the PFC. The acceptance and approval process.
Procedural	Search, selection and processing of the information obtained. PFC presentation rules. The acceptance and approval process.
Attitudinal	Collaborative Work (team). Respect for standards. Constancy.

Teaching and learning strategy

Challenge-Based Learning (Gibert Delgado *et al.,* 2018; Demuth & Sánchez, 2019; Rodríguez Borges *et al.* 2021) was chosen as the teaching and learning strategy. This pedagogical approach actively involves the student in a real, relevant problem situation that is linked to his environment, which implies the definition of a challenge and the implementation of a solution.

In this context, the STAR Legacy cycle provides a setting that allows students to collaboratively engage in solving a problem or challenge relevant to them, while providing the opportunity to self-evaluate (Rowe & Klein-Gardner, 2007). The elements considered and associated with this cycle are:

- Challenge: problem and definition. Associated with the PFC project.
- Generate ideas: first reflections on the challenge, aimed at solving a problem in the context.
- Multiple perspectives: different approaches to the challenge and possible ways to approach it. Different approaches may require different known or emerging technologies.
- Investigate and review: participation in activities of inquiry, investigation and review of data and information, background, approaches to resolution.
- Testing the skill: formative self-assessment by the student. That is, how skilled are they in proposing solutions to the selected challenge.
- Publish the solution: publication of the products and results achieved. Preparation of a printed report, oral defense of the solution. In some cases, these products are previously validated by the beneficiaries of the solution.

Table 2 shows the proposed didactic sequence. The actions indicated in the development and completion columns involve up to three iterations to achieve a viable project that responds to the challenge posed and provides meaningful learning to the student.

Therefore, students must exploit their creativity, overcome obstacles, get closer to the reality of the community, strengthen teamwork and leadership, understand in depth the topics of interest, generate collaboration networks with people specialized in the area, elements that contribute to their growth as future ICT professionals.

Assessment strategies

Challenge Based Learning is related to assessment. Common strategies applied by teachers, academic leaders and researchers

can be identified to assess the processes and products of the solutions designed and developed and some of them are in the process of being implemented. It is highlighted that the feedbacks of the solutions of those who collaborate and intervene in the learning experience of the students contribute to the professional skills.

At the beginning of the course, the modalities of formative and summative evaluations applied in the subject are made known. Considering the strategies and instruments for an authentic evaluation, the questions posed in Demuth & Sánchez (2019) were answered, where table 3 addresses the requirements for PFC considering the clarity of purposes, criteria to determine and criteria to assess.

Table 2- Didactic sequence developed in the 2020 school year

Activities		
Start (approximate duration: 1 month)	**Development** (approximate duration: 1 month and a half)	**Completion** (approximate duration: 15 days)
1. Resources are available: calendar, regulations, program and content material, in the virtual classroom. 2. The teacher presents topics 1, 2 and 3 in face-to-face sessions. 3. It inquires about project ideas that could be developed within the framework of the PFC. 4. Sharing is promoted: previous experiences, developments within the framework of undertakings, subjects, and research projects, among others. 5. Professionals and graduates are invited to disseminate the productions feasible to tackle. 6. You are invited to consult the works defended and available at FACENA. 7. It is invited to retrieve from repositories publications related to the thematic areas of	1. The students begin the development of the project idea. The evidence shows that they are associated in teams of two to develop together or advance on a topic of interest to later design individual projects where disciplinary knowledge is applied to different areas. 2. Students share their progress with their peers and with teachers in the next three face-to-face classes. 3. Teachers promote the search for technological solutions in order to solve challenges in the context, both in person on established days and hours and via email. 4. Annex II is completed considering thematic units 1, 2 and 3. 5. It encourages: critical reading, the search for and selection of information from sources of recognized scientific, technological or academic value, the capacity for exposition and defense of ideas and proposals, the written production in which the good use of technological resources for presentations of professional quality, demanding compliance with the formats is valued. 6. Small group and personalized tutorial	1. An exhibition of the different projects is made in three instances ruled by the subject and communicated to the student. 2. In each exhibition indications are made with a view to improvement. This positive feedback tends to improve production. 3. The students deliver the different versions of Annex II, each project is returned with the observations. In addition, the commented document is copied to the guidance teacher in order to promote responsible and team work. 4. The student answers an online survey regarding the Teaching-Learning Process; an attempt is made to recover their findings in conceptual, procedural, and attitudinal performance. 5. Student presentations are shared in the virtual classroom in order to promote collaborative work.

interest. 8. The documents or annexes to be completed are disclosed according to current regulations. 9. The student answers an online survey. 10. Students are invited to advance the project idea. 11. Sessions are held on the use of tools to support project formulation.	actions are carried out.	

Table 3- Requirements for the PFC, based on Demuth and Sánchez (2019)

Requirements	Questions
Clarity of purpose	The purpose of the intervention is based on a formative and summative space, defining the ABR as a strategy. The competence: conceiving, designing and developing engineering projects is contextualized to the design and development of the PFC. The processes involved illustrate the progress from the initial idea to the project that is then approved by resolution; therefore they are evaluated from the summation, formative and metacognitive aspects. The inputs for analysis constitute the projects presented in Annex II; the viability of the proposal is validated.
Criteria to determine	The evidences constitute the documents generated by the students with teacher feedback to achieve the challenge. These documents, in their different versions, are filed in the e-portfolio. The e-portfolio stores the evidence generated in this Teaching-Learning Process. It contains instructions from the teacher with delivery dates and presentation conditions, the student's product, a detailed return from the teacher, which is also communicated to the guidance teacher.
Criteria to assess	The work is valued individually and in a group or team of two members. In addition, the team is joined by the guidance teacher and the teachers of the subject. The evaluation is done in process. From the initial idea of the PFC embodied in conversations to the realization of Annex II. To achieve this final version of Annex II, progress is made in the construction of the IT product or solution and thus the feasibility of the PFC is corroborated. The instrument selected to evaluate are the follow-up rubrics (Table 4). The modality is used as: • Hetero-evaluation: detailed monitoring of students from the subject and external third parties, demanding the challenge. • Self-evaluation: generated within the framework of feedback, mediated through different advances in the proposal. • Co-evaluation: informal, if students consult with their peers about the proposals that are generated; Formal, if presentations are made in front of their peers, a space for consultations or debate can be generated.

Table 4 exemplifies the rubric designed to evaluate the PFC project, where up to three preliminary presentations were made with delivery and return dates, scheduled and communicated to the students.

Table 4- Rubric to evaluate the PFC project in 2020 (1)

Elements	Excellent	Very good	Good or Fair	Incorrect	Negative
Presentation (according to the regulation of the subject)	Meets established guidelines. Presentation that invites you to read.	Respect the established guidelines.	Adequate minimal presentation. Meets most established guidelines.	Incorrect use of tools. Incorrect application of established guidelines.	Incorrect use of tools. Incorrect application of established guidelines. Incorrect filing date.
Written expression	Reflections that contribute to the context are incorporated.	Deficiencies in written expression. Incorporate opinions	Correct expression. Clarity of ideas.	Incorrect expression. Summary sentences, Lack of clarity of ideas, opinions or criticism.	Non-understandable phrases Incorrect syntax. Incorrect semantics.

		into the content.		Spelling mistakes.	Disjointed data. Numerous misspellings.
Project contents (2)	Contents treated with completeness and precision Includes details, descriptions, background. Evidence of knowledge of the subject. Includes updated references.	Basic content in the elements of annex II. Includes updated references.	Basic content in each of the elements of Annex II. Viable to improve.	Minimum content. Lacks current references.	Minimum content. Present incorrect evidence. Lacks current references.
Contents (3) External contributions Networking	It contributes to the professional field, with social, economic or cultural involvement. It has institutional endorsement. Discipline contributions are incorporated.	It contributes to the professional field with social, economic or cultural involvement. It has institutional endorsement.	It contributes to the professional field with social, economic or cultural involvement.	It lacks contribution to the professional field with social, economic or cultural involvement.	The project does not modify the conventional vision of the professional field.

Clarifications regarding the content of table 4: | (1) Up to three presentations are made with scheduled dates and communicated to the student. (2) Introduction, methodology, scope of work, resources, proposed developments, expected results, bibliographic references.
(3) Specific competences such as team and collaborative work are discussed.

Regarding the evaluation rubric, at the end of the three iterations the content of the projects responded in the two requested approaches: disciplinary, since it implies the acquisition or deepening of knowledge in an area of Computer Science and innovation or improvement to the context, considering that the projects apply specific knowledge to solve problems identified by the students. Therefore, the contribution of outsiders and the formation of networks is an element that emerges from this process. In addition, it should be noted that specific competencies such as team and collaborative work are addressed. One issue to highlight is that in all the projects ethical issues were considered and in accordance with Law No. 25,326 on Personal Data in Argentina.

It is noteworthy to mention that the projects responded to compliance with the presentation guidelines, the written expression improved incrementally, incorporating semantic and syntactic issues, and progress was made in the correct application of the IEEE standard in citations and references, according to the guidelines of the Regulation of the subject. The foregoing is evidenced from an analysis of the e-portfolio of projects complemented by the rubric applied to evaluate the PFC project in 2020 (table 4). In the future, the hetero-evaluation by third parties associated with the challenge, the self-evaluation, the co-evaluation associated with the projects will be quantified.

Formative assessment

The formative assessment prepares students to meaningfully understand and apply the feedback received from each version of Annex II. Therefore, to ensure meaningful learning, regular moments of project advancement are scheduled, both with the team and individually.

The foregoing favors the clarification of the objectives, phases of the process and

deadlines, as well as promotes reflection on the proposal to face the technological challenge. In particular, in this subject the dates on which the progress of the project and the product must be carried out are disseminated, as well as the dates and the way in which feedback will be given to the members of each project. In addition, it is requested that students have the endorsement of the guidance teacher, in order to maintain constant communication and agreements in the work team that is associated with each challenge.

It should be noted that in this learning modality, students assume a great responsibility. However, the role of the guidance teachers and the subject is relevant. That is, a detailed monitoring of each team is carried out, the feedback and how the solution they contribute to achieve the expected challenge or result is improved.

Summative evaluation

Summative evaluation of this proposal involved developing a solution with real-world validation. Students were given direct and immediate feedback that led to progressive improvements raised through successive versions of the final project. The foregoing illustrates the validity of this active learning method in the context of PFC, since students are urged to identify and propose technological solutions required in the context of action.

Among the way of evaluating students, individual and group instances are mentioned. The knowledge around the content is reflected in the reflections that are promoted from the teaching body, oral evaluations, exposition of the challenge and its defense, identification of the role they played in the PFC team voluntarily formed, among others.

Assessment with metacognitive elements

The proposal was validated in the 2020 school year. This active strategy, such as Challenge-Based Learning, favors the inclusion of metacognitive elements in the evaluation process. The students, through the realization of the practices and the successive exhibitions, have elements to reflect on the learning achieved in this active process. In this case, it is reflected in the documents and exhibitions aimed at defending the project proposal. The projects and their gradual progress were incorporated into the virtual classroom and the students presented the synthesis of their progress in a time of 5 to 10 minutes. From the direct observation applied to the practical work solved and incorporated as tasks of the virtual space and the exhibitions, the teaching staff gave personalized feedback and elaborated a general synthesis that was delivered to the attendees.

In this instance of the career, special importance is given to the social and professional training that constitutes every technological project, considering the implications of ICT in the bio-psycho-social-economic dimensions.

In the context of Social, Preventive and Compulsory Isolation, the completion projects of 12 students were approved. It should be clarified that three individual projects were defended in December 2020; two in the first quarter of 2021 and in the second quarter of 2021 the proposal of a team. Of the total number of students who defended or are in the final phase, a number that amounts to 7, a project defended corresponds to a female student.

These evidences show that the integration of the active Challenge-Based Learning methodology, which contemplated the didactic sequence designed for the *Identify, formulate and solve Engineering*

problems competence, summative and formative evaluation, incorporating metacognitive elements, the rubric, and that It involved different factors such as the student, the guidance teacher and the teachers of the subject, contribute to the realization of the PFC. All this given that more than 50% of the students specified or have a defense date of their PFC at most seven months after completing the course, considering the 45 days that there are no academic activities given the holidays.

DISCUSSION

Within the framework of a competency-based university proposal and following the guidelines established in the Red Book (Federal Council of Deans of Engineering, 2018) it is argued that the educational model of the subject Final Career Project is validated in a framework of active methodology.

Along the lines exposed in Icaza (2015), Gaskins *et al.* (2015) and Olmos (2015), in the PFC subject, the students faced the greatest challenge to scientific and academic writing to communicate the achievements derived from this end-of-degree production.

The ABR developed involved a deeper understanding of the topics covered in previous subjects and emerging technologies and the development of substantial competencies such as critical thinking, innovative project design, research competence, and oral and written communications competencies.

Therefore, it is agreed that some benefits for the students involved in the experience are:

- To achieve a deeper understanding of the issues, they learn to diagnose and define problems and their viability before proposing solutions, as well as develop their creativity (Icaza, 2015).
- Get involved both in the definition of the problem to be addressed and in the solution, they develop to solve it (Gaskins *et al.,* 2015).
- Become aware of a given situation, develop research processes, create models and materialize them, work collaboratively and multidisciplinary (Olmos, 2015).
- Get closer to the reality of your community; establish relationships with specialized people contributing to their professional growth (Probert, 2015).

The Challenge-Based Learning in the subject was carried out by solving a real-world problem. The students raised an idea of their interest or problem to be solved and developed it during the course with the accompaniment and guidance of the teachers (Counselor, Coordinator, and Chair Team).

Applying the ABR technique, significant learning was achieved since the students worked with the professors and experts of the community (through talks and seminars promoted by the subject), in addition they addressed real problems to develop a deeper knowledge of the issues that were studying. It is the challenge itself that motivates the obtaining of new knowledge and the necessary resources or tools (the use of both previous and new knowledge and new or already used technological tools throughout the career is highlighted). With this approach, it is emphasized that at the end of the project the student manages to solve a real problem. During the process, students analyze, design, develop and execute the best solution to address the challenge in a way that they and others can see and measure it in a specific technological product.

Other active methodologies will continue to be analyzed with a view to identifying and making explicit which ones are developed in

other moments of previous training and that contribute to this final degree course.

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The authors have participated in the writing of the work and analysis of the documents.