Miguel Botto-Tobar · Omar S. Gómez ·
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Trends in Artificial Intelligence and Computer Engineering

Proceedings of ICAETT 2021

Springer

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Volume 407

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Preface

The 3rd International Conference on Advances in Emerging Trends and Technologies (ICAETT) was held on the main campus of the Escuela Superior Politécnica de Chimborazo, in Riobamba–Ecuador, from November 10 until 12, 2021, and it was proudly organized by Facultad de Informática y Electrónica (FIE) at Escuela Superior Politécnica de Chimborazo and supported by GDEON. The ICAETT series aims to bring together top researchers and practitioners working in different domains in the field of computer science to exchange their expertise and to discuss the perspectives of development and collaboration [1, 2]. The content of this volume is related to the following subjects:

- e-Business
- e-Learning
- Intelligent systems
- Machine vision
- Security
- Technology trends

ICAETT 2021 received 96 submissions written in English by 140 authors coming from 15 different countries. All these papers were peer-reviewed by the ICAETT 2021 program committee consisting of 162 high-quality researchers. To assure a high-quality and thoughtful review process, we assigned each paper at least three reviewers. Based on the peer reviews, 22 full papers were accepted, resulting in a 23% acceptance rate, which was within our goal of less than 40%.

We would like to express our sincere gratitude to the invited speakers for their inspirational talks, to the authors for submitting their work to this conference and to the reviewers for sharing their experience during the selection process.

November 2021

Miguel Botto-Tobar
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Organizing Institutions

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Monitoring Tool to Improve Strategic and Operational Planning Processes in Universities

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Abstract. A close collaboration between the institutional planning department, the strategic leaders, the faculties, and departments is an important pillar to improve the strategic and operational planning of the Universidad Técnica de Manabí. This research presents an explanatory case study of how the web application automated the processes to contribute to the creation of the institutional strategic plan of the majors and the operational plans of the academic and administrative units with the respective monitoring and evaluation that determine whether or not the objectives and goals are met. The methodology applied is the V model and the tools used are the PHP programming language, the Laravel framework, and the PostgresSQL database manager. Its application was carried out in 10 Faculties with 33 majors and 9 departments, which expedited the registration of evidence in the comprehensive institutional planning system, improving the validation times of the evidence entered in 2017 with a 90-day spreadsheet compared to 45 days with the SIPI system in the 2018 period, in addition to constantly monitoring the objectives and goals planned by each academic and administrative unit, generating multiple reports that contain information that helps in making strategic decisions for university management and obtaining a positive impact on the monitoring of the performance indicators of the higher education institution.

Keywords: Higher education institutions · Information systems · Strategic planning · Strategic software · Software as a service

1 Introduction

Web systems have become very important at the present time, the mass use of the Internet has had an impact on the process transferring desktop applications to the web and this has generated to determine the best options for this transfer [18] due to the advantages it offers as a level of higher throughput and a high availability rate.

Strategic and operational planning within higher education institutions (HEIs) play a fundamental role in meeting objectives. According to [5] strategic planning, it is a holistic approach that arises both from the weaknesses and the strengths of the institution itself,

the opportunities and threats that result due to external factors, the need for a planning process and the support of those who make up the organization.

For this reason [6], the important point in strategic planning for the success of the institution is knowing that everyone must work to meet the objectives set. The success of the organization depends on its functioning as a single body. Strategic planning has three main elements: (1) To develop the Plan (2) To implement the Plan (3) To evaluate and Feedback the Plan. In addition to the agreement [9], strategic planning is the most common process used in the management of institutions that can be complemented with mechanisms for evaluating and monitoring performance from the perspective of the organization.

In this regard [15], it indicates that the management of processes in any organization is a complex task that must be developed under a review approach both at the micro and macro level to be able to cover all the needs of the areas that are part of the organization. Once the management commits to the fulfillment of a continuous and permanent task, the quality of its processes must be measured, and then actions taken to optimize its resources and increase the impact of its activities. HEIs as organizations are not alien to this because the quality of higher education must cover all its substantive functions and for the benefit of the university community and society in general.

Strategic planning processes are urgent requirements of the Ecuadorian educational system, universities deserve special attention to these processes due to their proactive nature and their anticipation of needs and changes. Without the adequate strategic intention that must be part of the organizational culture of senior managers and the institution in general, this transformation will not be possible [8].

At the national level, universities are in a process of modeling in institutional planning, institutions have begun with the generation of standards that allow the adequate use of information to promote decision-making assertively. In [4] this way, an integration between strategic planning and ICTs is achieved through information systems.

As [6] indicates, the use of an adequate management tool in planning provides the opportunity to increase academic, scientific and cultural quality by facilitating the process of competing with leadership in the increasingly demanding market for university education.

The Universidad Técnica de Manabí in its trajectory has generated four strategic plans with the participation of all those involved, with their respective POA, the processes were carried out manually through spreadsheets and the transfer of files; that caused delays in the delivery times of the information, the strategic objectives could not be fully met and there was not an adequate flow of processes for monitoring in each of the planning stages such as the preparation of the plan, monitoring and implementation monitoring, evaluation and feedback.

As an Institution of Higher Education, there was no tool that would allow control and monitoring of the fulfillment of PEDI and POA. With the development and implementation of an information system for the Directorate of Institutional Planning of the Universidad Técnica de Manabí (UTM), processes were managed in a more agile and efficient way; By existence of this tool, suitable process flows were established that allow adequate monitoring and feedback to be carried out, in this way the results obtained to provide support for institutional decision-making, which allow progress in each of the

areas: academy, management, research and the relationship with society that bring closer to the local reality and considering that strategic planning is an innovation to the higher education system of our country.

The present research work aims to identify the contribution that arises in the institutional planning processes through the implementation of a web tool as a computer strategy for the optimization of these processes. The proposal arises from the problem faced by Higher Education Universities and in this case in particular the Universidad Técnica de Manabí, having ineffective management of information through manual management of planning processes such as preparation, monitoring, and evaluation of strategic and operational planning.

2   Material and Method

The present research has a bibliographic and experimental nature. It was held at the Universidad Técnica de Manabí (UTM) located in the city of Portoviejo, Ecuador. The objective of which is to improve Institutional planning processes in academic and administrative units through the use of the Integral Institutional Planning System (SIPI) application.

The tools used were PHP and PostgreSQL in conjunction with the laravel framework, highlighting the use of the MVC model (model-view-controller), the Google Chrome and Mozilla Firefox web browsers, and their add-ons such as firebug for error detection and as a means of verification for response times. The execution was carried out using the V model development methodology, the project is presented as an explanatory case study where each of the phases that were executed to obtain the results are described [20]. The phases were carried out as detailed below:

2.1   Specifications Phase

In the first instance, it is observed the prerequisite analysis that according to [18], defines as the phase in charge of the knowledge model and the need to solve the existing problem [10], which describes the analysis of the processes that they are carried out within the Planning Directorate (DPI) of the UTM, likewise in the administrative and academic units, the directorates and institutes of the university in the field of strategic and operational planning. A special emphasis is placed on the prerequisites of institutional planning, which was carried out through interviews with the Director of the DPI and the Director of the ICTS, who outlined the limitations that existed in the execution of the strategic plan for institutional development (PEDI) and annual operating plan (POA).

The need on the part of UTM was to have a computer strategy that allows the automation of institutional planning processes, when carrying out a preliminary analysis it was evidenced that the processes were carried out manually, through the use of spreadsheets and the sending of emails, which caused delays in delivery times, duplicate information and inconsistency in the data, which significantly affected the fulfillment of the strategic objectives initially established.

Given this, a computer solution that allows to manage institutional planning processes in an automated way and have a higher percentage of compliance within the strategic objectives arises. The necessary roles for the correct functioning of the computer system were defined, in addition to the functions that the heads of the units will perform and the access levels that will allow greater control within the functionality and benefits established within the SIPI web tool (Integrated System of Institutional Planning).

2.2   High-Level and Detailed Design Phase

In this phase, the design of the structure that will contain the computer system was carried out, which is based on the MVC model (Model-View-Controller) under the LARAVEL framework, which contributed to the separation of the logical part of the application and the data displayed, among which the extraction of the data from the database server directed towards the indistinct user of the platform used [7] as shown in Fig. 1.
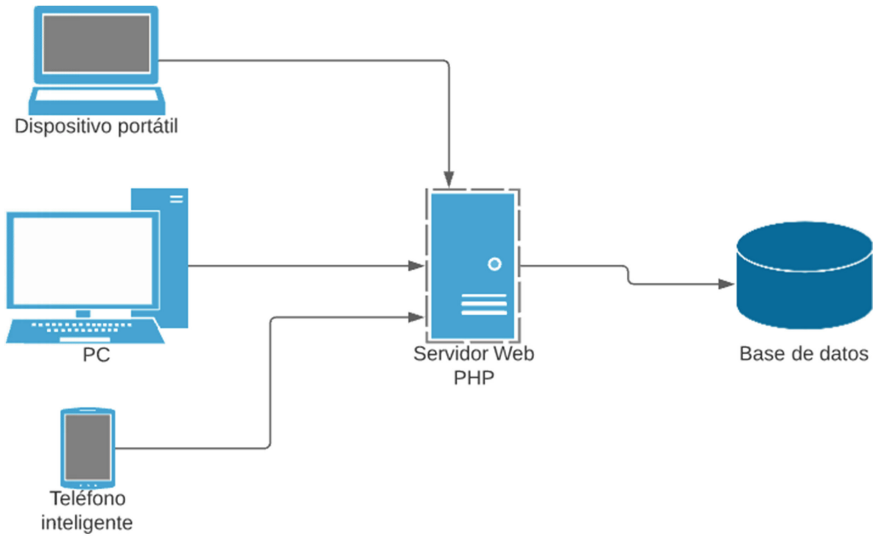

Fig. 1.   Web service architecture

2.3   Implementation Phase

For the implementation process, it was carried out in two phases. The first phase consisted of the installation and configuration of the necessary tools for the operation of the computer system in the ICT Directorate and the site was published for its first version. A Secure Sockets Layer (SSL) security certificate was used that allows the data between the user and the web application to be encrypted and the information cannot be intercepted by external agents.

The second process was the execution of training for the personnel involved in the institutional planning process for the heads of each unit of the Universidad Técnica de Manabí.

The application can be used from any web browser, regardless of the operating system. Among the main functionalities that it provides, are the registration and evaluation of each of the phases of the processes concerning to the POA or PEDI, at the level of each of the administrative units of the institution, the visualization of the status of each task through real-time monitoring during development. The tool was developed with user-friendly interfaces as shown in Fig. 2.
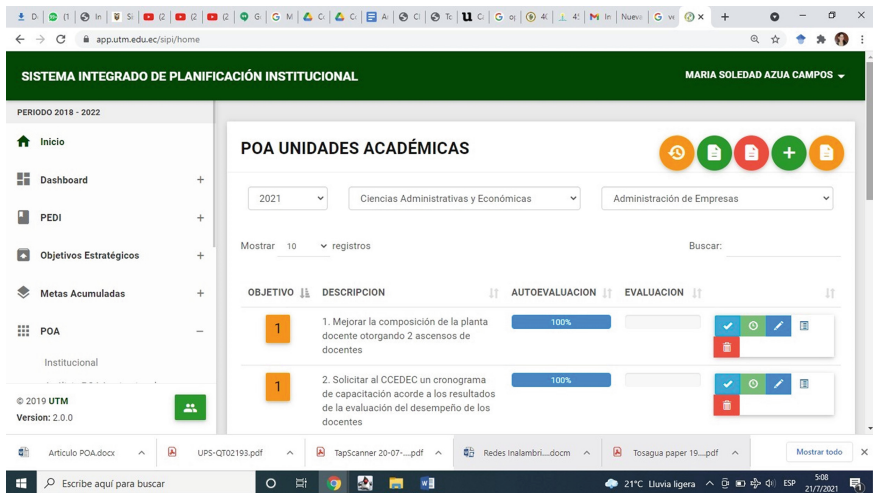

Fig. 2. SIPI POA tool of the academic unit

2.4 Unit, Integration, and Operational Test Phase

By testing through the use of firebug, it was possible to verify the proper functioning of the computer system, its server response times were within the allowed times as shown in Fig. 3.

For the development of the web application, the integrated development environments (IDE) were used, which allow its execution locally without the need for a physical server for the web service and as shown through the registry of events, a request has been made to the webserver where the tool is hosted correctly and it displays the data obtained in Fig. 4.
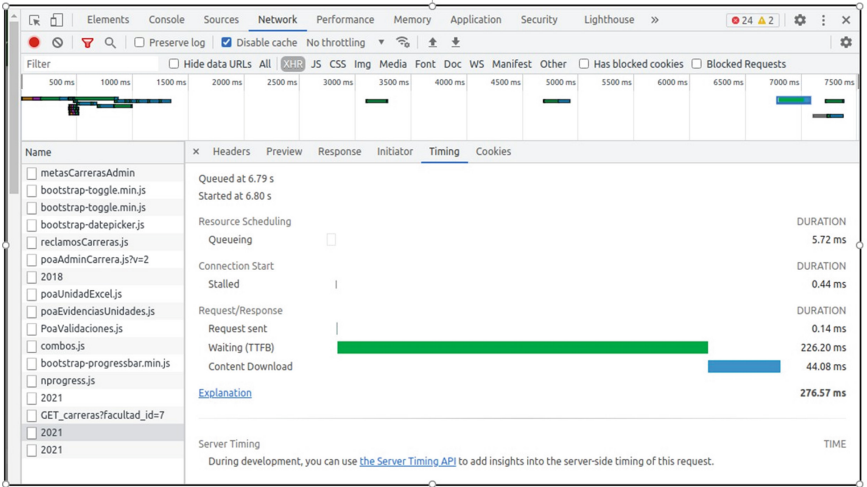
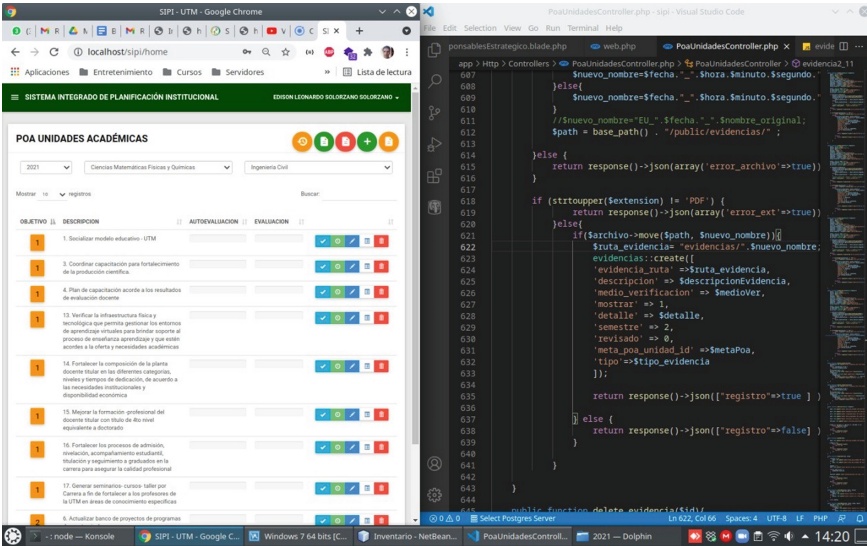**Fig. 3.** Verification of the response time of the Web Service

Fig. 4. Connection verification from the application and data collection

3   Results and Discussion

Web systems in higher education institutions play a fundamental role and provide tools that promote the automation of processes with which employees and teachers feel supported in their daily actions comfortably and adjusted to the needs of each institution [12]. This computer strategy has allowed providing mechanisms for the monitoring and control of institutional planning operations, as relevant aspect it can be noted that this type of

strategy within an organization is not something static, rather one of the most challenging tasks is maintenance of a tool that generates information for decision-making.

The strategic and operational planning tool allows the process of creating each process to be carried out in an organized way as shown in the following figure where block one defines the institutional strategic objectives, in block two the accumulated goals that indirectly serve in planning to constitute long-term results to be achieved, in block three the end of the chain is constituted, where the relationship between the institutional strategic objectives and the institutional accumulated goals that derive in the formation of the annual operating plan and department or career plan is established, as shown in Fig. 5.

Fig. 5. Creation of institutional objectives and goals by academic units

The evaluation of strategic planning in higher education institutions is a complex process to achieve as indicated [13]. For this reason, countless methods with divergent opinions have been used to identify the most suitable indicators for a certain function that have been categorized as components of teaching, research, social responsibility, well-being, internationalization, management, and resources [17]. On the other hand

[3] indicates that there are evaluation tools that have been used by the education sector to maintain sustainable monitoring and benchmarking through the use of software as a service.

Once the implementation of the SIPI tool was carried out, its application was carried out in 10 Faculties with 33 majors and 9 departments, it was possible to identify the improvements in the response times of each institutional planning process, specifically in two processes: the entry of evidence and the evaluation of the execution of the annual operating plan. A record of the response time of the first year the tool was implemented and the comparison with the record of the time of these processes when they were kept in the spreadsheets in 2017, as shown in the following table one and two:

Table 1. Record of the time spent in the processes of input and evaluation of the information of the annual operating plan with spreadsheets 2017.

Participants in planning 2017	First semester		Second semester	
	Total of days of the process of entering the Informacion for the evaluation in spreadsheets and means verification on CD	Total of days of the process validation and evaluation of evidences from the planning direction from the spreadsheet	Total of days of the process of entering information for the evaluation in spreadsheets and means of verification on CD	Total of days of the process validation and evaluation of evidence from then planning direction from the spreadsheet
Faculties departments Institutes	45 days	90 days	38 days	90 days

When reviewing the comparative records of Table 1 and Table 2, it can be identified that the execution times of the processes of entry of means of verification and self-evaluation are reduced from 45 days (2017) to 15 days in 2018 in the first Semester equivalent to a time saving of 67% and for the second semester from 38 days (2017) to 15 days (2018) which is equivalent to a 61% saving in execution time of these processes. In turn, the validation and evaluation of the evidence from the Institutional Planning Department until issuing the evaluation report is reduced from the 90 days that the manual process took in 2017 through the spreadsheets to 50% less in days (45) in 2018 through the SIPI computing strategy, with 2018 being the first year of implementation, which guarantees that in future years its optimization in the planning processes and specifically in these two key processes will be significantly reduced in time, according to the optimization of the web tool and the expertise of its operation, Fig. 6 shows the evaluation of the POA of an academic unit in charge of the institutional planning department.

Table 2. Record of the time spent in the processes of input and evaluation of the information of the annual operating plan with spreadsheets 2018.

Participants in the planning 2018	First semester		Second semester	
	Total of days the self-assessment entry process and means if verification in SIPI	Total of days of evidence evaluation and validation process from the planning directorate at SIPI	Total of days of the self-assessment entry process and means of verification in the SIPI	Total of days evidence evaluation and validation process from the planning directorate at SIPI
Faculties departments Institutes	15 days	45 days	15 days	45 days

The report issued by the system offers the benefit of knowing the progress of the execution of the planning of each administrative or academic agency as shown in Fig. 6. This report can be presented making a distinction between each semester (first or second semester) or in turn, a general report can be generated where the behavior of the goals for each of the objectives in the two semesters and their annual fulfillment is evidenced. For the preparation of the execution report of each agency and in the institutional report these graphs are used, therefore the reduction of time in the elaboration of this type of statistics is significant for the entire institution.
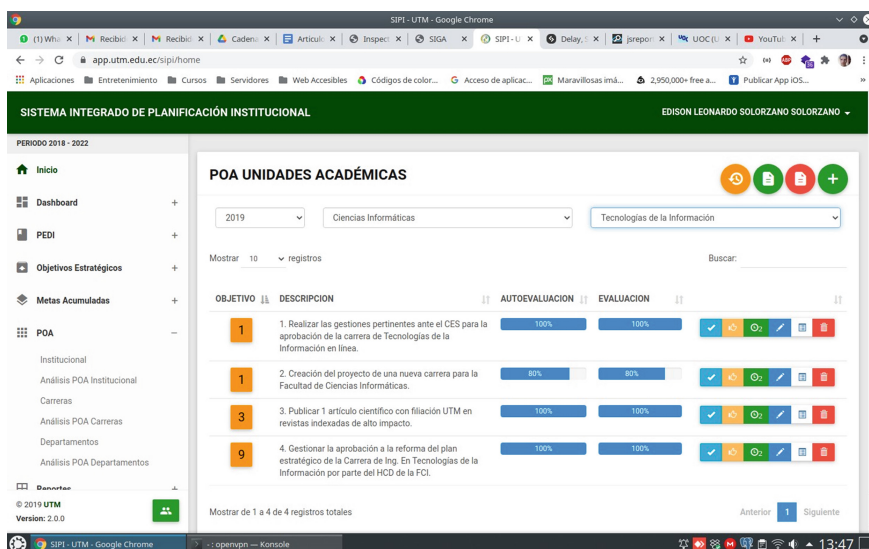
Fig. 6. Evaluation of institutional objectives and goals by academic units

According to the research [14], out of the 53 Federal Universities investigated by their efficiency and quality in high-level educational institutions (HLEI), 6 did not follow the PDI in all, 7 monitored their progress using specific software and 16 used a spreadsheet. It should be noted that 34 institutions used other forms of monitoring, including a management report (14%), special committee (13%), regular meetings (13%), custom software development (8%), occasional meetings (5%), and technical Advice of a contracted company (2%).

In tentative periods established by the Planning Directorate of the Universidad Técnica de Manabí, the Evaluation process of each Operational Plan is carried out, therefore, at the end of the process mentioned before, graphical results are obtained which allow knowing the status of the planning of each University dependency.
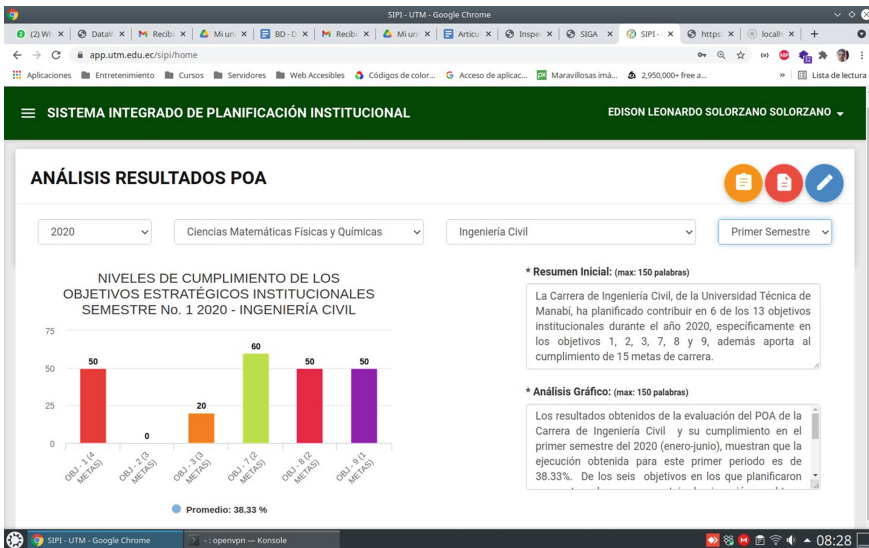

Fig. 7. Result of execution of the POA of the Civil Engineering major in the first semester of the year 2020.

The report issued by the system offers the benefit of knowing the progress of the execution of the planning of each administrative or academic agency as shown in Fig. 7. This report can be presented making a distinction between each semester (first or second semester) or in turn, a general report can be generated where the behavior of the goals for each of the objectives in the two semesters and their annual fulfillment is evidenced. These graphs are used for the preparation of the execution report of each agency and in the institutional report, so the reduction of time in the preparation of this type of statistic is significant for the entire institution.

The DPI as the monitoring unit of the Institutional Planning processes through the various graphic reports, Excel matrices, and pdf report documents that can be generated in the SIPI, including the report for the Council of Citizen Participation, report of general institutional compliance, a summary of goals of the POA, a summary of pieces

of evidence of all the dependencies, objectives and participating units, a summary of objectives and goals, financing of goals and objectives among others. These reports have optimized the follow-up and feedback provided to those responsible for the execution of planning in the administrative and academic units. The Institutional Strategic Managers that are confirmed by the highest authorities can also view this type of reports that allow them to make decisions in a timely manner through the strengths and weaknesses evidenced in them that are easily obtained through the web tool and that manually would take weeks and months in being generated (Fig. 8).
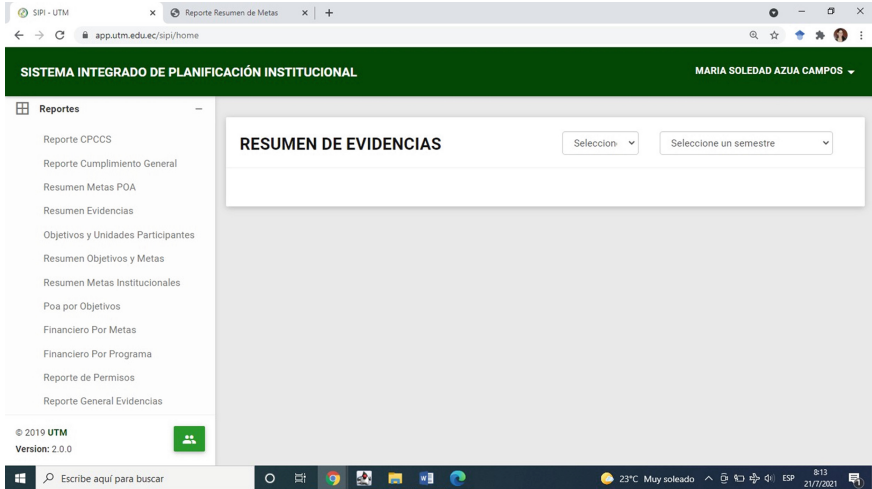

Fig. 8. Result of execution of the POA of the Civil Engineering major in the first semester of the year 2020.

University decision-making is a complicated process that involves several dimensions such as structure, logic, processes, information, interaction, and communication. The characteristics that can define a decision as "A human and daily process", in which the subjective dimension of the one who makes the choices of the decisions is decisive [19].

For the quality in the processes of the HEIs and to achieve an optimal measurement and control of them, it is important to have a measurement tool, which allows the monitoring of the fulfillment of the planned and thus determine the impact on the university community and the society. In the exercise of institutional and operational planning, the collaboration of all those involved is essential for the fulfillment of all phases [15].

In addition, it is important to emphasize that the SIPI tool allows adapt- ability to changes in the indicators for strategic development and their objective values for academic and administrative units, which according to [16] plays a crucial role in planning which is defined as an organizational and technical activity that is oriented to satisfy the external demands of the university through the effectiveness of the indicators of each unit.

The SIPI tool encourages the participation of those involved in the strategic and operational planning process, in such a way that, according to [11], this promotes new strategic ideas to form a high rate of greater effectiveness in the development of the POA and PEDI. In addition, it is important to emphasize that participation was permanent during each of the phases for the development, evaluation, and feedback for the fulfillment of the strategic objectives both at the unit and university level [1, 2].

4   Conclusions

The importance of using a computer tool for the implementation of mechanisms for measuring the quality of HEIs is highlighted. In the case of the Universidad Técnica de Manabí, the SIPI computer system has promoted improvements in the administration and control of the strategic and operational planning of the UTM.

The comprehensive institutional planning software enabled a close relation- ship between the faculties and the institutional planning management, helping to improve the validation times of the evidence entered into the system from 90 days to 45 days and to carry out constant monitoring of the objectives and goals planned by each academic and administrative unit and thereby improve the strategic and operational management of the UTM.

The introduction of the comprehensive institutional planning system contributed to better monitoring the achievement of the university's strategic development indicators and as a result the application of strategies to the first semester of the year in the indicators that did not have evidence in coordination with the planning team and the faculty management team.

Higher education institutions need a tool to measure and control their processes in order to evaluate the impact of their activities. The SIPI is aligned with most of the modern strategic planning systems used in universities and as future projects the software incorporates a mobile app and sentiment analysis for the construction of strategic planning for institutional development.

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