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Implementación del aprendizaje basado en proyectos como herramienta en asignaturas de ingeniería aplicada

Implementation of project-based learning as a tool in applied engineering subjects

Implementação da aprendizagem baseada em projetos como uma ferramenta em disciplinas de engenharia aplicada

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Resumen

Este trabajo aplica la metodología de enseñanza que tiene como sustento teórico el aprendizaje basado en proyectos (ABP) a una asignatura de ingeniería denominada Base de Datos, ya que se ha demostrado que las competencias colaborativas implicadas auxilian en la formación del estudiante. El uso de esta metodología, con base en la estrategia de aprendizaje para abordar problemáticas de la vida real de interés para el alumno, contribuye en el desarrollo profesional del ingeniero en formación. Una característica especial de la variante de ABP propuesta en esta investigación consiste en que la evaluación es continua y directamente aplicable a cada alumno que resuelve un problema con una aplicación práctica diferente. Otra diferencia es que, al desarrollar el proyecto a lo largo del semestre integrando los conocimientos adquiridos en forma gradual, a través de las 3 etapas, con retroalimentación constante, objetiva y sistemática, motiva al alumno a continuar con el proyecto. La planeación didáctica por parte del profesor considera actividades, resultados y rúbricas bien definidos, para después entrar en la primera etapa, que corresponde a la planeación del proyecto por parte del equipo e incluye tanto la determinación de los requerimientos, así como el diseño de la base de datos; la segunda etapa permite implementar la base de datos en un lenguaje adecuado, y, finalmente, la tercera etapa considera la integración de la base de datos y su manejo dentro del sistema de gestión. Los resultados del caso de estudio que se presentan corresponden al proceso de implementación ABP, a través de cada una de sus etapas, con un grupo de 30 estudiantes, en donde más del 80 % logró concluir su proyecto con un buen diseño, desarrollo e implementación, al cumplir con los requerimientos del sistema planteados. Esta estrategia les permitió a los estudiantes desarrollar habilidades de investigación, incrementando las capacidades de análisis y de síntesis y logrando una experiencia educativa motivada, con un alto índice de compromiso por parte de los involucrados para llegar al final.

Palabras clave: aprendizaje basado en proyectos, base de datos, competencia, estudiantes de ingeniería, SQL, trabajo colaborativo.

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Abstract

This work applies a teaching methodology that is based on Project Based Learning (ABP) theory to an Engineering subject called Database. ABP had shown that the collaborative competences enhancement the engineer profile. The use of this methodology based on the learning strategy to address real-life problems that are interesting to the student, contribute to their professional development as an engineer. A special feature of the proposed ABP variant is that the assessment is continuous and directly applicable to each student who solves a problem with different practical application. Another difference is that developing the project along the semester and integrating the knowledge acquired gradually through the 3 stages, with a constant, objective, and systematic feedback, motivates the student to continue with the project. The didactic planning done by the teacher, considers activities, expected results and well-defined rubrics. Considering, the first stage as the planning of the project by the team and includes both the determination of the requirements, as well as the design of the database; then in stage 2, the database implementation in an appropriate language and finally stage 3 considers the integration of the database and its management within the data system. The results of the study case presented correspond to the ABP implementation process, through each of its stages, with a group of 30 students, whose over 80% were capable to complete their project with a good design, development, and implementation, complying with the system requirements proposed. This strategy allowed students to improve their research, analysis and synthesis skills and achieving a motivated educational experience with a high level of commitment of the students to reach the end.

Keywords: project-based learning, competence, generic competences, educational strategies, SQL, collaborative work.

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Resumo

Este trabalho aplica a metodologia de ensino que tem como base teórica a aprendizagem baseada em projetos (PBL) para uma disciplina de engenharia denominada Banco de Dados, uma vez que foi demonstrado que as competências colaborativas envolvidas auxiliam na formação do aluno. O uso desta metodologia, baseada na estratégia de aprendizagem para resolver problemas reais de interesse do aluno, contribui para o desenvolvimento profissional do engenheiro em treinamento. Uma característica especial da variante ABP proposta nesta pesquisa é que a avaliação é contínua e diretamente aplicável a cada aluno que resolve um problema com uma aplicação prática diferente. Outra diferença é que, ao desenvolver o projeto ao longo do semestre, integrando os conhecimentos adquiridos gradualmente, ao longo das 3 etapas, com feedback constante, objetivo e sistemático, motiva o aluno a continuar com o projeto. O planejamento didático do professor considera atividades, resultados e rubricas bem definidas, para então entrar no primeiro estágio, que corresponde ao planejamento do projeto pela equipe e inclui tanto a determinação dos requisitos, quanto o desenho do projeto. base de dados; o segundo estágio permite que o banco de dados seja implementado em uma linguagem apropriada e, por fim, o terceiro estágio considera a integração do banco de dados e seu gerenciamento dentro do sistema de gerenciamento. Os resultados do estudo de caso apresentado correspondem ao processo de implementação da ABP, através de cada uma de suas etapas, com um grupo de 30 alunos, onde mais de 80% conseguiram concluir seu projeto com um bom desenho, desenvolvimento e implementação. , ao cumprir os requisitos do sistema proposto. Essa estratégia permitiu que os alunos desenvolvessem habilidades de pesquisa, aumentando as habilidades de análise e síntese e conseguindo uma experiência educacional motivada, com um alto nível de comprometimento por parte dos envolvidos para chegar ao fim.

Palavras-chave: aprendizagem baseada em projetos, banco de dados, competência, estudantes de engenharia, SQL, trabalho colaborativo.

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Introduction

In the classrooms, both teachers and students need to have new information that connects to relevant existing concepts (Moreira, 2005). New ideas, concepts, propositions, among others, can be significantly learned, and retained, insofar as other ideas, concepts and propositions that are specifically relevant and inclusive are adequately clear and available in the student's cognitive structure and function as anchoring points. , that is to say, of reference with the adequate motivation to achieve a significant learning.

This implies the constant search by the teacher of interesting challenges of application of knowledge in the real world. A valuable learning strategy in this context is the project method, which provides an axis of support for engineering students to acquire a varied set of competences, and this in turn reinforces their motivation to learn. On the other hand, the professor in the area of engineering gives him the opportunity to propose learning spaces that allow the use of different skills in solving specific problems.

In the present work the implementation of a pedagogical strategy is approached that has as a theoretical support project-based learning (PBL), which translates into a fundamental strategy to work in software engineering matters. The case of application is the subject of Database that is taught in the career of Engineering in Telematics, in one of the academic units of the National Polytechnic Institute (IPN). The subject is in the second level of competences (Vocational Training) of the curricular map of this career, which is composed of 280 credits of the Academic Credit Assignment and Transfer System [SATCA] (IPN-UPIITA, 2012).

In the database learning unit, what matters is that the student solves problems that involve the implementation of relational databases, for which a good design and programming knowledge in structured query language is required (SQL, for its acronym in English); and thus specify telematic systems that use the knowledge of the subject. This learning unit allows contributing to the graduation profile through the development of necessary skills for the telematics engineer of the National Polytechnic Institute (IPN,

2012), with the help of the didactic orientation dictated in the syllabus of the subject, as well as using the ABP.

According to Aravena, Caamaño and Giménez (2008), the use of this strategy allows the process of integration, construction and appropriation of the concepts by the students, as well as contextualizing them in a problem-solving environment, also allowing the feedback of the students. teacher through continuous monitoring of learning. The problem that is presented in this subject that is taught in 18 weeks is that, although the method of projects is suggested in the study program, this is not carried out since the beginning of the course; but the projects are proposed by the teacher in the last four weeks of the course, which means that students can not always finish the project 100%, coupled with a feeling of frustration for not remembering what was seen in the first sessions . All this is reflected in a deficiency in significant learning in the higher level student.

Objective

The objective of this work is to evaluate the efficiency of the use of the PBL in a transversal way since the beginning of the semester and that each topic is applied directly to your project, with the intention of connecting the previous knowledge of the student with the context in which it develops and its surrounding reality, specifically when working with the learning unit called Database.

The first section deals with the theoretical framework where the PBL is described and the competences developed; subsequently, the empirical framework for the development of didactic planning is presented and the methodology of the implementation of each of the stages of this type of learning in the subject Database is described, as well as the way to evaluate its implementation, and finally the results of the application of the strategy are discussed to a group of 30 engineering students and the conclusions of the work are given.

Theoretical framework

About the project-based learning strategy

The ABP is a work strategy in class that takes a sequence of steps. The following describes each of them:

1) Connections must be established between the student's prior knowledge and its surrounding reality, which allows the teacher to have knowledge about the daily practices of their students and the context in which they develop. This allows access to some important knowledge from the classroom (Sayago and Chacón, 2006).
2) A planning must be carried out so that the teacher, along with his students, can pose problematic situations that emerge from the needs of the student or their environment. This planning includes the learning objectives and the projection of the educational scenario, in order to achieve an articulation that goes beyond the classroom, generating in the students reflections that allow these processes in their daily life to become a scenario of constant questioning.
3) The project should be seen as a work strategy, where learning should have the following characteristics, as indicated Cánovas (2007):
    - It is built on the basis of action.
    - It occurs in interaction with others.
    - Requires discipline, which is not the same as silence.
    - It occurs in environments and situations that are significant for students.

So this process recognizes in the student an active subject, whose participation is fundamental for the development of the project. In relation to the evaluation process, this is not thought of as content evaluation, but is seen as part of a training process.

4) Implementing the PBL implies the development of attitudes in the student and not only the memory apprehension, this must be articulated with the educational commitment of each of the teachers, but in general the project seeks to pose the problematization and resignification of daily practices.

5) The PBL implies the development of a capacity for student-teacher interaction, which must be understood in the terms proposed by Harwell (1997), where negotiation is a fundamental practice to be developed. Although the teacher proposes a general project under which the class is going to be conducted, the students, from the point of view of the subject, can consider the development and execution, as well as intervening and glimpsing their daily interests, guaranteeing that they feel the thematic choice as their own. , in the same way, guaranteeing to a great extent the success in the training purposes of the same.

Collaborative competence

Collaborative work is essential for upper level students, as well as for their performance in the labor field, since currently in different companies the contribution of professionals with different training is needed to reach the required goal; so interpersonal relationships are very important. This implies that professionals must have training not only in the specific content of their career, but in the development of competencies such as collaborative. In some study programs at the university level, the development of the generic competency of collaborative work is contemplated due to its importance and variability, since, at the same time, it helps the development of other fundamental procedural competences, for example, the resolution of problems. Magraner and Valero (2013) point out that "the versatility of this competition has led to the group process being left unattended, relying on the interpersonal skills of the students" (p.4). Similarly, the evaluation of teamwork is limited to the quality of the final work without addressing the procedural elements. And the same authors add that team work must be systematized, as well as attending to the group processes, separating the evaluation of the collaborative competence from the evaluation of the practical quality of the work.

According to Johnson, Johnson and Holubec (1999), the principles of collaborative work are positive interdependence, face-to-face interactions, individual responsibility, the development of social skills and group self-reflection. The development of these principles will lead the group of people involved in a common goal to participate equally and communicate fluently, negotiating and sharing leadership tasks.

Empirical framework

Context for the implementation in a practical case of the PBL strategy

Allowing to experience educational experiences, in addition to an increase in motivation, as described in Sánchez, Ferrero, Conde and Cendón (2016), the ABP was applied in accordance with the methodology that contemplates the didactic planning that the teacher must carry out beforehand. start the course and the three stages that include the analysis and design of the problem raised by the student, the programming developed by the designer and, finally, the implementation of data management systems, which allows covering all the necessary aspects for the application of this type of learning.

This methodology was applied to students of the career of Telematics Engineering of the National Polytechnic Institute, as already mentioned, assigned in fourth semester, who were in an age range between 19 and 22 years, in non-heterogeneous groups because The curriculum allows for academic flexibility and not all of them have the same predecessor subjects.

To carry out the inclusion of the strategy of the PBL in a transversal way, it is necessary to have a didactic planning by the teacher in which the necessary elements for its implementation are included, which integrate both the pedagogical and technological resources to be used in practice. teacher, in order that the student applies what he has learned and manages to provide a solution through the knowledge of the administration of the databases to a real problem**.**

Tabla 1. . Etapas de la metodología para la implementación del ABP

Etapa 1: Planeación del proyecto (análisis y diseño de la base de datos)	Etapa 2: Ejecución (Uso de lenguajes de programación	Etapa 3: Implementación de sistemas de datos
a) Definir los requerimientos del proyecto basados en el estándar IEEE-830 ***b)*** Modelar la base de datos con los modelos relacionales	*a)* Comprender y utilizar el lenguaje de programación para el BD. *b)* Conexión de la base de datos con el lenguaje de alto nivel	*a)* Crear y manipular la base de datos del proyecto con el lenguaje de las bases de datos relacionales, a través de implementar las reglas de negocio y las interfaces graficas de usuario

Fuente: Elaboración propia

In this didactic planning the following is taken into account: a) dividing the group into work teams according to the number of students; b) the organization of the didactic elements, and c) establish the evaluation rubrics.

These didactic elements and assessment tools are used in each of the stages of the PBL strategy (see table 1); the way to apply the didactic methodology is broken down below.

But before it is important to note that the application of the methodology proposed in this project was tested on students who are in the second level of their career, therefore, they integrate three subjects as predecessors. This characteristic showed that the strategy of the PBL coincides with what was pointed out by Pérez, Nava, Castillo, Vital, Silvia, and Ramírez (2017): "The success lies not in the project itself, but in the possibilities involved in its realization implement and develop different competencies*"* (p. 8).

Educational planning

Divide the group into work teams

For this case, in which the group consists of 30 students, the work teams were of two members. The concept of collaborative learning was considered (Collazos, 2006), since students are the ones who design the structure of interactions and maintain control over the different decisions that affect their learning, which is related to the level of involvement proposed. The use of small groups allows students to work together to maximize their own learning; therefore, the involvement per student was considered 50%. Normally the students themselves are allowed to choose their teammate; In the event that a number of students do not agree or the number is odd, the teacher will be in charge of forming the teams. As for this case study, the total number of students was even, the intervention of the teacher was not necessary. Therefore, the students were organized into 15 teams.

Organization of the didactic elements

In accordance with the times and scope of the learning unit, planning was developed. This includes the determination of the expected learning, the competences to develop, the resources to be used by the teacher and the student and the product to be obtained in the following two stages. The temporality of each of the stages and the type of weight to be used were also defined.

Tabla 2.Etapa 1: Planeación, que incluye el análisis y el diseño de las bases de datos

Resultado parcial del producto final	**El alumno deberá realizar un documento donde elabore el análisis y diseño de acuerdo con el estándar IEEE -830 [a], utilizando el Lenguaje Unificado de Modelado (UML) para presentar los casos de uso. Como producto de esta etapa deberá entregar el modelo relacional normalizado de acuerdo con las reglas de Cood con base en la transformación del modelo entidad-relación[b].**
Recursos digitales profesor	- Diapositivas y videos: Utilizados para la exposición en clase. - Internet, procesador de textos y Dropbox©. - DBDesigner©: *Software* utilizado para presentación del modelo relacional.
Recursos digitales alumno	- Videos, Internet, procesador de textos y Dropbox© para fortalecer el trabajo autónomo. - DBDesigner©: *Software* utilizado realizar modelo relacional.
Competencias transversales	Realizar trabajo autónomo. Resolver el problema a través de la toma de decisiones propias; explicar el diseño y ser capaz de modificarlo de acuerdo con las necesidades del proyecto; todos los integrantes del equipo explican la solución al problema planteado con actitud amigable y respetuosa y resumen la información con base en el análisis realizado y con pensamiento crítico. Ser proactivo en el ambiente de trabajo en equipo y cumpliendo con los lineamientos planteados por el profesor.
Aprendizajes esperados	El alumno deberá ser capaz de diseñar el modelo relacional normalizado de un sistema de información con base en la transformación de un modelo entidad relación o modelo entidad relación extendido.
[a] Documento generado por el Instituto de Ingeniería Eléctrica y Electrónica (IEEE) para estandarizar el diseño de algoritmos (Arévalo, Linares, Correa, Parra, y González, 2008). **[b] Metodología según Barker (1994).**	

Fuente: Elaboración propia

Deliveries of the project based on the phases contemplated in the stages of the ABP strategy. The competences to develop in students are the use of information and communication technologies (ICT), decision making, resource planning, critical and reflective thinking and collaborative work.

At the end of each stage, an evaluation by the teacher is considered to give feedback to the team, considering two important areas: specify the objectives of knowledge application and the development of the competences involved. Table 2, Table 3 and Table 4 break down the planning, defining the expected result, as well as the skills to be developed, the learning and resources contemplated in each stage.

Tabla 3. Etapa 2: Lenguaje de bases de datos

Resultado parcial del producto final	**Programa codificado para crear y manipular la base de datos del proyecto con el SQL.**
Recursos digitales profesor	Internet, diapositivas, videos: Exposición en clase. Procesador de textos, Dropbox©, Internet. Sistemas manejadores de base de datos para la creación y manipulación de la base de datos.
Recursos digitales alumno	Videos, Internet, procesador de textos y Dropbox© para realizar trabajo autónomo. Sistemas manejadores de base de datos para la creación y manipulación de la base de datos del proyecto por el alumno.
Competencias transversales	Deberá cubrir los requerimientos funcionales utilizando su propio criterio de forma ágil, al emplear las sentencias del SQL. Todos los integrantes del equipo explican la solución al problema planteado con actitud amigable y respetuosa. Presentan la información y su análisis con pensamiento crítico. Aplicar el trabajo colaborativo.
Aprendizajes esperados	Deberá de codificar programas de bases de datos en el lenguaje de consultas SQL.

Fuente: Elaboración propia

Tabla 4. Etapa 3: Integración de la base de datos a los sistemas gestores de información

Resultado parcial del producto final	**Realizar todas las consultas con** el **SQL en procedimientos almacenados, cubriendo los requerimientos funcionales planteados en la etapa 1. La codificación de las interfaces de usuario en un lenguaje de alto nivel para la administración de la información a través de ellas.**
Recursos digitales profesor	Internet, Diapositivas, Videos: Exposición en clase. Procesador de textos, Dropbox ©, Internet, para promover el aprendizaje autónomo. Sistemas manejadores de base de datos para la creación y manipulación de la base de datos. Ambiente de desarrollo para lenguajes de alto nivel para generar las interfaces de usuario.
Recursos digitales alumno	Videos, Internet, procesador de textos y Dropbox© para realizar trabajo autónomo. Sistemas manejadores de base de datos para crear y manipular la base de datos del proyecto. Ambiente de desarrollo para lenguajes de alto nivel para la creación de las interfaces de usuario.
Competencias transversales	Es capaz de elaborar a través de lo aprendido en la asignatura de las bases de datos un sistema completo con una buena implementación (diseño y desarrollo), cumpliendo con el análisis de requerimientos del sistema. Todos los integrantes del equipo son capaces de explicar la forma de implementación al problema planteado con actitud amigable y respetuosa y presentan la información analizando con pensamiento crítico los resultados.
Aprendizajes esperados	Deberá de ser capaz de implementar transacciones en bases de datos con sustento en técnicas de bloqueo y niveles de aislamiento, además de implementar los programas con aplicaciones de bases de datos en lenguajes de programación de alto nivel gracias a la implementación de conectores ODBC[a].
[a] Open DataBase Connectivity.	

Fuente: Elaboración propia

Establish the evaluation rubrics and their percentages by stage in the elaboration of the project

The evaluation system based on rubrics is used to measure the degree of knowledge acquisition, quality of the results obtained and performance of the indicated competences, in a consistent manner and considering the expected quality in each of the items to be considered. Therefore, not only the final result is evaluated, but the whole process and a feedback is given to the student in each evaluation stage. For stage 1, the student should be able to analyze and apply the requirements engineering, as well as design the entity-relationship model and the standardized relational model of the information system. (The rubrics proposed for this phase are shown in detail in Table 4, which is found in Annex 1). In this first stage, four criteria are evaluated, assigning a percentage to each one, depending on the level that the students have developed and on the way they structure, manage and document each category. And the categories are the following: Research Problem (30%), Project Design (40%), Team Integration (10%) and Documentation (20%). The scale that is used to assign the percentages, on the other hand, is the following: Excellent, Good, Fair and Insufficient.

In stage 2, the student must be able to code database programs using SQL, reinforcing the competences of collaborative work and formal documentation of the processes, for which reason the rubric shown in table 5 was generated, which is in Annex 2. The categories that are evaluated in this second stage are: Project Coding (60%), Connection to the Database (10%), Documentation (20%) and Team Integration (10%) . Having a scale equal to that in the first stage.

For stage 3, the student should be able to implement transactions in the database efficiently, using blocking techniques and isolation levels, as well as application programs for databases in programming languages based on connectors.

The evaluation tools of this last stage, after feedback, prioritize the transfer of how to learn how to do within the cognitive field, without neglecting the development or revision of self-management skills by the working group.

The categories that are evaluated in this third stage are: User Interface [UI] (40%), Database Integration and UI (30%), Team Integration (10%), Project Documentation (20%) . Using the same scale as in the previous stages, according to the way in which the students deliver the system including the collaborative work developed. Table 6, which is found in Annex 3, details each assigned percentage.

Methodology of the implementation of the PBL strategy during the delivery of the learning unit Database

Stage 1: Analysis and design of the database

Define project requirements

The students developed the requirements analysis according to the IEEE-830 standard (Arévalo et al., 2008). The use cases were developed and a set of business rules describing the complete application were created. Although the requirements in this stage are still qualitative, information is contained to determine the functional and non-functional requirements. During this work, time is spent understanding the requirements and exploring possible solutions. The use cases should be written based on the users' interactions with the system and analyzing the processes. Due to the exploratory nature of this process, well-documented requirements are produced that benefit the development of the rest of the project (Fernández and Fillottrani, 2003).

The objective of the learning unit is to develop databases with support in the relational data model, supported by normalization and SQL. In order to fulfill the stated objective and that knowledge is meaningful, the interaction between new knowledge and prior knowledge must be encouraged, taking into account that learning must be progressive, that is, meanings are captured and internalized; In this process, interaction with prior knowledge is very important (Moreira, 2005). This is why it is requested to clearly define the objective and the requirements of the final system: it should be a case of real life to achieve interaction with previous knowledge, as well as the progressive relationship with new knowledge of database theory. For all the above, the project must meet the following requirements:

1. When setting the objective, emphasize that the system gives priority to the storage of information.
2. The problem to solve must be real life and useful for an end user, that is, it is necessary to have a person who can advise them in the definition of functional requirements (role of the client).
3. For the implementation of the information system, specificity is required in each of the stages to be developed, namely, analysis, design and implementation.

The student must perform, within the software engineering stage, the requirements engineering (IR) process, which is used to define all the activities involved in the approach, documentation and maintenance of the requirements for a particular software product. At this point it is very important to take into account that the contribution of the requirements determines the viability of the software (if it is feasible to carry it out or not), going through a subprocess of obtaining and analyzing requirements and its formal specification, to end with the validation subprocess, where it is verified that the requirements really define the system that the client wants (Arias, 2005). The result of this stage within the study is summarized in table 5.

Model the database

After having understood the problem according to the theory of databases, the entity-relationship model was developed, which is an information engineering technique to develop a high-quality data model, offering a standard way of defining the data and the relationships between these for all the information systems (Barker, 1994).

Tabla 5. Información de los 15 proyectos elaborados por el grupo de estudio

Título del proyecto	**Objetivo**	**Giro de la empresa**	**Cliente solicitante**	**Equipo a cargo**
Balder43 HUB	Gestión de información de los integrantes de un grupo de Scout.	Asociación civil	Jefe del grupo Scout	Equipo 1
P**rojects of applied enginnering**	Gestión de insumos de un taller mecánico automotriz.	Automotriz	Dueño del taller automotriz	Equipo 2
PCA **center**	Gestión de la venta de libros a escuelas públicas y privadas.	Venta de libros	Gerente la librería	Equipo 3
Body Factory	Sistema para la administración financiera de un gimnasio.	Salud y cuidado personal	Dueño del gimnasio	Equipo 4
T-soft	Administrar la manufactura de playeras.	Manufactura	Empleado/vendedor	Equipo 5
Forte	Gestionar los parámetros de las enfermedades de diabetes e hipertensión.	Salud	Médico	Equipo 6
Concesionaria automotriz	Administrar la información de los	Automotriz	Gerente de la concesionaria	Equipo 7

	servicios automotrices.			
Mozart coach system	Administrar equipos de juegos electrónicos.	Juegos electrónicos	*Coach* de videojuegos	Equipo 8
Pancita carmelita	Gestionar las ventas del restaurante.	Restaurante	Dueño	Equipo 9
Sistema indicador de desempeño	Administrar encuestas a trabajadores y clientes de satisfacción en una agencia automotriz.	Automotriz	Jefe del área de sistemas	Equipo 10
Administración de ganado bovino	Gestionar información de ganado bovino de la Facultad de Estudios Superiores Cuautitlán.	Educación	Módulo de enseñanza agropecuaria	Equipo 11
Venta de tamales	Gestionar la información en una tienda de abarrotes.	Restaurante	Dueño	Equipo 12
Sigma	Gestionar la información de alumnos de un estudio de danza.	Recreativo	Dueño	Equipo 13

Venta y compra de zapatos	Gestionar compras y ventas de una zapatería.	Ventas	Dueño	Equipo 14
Sistema taller	Gestionar la información de servicios de un taller de hojalatería.	Automotriz	Dueño	Equipo 15

Fuente: Elaboración propia

The diagram is related to the previous step and it is necessary for the student to develop it in this phase, since, in this model, the data are perceived as tables based mainly on set theory and predicate logic (Silberschatz et al. al., 2002). As the student manages to systematize the identification of the entities, define the relationships between them and translate them into structure, it will be possible to migrate to the way in which the database management system (SMBD) understands the information to be stored and processed.

To finalize this stage it is necessary that the normalization rules are applied to the relational model, since they are indispensable to correct redundancies if they still exist. With this procedure you can specify a set of attributes and their basic functional dependencies. The student should normalize to the normal way we indicate (usually up to the third normal form or the normal Boyce Codd form) and, using the relational database design, each of the normalized relationships should be entered, selecting their attributes and their main and external keys. In the same way, multi-valued and meeting dependencies can be specified, if the exercise contemplates the fourth and the fifth normal form (Soler, Prados, Boada and Poch, 2006). This process implies that the student knows, internalizes and applies the design concepts of the relational databases to real life cases.

Stage 2: Programming languages

Understand and use the programming language for databases

The learning of SQL is undoubtedly another of the necessary objectives for the development of the project. The SQL is a generic statement in which the tables that make up the database are described, followed by all the queries that you want to formulate. Each of them is associated with one or more correct solutions. Likewise, each problem is also associated with the SQL instructions for the creation of the different tables, as well as the insertion of data in them (Soler et al., 2006). In this way, the student must use their own criteria and manage to implement the business rules, using all the SQL statements in an agile way. It is expected that, with practice, the student will achieve the application of the knowledge acquired during this course in a viable product.

Connecting the database with the high level language

For this stage, the student must already connect the SMBD with a high level language and apply the data definition language (LDD) and the data manipulation language (LMD) of the SQL, which implies creating, modifying and eliminating tables in the database, as well as update the information with instructions to insert, update and delete. For the development of queries, SQL is used with simple queries, multitasking queries, stored procedures, triggers and transactions. The student must implement transactions in database using blocking techniques and isolation levels; and implement application programs for databases in high-level languages based on connectors and cigars.

Stage 3: Generation of the data management system

In order to implement the business rules and graphical user interfaces, it is necessary for the student to program the business rules set out in stage 1 that were generated with the requirement analysis, with the SQL and the high level language. It should be noted that the main objective of the course is not to teach the high level language in which the user programs the user interfaces, since in this case it is an predecessor of the Database, such as the Java language. But I do associate that prior knowledge with the application of new knowledge.

Project evaluation

For the evaluation, it is taken into account that the project is finished, that it has an optimized design, that it has been fully developed and that the minimum functionality tests are met with the analysis of system requirements. The evaluation is based on the evaluation rubrics raised in table 6 and the results can be seen in the next section.

Results

Stage 1: Project planning

For stage 1, the evidences shown by the students were reviewed in relation to the four criteria that were considered, namely, the problem statement (40%), the project design (30%), the development of the competence of the collaborative work through the integration they had as a team in solving the problem, for which they presented an oral report and a written report (10% and 20%, respectively). Figure 1 shows the averages obtained from the 30 students for stage 1.

As shown in the graph, only five students failed to meet the needs with knowledge of databases to establish the problem of an information system, this results in 83.33% of students considered to be excellent to excellent, achieving the expected results for stage 1. These, likewise, indicate that the approach of realization in a technological environment of motivation to young people to learn allows them to select topics that interest them and that are important for their lives as professionals and solve problems of practical application (Martí, Heydrich, Rojas and Hernández, 2010). On the other hand, 30% of the students had a regular result, so feedback was required on the part of the teacher both on their performance in the skills worked and on the points of improvement in the project.

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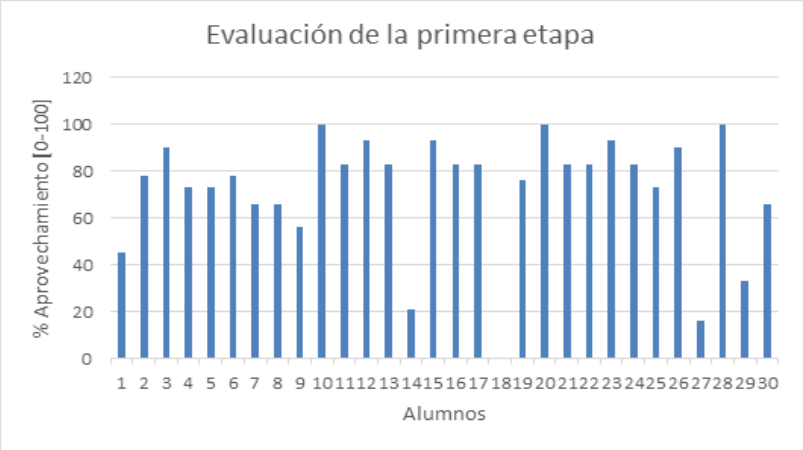
Figura 1. Resultados. Etapa 1: Planeación del proyecto

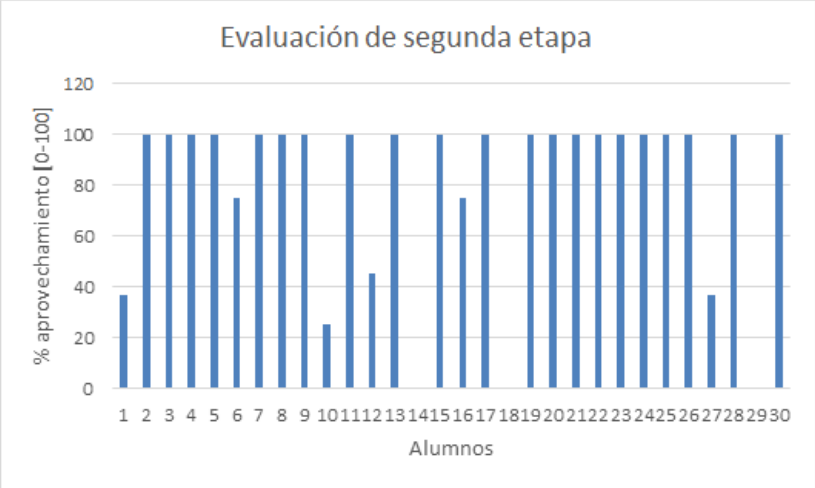


Fuente: Elaboración propia

Stage 2: Execution of the project

Using his own criteria, the student manages to solve business rules by agilely using all SQL statements. In this stage, the coding of the business logic of the project implemented in SQL (60%) and the connection to the database (10%) are prioritized because it reflects the application of the knowledge provided by the learning unit. Documentation and integration competencies make up the other segment to be evaluated and feedback. Figure 2 shows that 70% of the group achieved excellent performance and that 60% of those students improved with respect to the previous stage, demonstrating that the feedback allowed them to improve their performance, especially in the required skills. It should be noted that for this particular study case, personal or family problems influenced 10% of the students, so it was not possible to give continuity to some projects (14, 18 and 29) and this was reflected in their performance. In the other 20%, it was observed that the feedback allowed them to improve their performance in the presentation and defense competencies of their work, although the implementation of the project did not always take place effectively. In general, 76% of the students ranged from regular to excellent.

Figura 2. Resultados. Etapa 2: Ejecuciones del proyecto

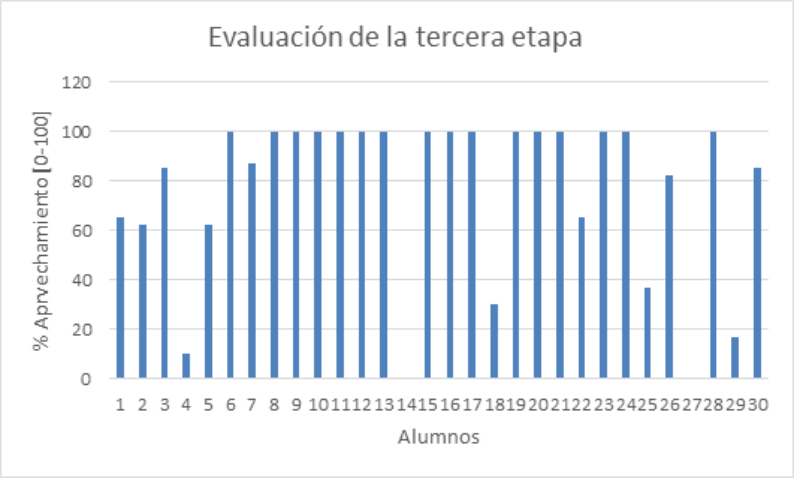


Fuente: Elaboración propia

Stage 3: Implementation

In the final part of the implementation of the information management system and where prior knowledge of other subjects is involved, such as programming in high-level languages, for example, Java, Visual C #, PHP, among others, on the one hand , it was considered the implementation of the user interface (40%) and the integration of the database with the user interface (30%); and on the other, team integration skills (10%) and documentation (20%). The results are presented in figure 3.

Figura 3. Resultados. Etapa 3: Implementación



Fuente: Elaboración propia

As shown in Figure 4, the results for this stage indicate that 13.33% of the students did not complete their project (14, 18, 27 and 29), while 86.66% achieved a finished project with a good design, development and proven , complying with the requirements of the system proposed in stage 1. In addition, 76% of the group managed to integrate the previous knowledge and complete the system in an appropriate manner; In contrast, 23% had problems integrating the previous information (although they managed to specify the system in some cases out of time). It is important to emphasize that the members of the team explained the solution of the problem with a friendly and respectful attitude in all cases. And although there were 10% that did not reach the objectives, detected from the first stage (14, 18 and 29), the rest presented an improvement, although in some cases it was not enough to adequately conclude their project by integrating the knowledge prior to the final design

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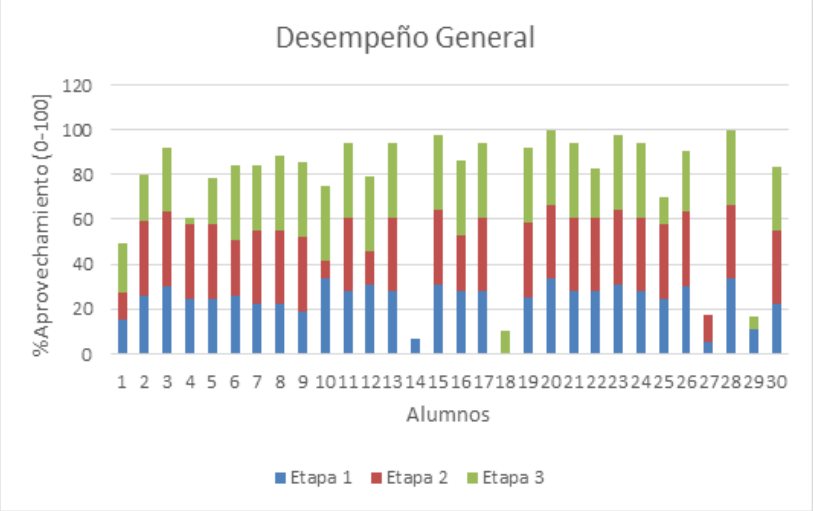
Discussion of the project evaluation

Figure 5 shows the percentages reached of the results in the three stages of the project throughout the semester, with respect to the total expected utilization. A high percentage of the group managed to conclude their project satisfactorily, and was able to maintain teamwork throughout the semester, as well as analyze the information with critical thinking to solve the proposed problem (83%). To consider that the project is finished with an optimized design, it must cover the minimum tests of functionality complying with the analysis of system requirements. It is observed that 70% of the evaluation of each rubric evaluated the project and allowed to demonstrate the adequate development of the same in 80% of the students throughout the project. On the other hand, 13% of the students who did not comply with the project, did not finish the course either, for personal reasons; the remaining 7% represents two students, who presented a different case individually: one increased their performance during the course (subject 1) and another stopped working on the last evaluation (subject 4).

Figura 4. Resultados del seguimiento de las tres etapas del aprendizaje basado en proyectos en la asignatura de Base de Datos



Fuente: Elaboración propia

It was observed, in addition, that the continuous feedback, the indication on the points to improve in the self-management of the working group and the presentation of the documentation worked as motivating elements for the students. The inclusion of the elements studied in the learning unit in the implementation of the project from the beginning of the course allowed the student to verify if the acquired contents and their meaning during the class were satisfactorily obtained and in the case that detected an omission, could do use of the complementary educational resources available. It was also observed that, in the third stage, the knowledge that is not covered by the program, because it forms part of the predecessor matters, affected the efficient conclusion of the system; but that in the approving cases, the use of ICT and the joint commitment with the teammate allowed them to reinforce or approach the concepts under different perspectives or explanations to solve this problem.

Conclusions

The implementation of project-based learning in a cross-disciplinary manner in the Database area, which contributes to professional training in the engineering area curriculum, allowed students to increase the level of knowledge and skills in the implementation of information systems, with the main objective of implementing databases. It allowed students to develop research skills and, through project development, improve research skills, increasing analysis and synthesis skills.

In addition, teamwork and the use of PBL allowed them to put aside individualized learning and share challenges and achievements with their peers; he made them aware of his capacity, as well as that knowledge about databases can solve real-life problems through the use of ICT, and the relevance that these tools have in his professional life as telematic engineers.

On the part of the teacher, guiding the different projects in a systematic and documented manner, directing the application of knowledge to real-world challenges, allows him to maintain students' interest in complex topics and some arid cases, as well

as feedback on the appropriation of knowledge and encourage the analysis of theoretical information in a continuous manner, without neglecting the development of different competences that are desirable in engineering students. The proposed methodology not only allows the evaluation criteria to be standardized in the initial didactic proposal, and to establish motivational or remedial strategies in the future, but also allows for a careful subsequent analysis of the effect of these and to document the process in a systematized manner.

References

Aravena, M., Caamaño, C. y Giménez, J. (2008). Modelos matemáticos a través de proyectos. *Revista Latinoamericana de Investigación en Matemática Educativa*, *11*(1), 49-92.

Arévalo, O., Linares, S., Correa, L., Parra, J. y González, H. (2008). *IEEE-STD-830-1998: Práctica Recomendada para las Especificaciones de Requisitos del Software*. Bogotá, Colombia: Universidad Nacional de Colombia. Recuperado de https://www.coursehero.com/file/26783786/Requerimientos-Norma-ieee830doc/.

Arias, M. (2005). La ingeniería de requerimientos y su importancia en el desarrollo de proyectos de software. *InterSedes: Revista de las Sedes Regionales*, *6*(10), 1-12.

Barker, R. (1994). *El modelo entidad-relación. CASE*Method*. Massachusetts, Estados Unidos: Adison-Wesley Iberoamericana.

Cánovas, C. (2007). Reflexión de la práctica docente en un proceso innovador. *Actualidades Investigativas en Educación, 7*(3), 1-19

Collazos, C. (2006). How to take advantage of "cooperative learning" in the classroom. *Educación y Educadores, 9*(2), 61-76.

Fernández, M. y Fillottrani, P. R. (2003). Casos de uso: una propuesta para la reunión de requerimientos. En Caluva, C., Aranguren, S. y Muzachiodi, S. (eds.), *Memorias del V Workshop de Investigadores en Ciencias de la Computación* (pp. 700-704), Buenos Aires, Argentina: RedUNCI.

Harwell, S. (1997). Project-based learning. In Blank, W. and Harwell, S. (eds.), *Promising practices for connecting high school to the real world* (pp. 23-28). Tampa, United States: ERIC.

Instituto Politécnico Nacional [IPN]. (2012). *Unidad Profesional Interdisciplinaria en Ingeniería y Tecnologías Avanzadas (UPIITA)**:** Cursos de Ingeniería Telemática.* Ciudad de México, México: IPN. Recuperado de http://www.telematica.upiita.ipn.mx/archivos/nivelII/.

Johnson, D. W., Johnson, R. y Holubec, E. (1999). *El aprendizaje cooperativo en el aula*. Barcelona, España: Paidós.

Magraner, B. y Valero, B. (julio de 2013) ¿Cómo desarrollar la competencia colaborativa en el alumnado universitario? una propuesta de implementación y evaluación. Ponencia llevada a cabo en las XI Jornadas de Redes de Investigación en Docencia Universitaria. Alicante, del 4 al 5 de julio de 2013**.**

Martí, J., Heydrich, M., Rojas, M. y Hernández, A. (2010). Aprendizaje basado en proyectos. *Revista Universidad EAFIT*, *46*(158), 11-21.

Moreira, M. A. (2005). Aprendizaje significativo crítico (Critical meaningful learning). *Indivisa. Boletín de Estudios e Investigación, 6* (1) 83-102.

Pérez, H. G., Nava, S. E., Castillo, F. E., Vital, O., Silvia, L., Vaca y Ramírez, F. J. (2017). Experiencia de Aprendizaje Intensivamente Orientado a Proyectos para la Enseñanza de Ingeniería Computacional. En Callaos, N. (ed.), *Memorias de la Décima Sexta Conferencia Iberoamericana en Sistemas, Cibernética e Informática* (pp. 8-15). Florida, Estados Unidos: Internacional Institute of Informatics and Systemics (IIIS).

Sánchez, L., Ferrero, R., Conde, M. Á. y Cendón, J. (septiembre de 2016). Experiencia de aprendizaje basado en la implementación colaborativa de proyectos para el desarrollo de competencias emprendedoras. Ponencia llevada a cabo en el XVIII Simposio Internacional de Informática Educativa. Salamanca, del 14 al 16 de septiembre de 2016.

Sayago, Z. B. y Chacón, M. A. (2006). Las prácticas profesionales en la formación docente: hacia un nuevo diario de ruta. *Educere, 10*(32), 55-66.

Silberschatz, A., Korth, H. F., Sudarshan, S., Pérez, F. S., Santiago, A. I. y Sánchez, A. V. (2002). *Fundamentos de bases de datos*. Ciudad de México, México: McGraw-Hill.

Soler, J., Prados, F., Boada, I., y Poch, J. (2006). Utilización de una plataforma de e-learning en la docencia de Bases de Datos. En Ezpeleta, J. (ed.), *Actas de la XII Jornadas sobre la Enseñanza Universitaria de la Informática* (pp. 584-586), Bilbao, España: Universidad de Deusto.

Anexo 1

Tabla 4.Rúbricas establecidas para evaluar la etapa 1 del desarrollo del proyecto

Criterio / % asignado	Excelente	Bien	Regular	Insuficiente
Problema de investigación	(30-21 %)	(20-16 %)	(15-11 %)	(10-0 %)
30 %	Es capaz de entender y resolver el problema a través de la toma de decisiones propias, generando argumentos en un problema real, considerando los conceptos de BD.	Plantea las necesidades a resolver usando los conocimientos de las BD, en un problema real.	Entiende las necesidades que debe resolver utilizando los conocimientos de BD en un problema real.	No entiende las necesidades a resolver, ni utiliza los conocimientos de BD en un problema real.
Diseño del proyecto	(40-30 %)	(30-21 %)	(20-11 %)	(10-0 %)
40 %	Es capaz de explicar los diseños de BD entidad – relación y relacional. Además de modificarlos de	Es capaz de explicar el diseño de BD entidad – relación y relacional, considerando las necesidades	Diseñó el modelo entidad –relación y relacional según las reglas de diseño de BD	No fue capaz de diseñar un modelo entidad – relación y relacional de forma correcta.

	acuerdo con las necesidades planteadas en el documento de requerimientos.	planteadas en el documento de requerimientos.		
Integración del equipo	(10-7.6 %)	(7.5 – 5.1 %)	(5 – 2.6 %)	(2.5-0 %)
10 %	Todos los miembros del equipo de trabajo explican la solución a la problemática con actitud amigable y respetuosa.	Explican la solución propuesta con actitud amigable y respetuosa, pero se corrobora que la distribución en las tareas en el equipo no fue equitativa.	No todos los miembros del equipo pueden explicar la problemática, de forma eficaz.	Los resultados del trabajo son entregados por separado.
Documentación	(20-16 %)	(15-11 %)	(10-6 %)	(5-0 %)
20 %	Entrega documentación de manera clara y concisa, con base en el análisis de la información, con	Entrega información con base en el análisis de la solución de la problemática y cumple con los	Entrega información de la problemática y cumple con los estándares de la IS	No se expresa la propuesta o no se atiende a lo solicitado.

	pensamiento crítico para la solución de la problemática y cumpliendo con los estándares de la IS.	estándares de la IS		
Nota: IS: Ingeniería de Software. UI: Interfaz Gráfica. BD: Base de Datos				

Fuente: Elaboración propia

Anexo 2

Tabla 5. Rúbrica de evaluación establecida para etapa 2 del desarrollo del proyecto

Criterio / % total asignado	**Excelente**	**Bien**	**Regular**	**Insuficiente**
Codificación del proyecto	(60-41 %)	(40-21 %)	(20-11 %)	(10-0 %)
60 %	Resuelven los requerimientos funcionales con criterio propio, cumplen con las reglas de negocio,	Resuelven los requerimientos funcionales con las reglas de negocio, usando todas las sentencias	Resuelven los requerimientos funcionales con las reglas de negocio utilizando la mayoría de las	Resuelven los requerimientos funcionales sin cumplir con las reglas de negocio con el lenguaje SQL.

	usando de forma ágil todas las sentencias de SQL.	requeridas de SQL.	sentencias de SQL.	
Conexión a la BD	(10-7.6 %)	(7.5-5.1 %)	(5-2.6 %)	(2.5-0 %)
10 %	Realiza eficientemente las conexiones de los lenguajes de alto nivel con los manejadores de BD.	Logra las conexiones de los lenguajes de alto nivel con los manejadores de BD	Con ayuda, logra la conexión de un manejador de BD a un lenguaje de alto nivel.	No logra las conexiones con las BD.
Documentación	(20-16 %)	(15-11 %)	(10-6 %)	(5-0 %)
20 %	Documento con un análisis crítico de la información para la solución de la problemática que cumple con los requisitos de la IS	Documentos con un análisis crítico de la problemática y cumple con los requisitos de la IS	Documento con la información de la problemática y cumple con los requisitos de la IS	El documento no cumple con lo que se le solicito.

Integración del equipo	(10-7.6 %)	(7.5 - 5.1 %)	(5 - 2.6 %)	(2.5-0 %)
10 %	Todos los miembros del equipo de trabajo explican la solución de la problemática planteada con actitud respetuosa.	Se observa que la distribución en las tareas del equipo no fue equitativa.	No todos los miembros del equipo de trabajo logran explicar la solución al problema, de forma eficaz.	Los trabajos solicitados son entregados por separado.

Fuente: Elaboración propia

Anexo 3

Tabla 6. Rúbrica establecida para etapa 3 en el desarrollo del proyecto

Criterio / %asignado	**Excelente**	**Bien**	**Regular**	**Insuficiente**
Interfaz de usuario (IU)	(40-39 %)	(30-29 %)	(20-11 %)	(10-0 %)
40 %	El sistema está bien terminado, es amigable al usuario y cada requerimiento funcional está validado.	El sistema está bien terminado, cada requerimiento funcional está validado.	El sistema cumple con cada requerimiento funcional del sistema.	El sistema no está terminado o no cumple con los requerimientos funcionales.

Integración de la BD e IU	(30-21 %)	(20-16 %)	(15-11 %)	(10-0 %)
30 %	El sistema está terminado con un buen diseño, desarrollo y probado. Cumple el 100 % de los requerimientos del sistema.	El sistema terminado cumple con el 80 % de los requerimientos.	El sistema terminado cumple con el 60 % de los requerimientos del sistema.	Cumple con menos del 60 % de los requerimientos del sistema.
Integración del equipo	(10-7.6 %)	(7.5-5.1 %)	(5- 2.6 %)	(2.5-0 %)
10 %	Todos los miembros del equipo de trabajan explican la solución a la problemática con actitud amigable y respetuosa.	El profesor observa que la distribución en las actividades del equipo no fue equitativa.	No todos los miembros del equipo de trabajo explican la solución al problema, de forma eficaz.	Los miembros del equipo entregan trabajos por separado.
Documentación del proyecto	(20-16 %)	(15-1 %)	(10-6 %)	(5-0 %)

20 %	Documento basado en el análisis crítico de la información para la solución de la problemática que cumple con los requisitos de la IS.	Documento con el análisis de la información de la problemática que cumple con los requisitos de la IS.	Documento que presenta información de la problemática y que cubre los requisitos de la IS.	El documento no se refleja lo solicitado para la elaboración del sistema.
Nota: **IS: Ingeniería de Software. UI: Interfaz Gráfica. BD: Base de Datos**.				

Fuente: Elaboración propia

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Software	**No aplica**
Validación	**Blanca Alicia Rico Jiménez**
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