Implementation of a technological, information, and communication tool for project management in the network of Tecnoparque, Colombia

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Abstract. In Colombia, the development of technology-based projects is being promoted and encouraged. In this sense, different institutions, both private and governmental, allocate a large amount of technical and financial resources to develop or contribute to the development of such initiatives. However, in entities such as the "Red de Tecnoparque Colombia del Servicio Nacional de Aprendizaje", strategies that allow managing and evidencing the activities developed by each of the projects carried out in the network had not been implemented. Therefore, no information support allowed to measure or sustain the technological maturity of the projects gestated. Thus, in “Tecnoparque Nodo Medellín”, a software platform was developed to register and manage the entire development path of technological projects. Also, the platform provides management indicators and a repository of evidence to use at the national level, allowing monetization of the activities of support in Investigation and development of the "Red Tecnoparque" in Colombia.

1. Introduction

Scientific, technological, and innovation activities in Colombia are executed under the “Sistema Nacional de Ciencia y Tecnología (SNCyT)”. This system is made up of private and governmental institutions that generate and develop scientific and technological knowledge [1]. In the case of the “Servicio Nacional de Aprendizaje (SENA), Colombia”, activities start from 2011 with the conceptual proposal of the knowledge management system, through resolution 818 of 2012. Later, through agreement 016 of 2012 of the National Board of Directors of SENA, which created the “Sistema de Investigación, Desarrollo Tecnológico e Innovación (SENOVA)”. The purpose of SENNOVA is to carry out actions to strengthen research and innovation (R&I) processes in the Colombian productive sector [2]. Three programs are worked on in this system: innovation, research, and technological development. Each program is made up of work lines, called programmatic lines. The innovation program has the appropriation lines of science, technology, and culture of innovation in training centers; and the strategies of innovation and productive technological development, through the relationship between the centers and the companies. In the research program, innovation is developed through research groups and seedbeds within the training centers. The technological development program is composed of “Tecnoparque” and “Tecnoacademia”, and the processes of strengthening of the offer of
technological services for companies, technological modernization of training centers, technological extension and contests for improvement of training programs [2].

As indicated, “Tecnoparque” is positioned within the SENNOVA Technological Development program, aimed at all Colombians interested in developing innovative projects materialized in functional prototypes and minimum viable products [3,4]. The objective of the formulation and development of projects in the “Red Tecnoparque Colombia” is the generation of prototypes, which are characterized according to the levels of Technological maturity or technology readiness levels (TRL) The “Prototipos Funcionales Finalizados (PFF)”. And the “Productos Mínimos Viables (PMV)” are the results of the execution of “Proyectos de Base Tecnológica (PBT)”, with prototypes between TRL5 and TRL 8 [5–7].

To show that a prototype meets the development requirements of a given level, the properly organized documentation evidencing adequate traceability in the development of the PBT must be available. So, a software tool has been implemented for PBT execution, to streamline the management of information in the “Red de Tecnoparque”. This tool allows managing the development phases of the PBT through the registration of the activities required to meet the objectives of each phase. The Tecnoparque management system also incorporates information related to the different actors with whom the network develops R&I projects, such as SENA research groups and external institutions of higher education, business enterprises, and entrepreneurs.

This work describes the development of the “Plataforma de gestión Tecnoparque Colombia”. The paper starts with the software architecture and then details the programming techniques and the development tools used. Finally, the system operation is evidenced in the results section. The platform has allowed efficient management of the indicators of productivity, technological maturity, and impact of innovation and technological development.

2. Experimental Procedure

2.1. Software architecture for the platform
The platform followed the parameters defined by the model-view-controller (MVC) architecture, which separates data and business logic from an application [8]. MVC uses three components: model (data), view (client), and controller (business logic). The framework offers the possibility of implementing repositories, or "bridges" communicating the controller with the model. These elements interact with each other, as shown in Figure 1.

All web applications are based on the information exchange between clients and servers, which should be as effective as possible. The fluidity of this exchange is the main objective of all architectures, technologies, and web languages. Among the advantages of the MVC pattern, the views always show updated information, and developers do not have to worry about updating requests. MVC also has extensive scalability, since the application can grow according to need. The MVC pattern offers a
modular implementation, meaning that the implementation of new modules does not directly affect what already exists within the application [9].

2.2. Programming techniques used in platform creation

In the case of the server, the programming language implemented is hypertext preprocessor (PHP) version 7.2. PHP is a multiparadigm language with dynamic characteristics. PHP is a popular open-source system also suitable for web development and can be easily implemented with hypertext markup language (HTML). In turn, for server-side development, a PHP framework called Laravel (V 5.8) was used. Laravel allows faster and easier work, simplifying tasks with database migrations, and handling aspects such as user sessions, cache, and views [10].

In the application data model, a relational database was used, consisting of a collection of organized elements with predefined relationships to each other. These elements are grouped into tables, where each column has a particular data association, which allows saving information about the objects to be represented in the database [11,12]. For the client-side, the programming language was JavaScript (JS). JS is an object-oriented language with first-class functions. Moreover, JS is known as the scripting language for web pages, but it serves in many browser-free environments, such as node.js, vue.js, or angular [13].

Finally, HTML was implemented for the layout of client views. HTML is a language marked for hypertexts, based on tags for the elaboration of web pages with a basic structure [14]. The template engine of the Laravel framework, called Blade template, was used for the layout of the client-side views. The latter compiles all the views of the application through the cache improve efficiency in the loading process.

2.3. Development tools

Open source text editors such as Sublime text or Atom were used, allowing quick and easy development of the application. The use of PHP language avoids the need for a complete integrated development environment (IDE) for web application development. Composer was employed to manage PHP packages/libraries, which provides a standard format for managing dependencies. For project version management, Git technology was used as a cloud repository. Gitlab was chosen because it offers a wide variety of statistics and allows keeping the repositories private for free. The Laragon server was used to run the application in a local environment. Laragon brings implemented Apache server and PHP language itself, in addition to allowing the creation of virtual servers automatically. MySql was implemented for the data model; that is the most popular open-source database in the world for its performance, reliability, and ease of use [15].

2.4. Project structuration

As mentioned earlier, the development of the application involved the MVC pattern with support from the Laravel framework. The use of Laravel changes the structuring of the application concerning a traditional MVC project. Laravel use generates the need to create folders for proper structuration, such as those listed in Table 1. Changing or deleting some folders may affect the correct operation of the application [16], due to the development of the platform through a framework.

3. Results and discussion

There are several SENA officials directly related to the operation of the platform. Among them, the following stand out: Coordinator of the research, innovation and academic production group, Advisor to the training center, vice-principals of the centers, Tecnoparque Managers (known as dynamizers), Tecnoparque Project promotors, and talents. Surveys and interviews were conducted with these officials to define the procedure for entering the system. The first step is a registration for access to the platform. Subsequently, the user will enter the platform with the permissions and restrictions corresponding to their role. The login webpage is presented in Figure 2.
Table 1. Application structuring.

| Folders in the app structure | Functionality description |
|-----------------------------|---------------------------|
| git                         | To handle the changes made in the project, versions, among others. |
| app                         | To establish the functions and operation to be performed on the application. Here are located the models (database) and controllers (business logic). |
| Repositories                | To bridge the communications between controller and model. This folder contains most of the requests and transactions performed in the database. |
| bootstrap                   | To hold together all the Laravel components. |
| config                      | To manage project settings, such as connection to the database, user permissions, files, cache, sessions, queues, emails (for sending emails), among others. |
| database                    | To manage database migrations, seeds (minimum data required by the application to function) and factories (allows the generation of test data only). |
| node_modules                | These are javascript libraries installed using node technology. |
| public                      | To save the images that will be displayed in the application (they are not images that are uploaded to the server), sources, javascript files, among others. The application is mainly run from this folder. |
| resources                   | To save project views. The developers archive here the javascript files for handling data in the views (these javascript files are not the same as those stored in the public folder). The libraries that developers manually installed are also included in this folder. |
| routes                      | Developers establish the routes for communication between views and project controllers. The application notifies the user directly of any existing route. |
| storage                     | To store the files that the user uploads to the server from the application. The framework caches the views of the project, making them faster to load. |
| test                        | To configure the application to perform test cases and find code errors. |
| vendor                      | To locate native framework code (Laravel). This code should not be modified because there is a risk that the application will not work correctly. Also found here are the libraries installed using Composer, which should not be modified either. |

Figure 2. Login webpage of the “Plataforma de gestión Tecnoparque Colombia”.

After entering the platform, users fill in the information concerning the projects executed within the technological lines of “Tecnoparque”. Figure 3 shows the form requesting the initial information on the execution of the project. In each project phase, a series of files must be attached as evidence of the state of development of the PBT. These files are previously established for the monitoring of every project. Figure 4 presents the form for the execution and closing phases of the technology-based project.
Figure 3. Form for the beginning and planning phases of a project in the “Plataforma de gestión Tecnoparque Colombia”.

Figure 4. Form for the executing and closing phases of a project in the “Plataforma de gestión Tecnoparque Colombia”.

From information registered on the platform, queries or reports can be generated for both the management of each project and the “Tecnoparque” in general. Figure 5 presents an overall report of the performance indicators of “Tecnoparque”, with the projects classified according to their progress status. Additionally, the economic investment associated with the execution of each project can be quantified, as illustrated in Figure 6.
4. Conclusions

The “Plataforma de gestión Tecnoparque Colombia” is a management and control tool for the “Red Tecnoparque”. This platform improves monitoring and offers a measure of the level of maturity of technology-based projects. Besides, it allows the monetization of the economic investment associated with the execution of each project. In this way, the platform helps the Colombian state to present in an accurate and agile way the information on the cultural and technical behavior of the country in the development of technology-based ventures.

The process of requirement inventory for the development of the platform involved different “Tecnoparque” Nodes nationwide. The analysis of this information was an essential element for software development, establishing the functionalities in each module. Also, the ample participation strengthened the user interaction in “Plataforma de gestión Tecnoparque Colombia”.

The platform allows the application of management indicators in the process of innovation and technological development in the “Red Tecnoparque”. Besides, it facilitates the presentation of reports on the impact of the R&I processes in the country through Tecnoparque Nodes.
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