

007. IMPLEMENTATION OF A MANAGEMENT INFORMATION SYSTEM AT THE UNIVERSITY OF OTAVALO (ECUADOR)

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Abstract

The purpose of this paper is to analyze the essential features of a Management Information System (MIS) designed and implemented at the Universidad de Otavalo to support strategic planning, institutional evaluation, and decision-making. A five-phase and fifteen-stage process was applied, along with their corresponding techniques and expected results. Based on the literature review and their experience with the implementation, the authors devised a novel MIS implementation approach, comprising the following phases: planning, information analysis, MIS design, implementation and evaluation. The MIS consisted of four main modules: teaching, research, linkages with society, and management, and was based on the client-server model. The literature review did not yield any publications that discussed truly integrated management information systems applied to university management covering the four main modules, thus confirming the originality of the work described in this paper. The MIS implementation results contributed to the improvement of the management of the university through the automation of most of the processes and activities related to institutional planning and evaluation, and considerably accelerated the processing and analysis of useful information for decision making.

Keywords: Management Information System, University Management, Strategic Information Systems, Strategic Planning, Institutional Evaluation.

Implementación de un Sistema de Información Gerencial en la Universidad de Otavalo (Ecuador)

El objetivo de este estudio fue analizar las características esenciales de un Sistema de Información Gerencial (SIG), diseñado e implementado en la Universidad de Otavalo para apoyar la planificación estratégica, la evaluación institucional y la toma de decisiones. Se aplicó un procedimiento integrado por cinco fases y quince etapas, con sus correspondientes técnicas y resultados esperados. En base a la revisión bibliográfica y las experiencias devenidas de la implementación, los autores elaboraron un procedimiento original, cuyas fases son: Planificación, Análisis de la información, Diseño del SIG, Implementación y Evaluación. El SIG estuvo formado por cuatro módulos principales: academia, investigación vinculación y administración, y se basó en el modelo cliente–servidor. En la búsqueda realizada no se encontraron evidencias de publicaciones referidas a sistemas integrados aplicados a la gestión universitaria, considerando el contenido de los cuatro módulos señalados, lo cual fundamenta la originalidad del trabajo. Los resultados de la implementación del SIG contribuyeron al perfeccionamiento de la gestión universitaria, mediante la automatización de la mayoría de los procesos y actividades vinculados con la planificación y la evaluación institucional y agilizaron considerablemente el procesamiento y análisis de la información útil para la toma de decisiones.

Palabras clave: Sistema de Información Gerencial, Gestión Universitaria, Sistemas de Información Estratégica, Planificación Estratégica, Evaluación Institucional.

INTRODUCTION

One of the most difficult challenges in higher education is the improvement of university management and the quality of university strategic, foundational, and supporting processes. At the World Conference on Higher Education, “Higher Education in the Twenty-first Century: Vision and action”, that took place in Paris in October 1998, organized by the UNESCO, a commitment was expressed to generalize the use of new technologies to help higher-education institutions, to reinforce academic development, to widen access, to attain universal scope and to extend knowledge, as well as to facilitate education throughout life. Governments, educational institutions and the private sector should ensure that informatics and communication network infrastructures, computer facilities and human resources training are adequately provided (UNESCO, 1998).

At times, the concepts of Information Technology (IT) and Information Systems (IS) become confused. When defining the term IT, certain aspects are generally emphasized, such as information handling, problem solving, decision-making, and technology integration, among others. In connection with this, Mansfield (1984) offers a broad definition when he affirms that IT can be defined as the set of technological developments related to the creation, transmission, manipulation and presentation of data, which, on the foundation of the microprocessor, are applied in the areas of communications, calculations and control. Many educational institutions have a powerful ally in IT (Martín-Gutiérrez et al., 2015) to the point where IT's progressive advance becomes one of the main sources of innovation and competitive advantage in the sectors where it's been implemented, as is the case in education.

To get the most out of IT it's necessary to manage it efficiently; this leads to the concept of IS: a set of people, data, processes and IT that interact to gather, process, store and supply the necessary information for the correct functioning of the organization. This is why IS are an essential foundation to develop and strengthen the teaching-learning process, to organize research according to the institution's own interests and those of its environment, and automate administrative processes and activities related to linkages with the community.

IT's own evolution has resulted in a parallel typology for IS. For Dastan (2011), from a decision-making perspective, IS can refer to: Transactional Processing Systems (TPS), Management Information Systems (MIS), Decision Support Systems (DSS), Executive Information Systems (EIS), and Expert Systems or Knowledge Based Systems (KBS).

What is known today as MIS has been evolving over time. At first, communication channels were informal in their structure and use; however, with the advent and subsequent mass use of IT, they became “electronic data processing systems”. Later on, they gave rise to the concept of “computer-based information

systems”, which became popularized as “Management Information Systems”. When the concept of “strategy”—the formulation, execution and evaluation of actions that are intended to allow an organization to achieve its objectives—was introduced, MIS became “Strategic Information Systems” (SIS). SIS became part of the organization’s fabric, either because they constitute themselves a competitive advantage, or because they are fundamentally tied to the business and make a unique contribution to its processes and decision making (Senn, 1992).

One of the most important goals for the 2015-2020 period established during the institutional planning process of the University of Otavalo (UO) in Ecuador was the creation and implementation of an MIS that would supply the necessary and timely, i.e., strategic, information for decision making. To accomplish this, the UO undertook the training of management and faculty in the importance of strategic direction and institutional evaluation. As well, team management, strategic alignment and objectives, and institutional vision were strengthened throughout the UO, aided by IT (Puello, 2014).

One of the main institutional strengths is educational technology in the classrooms and campus-wide access to the internet and the UO’s intranet. Another strength is faculty commitment and motivation toward the institution’s vision and strategic direction (Ali, 2014). Indeed, this work is the continuation of the research carried out by the first two authors and a team from the UO that was published as “Strategic Information System for University Management at the University of Otavalo (Ecuador)” in the “Formación Universitaria” journal (Acosta, Becerra & Jaramillo, 2017).

The authors of the present work have made changes to the earlier study’s methodology and present progress in the MIS implementation in 2018 as compared to 2016, when the earlier paper was published. It is precisely their experience with the implementation that motivated the authors to write this paper to document the unique implementation methodology they devised and applied. This methodology was created based on the cumulative learnings and application users’ experience throughout the implementation.

There remain, however, some problems or barriers (Hosseini, Karimzadegan & Sazvar, 2012) to be overcome. This paper focuses on what attributes an MIS in a university setting needs to have to effectively support the UO’s planning, evaluation and decision making, so that improvements in the quality of the institution’s processes can result.

The reasons why an MIS was implemented are: the lack of a single mechanism for information gathering, coupled with deficiencies in its handling, analysis and distribution; information not available in a timely fashion for problem solving; inadequate communication between management, the academic secretary and the rest of UO’s departments; insufficient IT knowledge among some of the staff; the use

of multiple criteria for the classification of information; duplicate databases; unreliable information and its misuse.

There are three key elements in strategic management: excellence, innovation, and foresight (proactive organization). Considering that information management includes elements of organizational management, one can also speak of strategic information management. When the organization that performs strategic information management anticipates the realization of its vision, proactive decisions can be made in the face of any circumstances in the organization's environment. Although the implementation of an MIS is more popular in the business sector, it is just as relevant for the management of a university (Martínez, 2006).

In a university context, IT enable the learning-teaching process in a virtual environment; the optimization of all academic processes; research in all disciplines; the development of linkages with society, and the automation of all management processes to support decision making. IT is an essential element in the improvement of higher-education institutions (Lau & Yuen, 2014), and it affects both management and core functions such as teaching, research and knowledge management (Yassin, 2013).

A modern Ecuadorian University's commitment to the goals listed above is captured in the 2010 Organic Law of Higher Education, in section V that pertains to quality in education. Chapter 1 refers to the principle of quality as the constant and systematic search for excellence, pertinence, optimal production, knowledge transfer. Article 94 defines quality assessment as the process to determine an institution's or academic program's condition through the systematic gathering of quantitative and qualitative data that would enable the rendering of a judgment or diagnosis, analyzing its components, functions, and processes, so that the results can be used to reform and improve a study or academic program, or an institution. Quality assessment is a permanent process and presupposes continuous monitoring (LOES, 2010).

In the authors' view, university management involves four core modules:

1. **Academics:** The education, didactic and pedagogical model dedicated to the reaching of high standards of quality in higher education management. It particularly promotes scientific research, technological and business innovation in an integral process whereby knowledge is continually being constructed and transformed, and the student is responsible for his or her own learning
2. **Research:** It is the cornerstone of the entire training process of future professionals
3. **Linkages with society:** They are constantly being created through research, pre-professional practicums, and linkage projects with the community
4. **Management:** It is essential to guarantee the economic sustainability of the university and to support the uninterrupted development of its core activities

A university is an organization that functions as a system, where the total is greater than the sum of its parts. Information, then, must be understood as a means to reduce uncertainty when supporting decision-making. Information Systems must, present, therefore, an integrated view of the organization rather than being a fragmented collection of databases, unaware of the true institutional dynamic. In order for planning to be useful, it is not enough that they are well supported by facts; it is also necessary that they be in harmony with strategic objectives. Assisting in this process are strategic variables, indicators, and information systems as a way to overcome traditional approaches and to develop an organizational culture that facilitates the management of the university.

The university system in Ecuador has experienced in the latter years a very important evolution toward greater responsiveness to social demands and to the need to improve institutional quality. The UO has embarked on a journey to improve the quality of all its processes, whether strategic, core, or support, on three levels: institutional, organizational units, and individuals. The essential pillars of its quality management system are shown in summary form in Table 1. The priorities are as follows: institutional planning, processes, evaluation, and the MIS.

Table 1. Pillars of UO's Quality Management System

Planning	Management Information System	Evaluation
Institutional Development Strategic Plan (IDSP-2015-20) <i>Key Result Areas:</i> a) Faculty b) Teaching c) Research d) Linkages with society e) University management	Identification of the processes and activities in the organizational units a) Strategic b) Key c) Support	Institutional Evaluation Model <i>Criteria:</i> a) Organization b) Academics c) Research d) Linkages with society e) Resources and infrastructure f) Students
Institutional Annual Operating Plan (AOP) <i>Key Result Areas:</i> a) Faculty b) Teaching c) Research d) Linkages with society e) University management	MIS applied to university management (MIS) <i>Modules:</i> a) Academics b) Research c) Linkages with society d) Management	Academic Program Evaluation Model <i>Criteria:</i> a) Pertinence b) Curriculum c) Teaching d) Institutional environment e) Students
Institutional Units' Annual Operating Plans a) Academics b) Offices & Services	Strategic Plan Monitoring and Evaluation (SPME) System <i>Modules:</i> a) Records b) Monitoring c) Evaluation d) Help	Individual performance evaluation a) Teaching b) Research c) Management
Individual Work Plan a) Teaching b) Research c) Management	Institutional Evaluation Information System <i>Modules:</i> a) Evaluation management b) Information for evaluation	Improvement plans: Decision making a) Improvement plans: institutional, academic programs, individual b) Process optimization in the organization

Institutional Planning

The UO has adopted a management model geared toward development strategies, where a strategic direction predominates. It is based on the proposed University Development Pyramid (PEDI, 2016), where the key results areas, development restrictions, the institutional context and the organization's strategic direction are integrated. In order to formulate and execute the Institutional Development Strategic Plan 2015-2020, the university implemented a participatory process, which included the entire university. The cumulative experience in the execution of past plans, as well as the education policy recommendations from national and international organizations, were also taken into account. Strategic alignment became part of the model (Barra, 2015). The methodology steps that were taken in the strategic planning process involved IT, as it brings about significant change wherever it is implemented (Arvidson, 2014).

Processes

Processes bring together planning and evaluation with the criteria and indicators to consider when working with evaluation models. To develop the MIS it is necessary to have previously identified strategic, key and support processes. IT's incorporation into the institution's process execution is done based on corporate planning being aligned with institutional objectives and with effective support for these processes. The charting stage is essential to understand a process, develop the software (Magaña, Santana-Mancilla & Cazares, 2015), and to depict workflow and its participants in a structured way (Espinosa & López, 2012).

Evaluation

For some time now, the UO has been focusing on the evaluation of its activities, developing a culture of quality and accountability in the process. The environment's dynamics are such that they steer the UO toward a permanent evaluation of objectives and results, and the shift from internal to external evaluation of the institution; this includes institutional and academic program evaluation, and individual performance evaluation (Almuiñas & Galarza, 2013). To accomplish this, the UO has implemented a variety of evaluation systems by type of activity, closely linked to strategic and operating planning, and university process management.

Management Information System

Within the university context, the MIS supports the day-to-day execution of university processes and automates the most important university management activities, ultimately aiding decision-making. It's important that IT be used right across all processes in the institution, so that solutions will have a broad base throughout the organization (a single corporate database, a single email system, an institutional website, an intranet-based virtual learning environment), so as to avoid the duplication of effort and to achieve the greatest effectiveness in the use of resources.

Methods

To ensure agreement between the MIS and the UO's quality pillars, an original methodology was devised that consists of five phases and fifteen stages. The phases were: (1) Planning, (2) information analysis, (3) MIS design, (4) implementation, and (5) evaluation. The procedure described by Nolan (1991) for the inclusion of IT was used. Nolan and Gibson (1974) defined a six-stage model to analyze IT's evolution in organizations: (1) initiation (learning and automation of routine processes), (2) contagion (proliferation of applications), (3) control (reconstruction of data processing operations), (4) integration (integration of current systems), (5) data administration (information is considered a resource and applications start to become integrated, and (6) maturity (applications are fully integrated and reflect the organization's information flows).

This traditional model is mainly focused on the change in an organization's budget, so Paños (1999) simplified it into three stages: Data processing (to improve efficiency through process automation), management information systems (to improve effectiveness satisfying information needs), and strategic information systems (to improve an organization's competitiveness).

The proposed model (Table 2) for this research includes five phases and fifteen stages with their corresponding techniques and expected results. This model represents the authors' contribution to the Business Intelligence field. Several methodologies were examined for the development of the MIS that was used (Kendall & Kendall, 2011; Zhan et al, 2003 y Ng et al, 2011).

Table 2. Phases and stages of the UO's MIS

Phases	Stages	Techniques	Expected Results
Phase 1. Planning	Evaluation of institutional strategic planning	Document analysis	Evaluation of strategic planning quality and its relationship to IT services
	Definition of the work team		
	Analysis of the system's technical and economic feasibility		
Phase 2. Information Analysis	Examination of available information in the organization	Document analysis Interviews and surveys	Problem identification Definition and identification of useful information Proposed indicators
	Identification of the necessary information for the preparation of the MIS		
	Remaining information: reconciliation between available and necessary information		
Phase 3. MIS Design	Identification and evaluation of design alternatives	Document analysis Interviews and surveys Programming	Definition of MIS components Development of computer applications
	Identification of the organization's processes		
	Definition of MIS components		
	Software development and documentation		
	Implementation approval		

Phase 4. Implementation	Preparation of strategic plans for the implementation of computer applications	Document analysis	Computer application implementation
Phase 5. Evaluation	Evaluation of results	Interviews and surveys	Results evaluation Improvement plans for the MIS and its computer applications
	Review of MIS improvement alternatives		
	Software's use and maintenance		

The research began as an exploratory study, including a detailed literature review about information systems and their applications in Ecuador and the rest of the world. Within the UO's specific context, the dependent variable was defined as the MIS, and the independent variables were planning, institutional evaluation, and decision-making. Research began in 2012 with scattered applications; these were partially integrated based on operational needs. There was a need to move to the next stage, so the development of the MIS began in 2014. The completion of the work is expected to be in 2020. The organization is focused on the quality of data collection, and on sharing the results via scientific events, publishing of the results, and networking. Nevertheless, the main emphasis is on the application itself due to its important contribution to organizational improvement, benefitting operational and strategic decision making, as well as in the general management of the UO.

To better understand the drivers behind the specific MIS that was developed for the UO, here is a brief history of the institution. The UO was created by an Act of the Ecuadorian Congress on December 17, 2002. The UO is a private, self-financed, and intercultural higher-education institution. Its main management instrument is the Institutional Development Strategic Plan for 2015-2020, which defines the following key result areas: faculty, teaching, research, linkages with society, and university management. One of the strategic plan's core elements is the improvement of its management model; it therefore relies on the MIS as one of its essential components. The Strategic Plan, in turn, drives the annual operating plans, right up to the individual professor's work plan.

At the end of 2014, the UO's organizational chart defined twenty-three functional areas. The University Council is the maximum executive authority, and the President manages two main areas: (1) the Office of the Provost, which oversees the following academic programs: Social and Cultural Development, International Commerce and Finance, Graphic Design, Tourism, Business Administration, Computer Science, and Law; and (2) the office of the Executive Vice-President, which oversees all administrative departments. The faculty includes 38 professors, of which 27 are full time and 11 part time. 80% of the faculty have a graduate-level degree, including 5 with a doctoral degree.

Three questionnaires were used for the study. The first one was used to identify the characteristics and content that the MIS should have, given the UO's size and unique features. The second one allowed the researchers to know in more detail what information was available and what was required to reach the proposed goals. The

third one was used to determine the set of indicators that is more appropriate to carry out strategic and operating planning, institutional evaluation, and decision-making.

The three questionnaires were given to the leaders of the organization's 23 academic and administrative departments, including seven academic department directors. This represented the entire population of leaders. The questionnaires were given at the end of 2014, when the decision was made to transition from the system in use at the time, the Academic and Administrative Management System (AAMS), to the MIS. A detailed analysis of the institution's bylaws, strategic planning, evaluation models and other documents, was carried out. The respondents provided input as to the information that might be useful to provide through the use of IT. Common denominators were identified in the strategic information coming from academics, research, linkages with society and management.

The next step in the analysis was to build a process map for the UO. Strategic processes were defined: institutional planning, institutional ethics, and quality management. Core processes were identified, undergraduate and graduate teaching, research, and linkages with society. Finally, support process were also defined: resource management and infrastructure, information and communications technology, and library management. Activities to be performed were defined for each one of these, and flowcharts were developed for each one of the academic and administrative areas.

Having defined the needs, the main areas to be studied, processes and activities, a work team was put together with the necessary IT knowledge and awareness of its importance for improving the organization's quality standards. This team included a project director (the Executive Vice-President); two project managers, one of which was the Planning Director; and four systems analysts, including the IT department director. The team determined where the UO was at in its information needs through data collection and analysis methods, and, in the last five years, it analyzed the upgrading of the process-management IT infrastructure with the goal of improving institutional performance. Furthermore, the team also defined, in conjunction with the UO's administration, the features and contents of the MIS to effectively support planning evaluation, and decision-making.

To evaluate progress in the MIS implementation, a survey was done in May 2018 whereby all leaders were asked to assess the degree of use and implementation of the applications belonging to each one of the four modules in the system, on a scale of 1 to 5: 1 = this application is not being used at the UO; 2 = The use of this application is planned, but it hasn't been implemented yet; 3 = this application is in the process of being implemented; 4 = This application is implemented and it needs to be improved; 5 = This application is fully operational.

Results

The MIS (see Figure 1) consists of four main modules with their respective applications. It uses the client-server model and includes the UO's most important processes and their respective activities. It has full access to the internet and intranet. It is a single integrated system that provides valuable information for decision-making and for continuous quality and management results improvement. The MIS is a digital space that not only reports information, but it also allows users to share and to communicate with one another (Zhan et al, 2003). The MIS's features, which match closely the objectives it was meant to serve (Ng et al, 2011), are: (1) personalized modules, (2) centralized information, (3) user administration, (4) role and permissions administration, (5) online reports, (6) client-server structure, (7) continuous monitoring, and (8) software quality standards.



Fig. 1. Entry screen to the UO's MIS

The MIS, to support the Institutional Development Strategic Plan (IDSP, see Fig. 2), includes the following: the UO's mission, vision, shared values, the IDSP's creation methodology and tools, key result areas, strategic objectives, strategies and action plans, strategic objective matrix, programs, projects and activities, the set of indicators used to measure the UO's management, budget, and the monitoring and evaluation plan. To support the evaluation process for the fulfillment of objectives, the MIS includes the verification process for the partial and total accomplishment of the results for each one of the strategic elements, programs and projects.

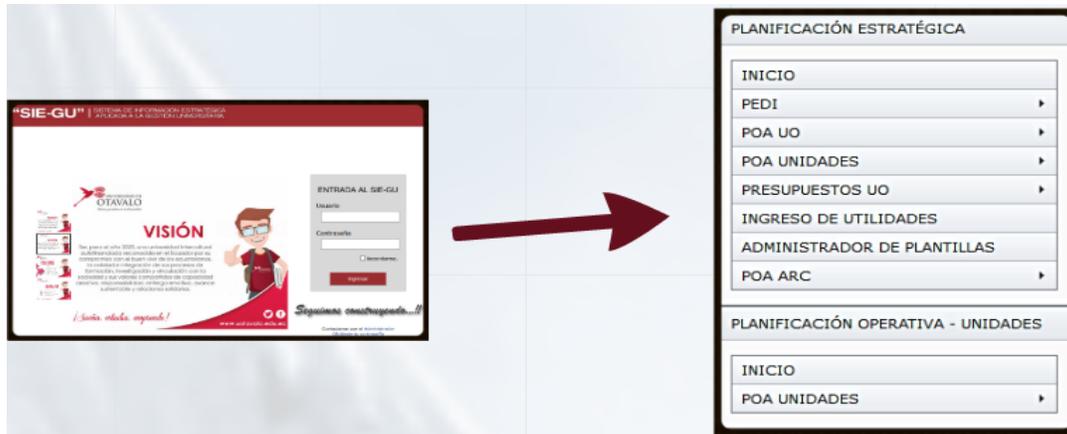


Fig. 2. Strategic and Operational Planning in the UO's MIS

To highlight the indicators' fulfillment level, the MIS uses a color-coded alert system (see Fig. 3) on a comprehensive dashboard. This is of great assistance to the UO's administration for results analysis and decision making related to the Annual Operating Plan and the evaluation model.

OBJETIVO ESTRATÉGICO						
FORTALECER LA COMPOSICIÓN Y PREPARACIÓN DEL CLAUSTRO DE PROFESORES.						
CÓD.	CRITERIOS DE MEDIDA					
91	1.01. % DE PROFESORES DE TIEMPO COMPLETO EN EL CLAUSTRO.					
GRADOS DE CONSECUCCIÓN PLANIFICADOS			GRADOS DE CONSECUCCIÓN EJECUTADOS			
AÑO 1	AÑO 2	AÑO 3	AÑO 4	AÑO 5	AÑO 6	
70.00	71.00	73.00	76.00	78.00	78.00	
						AÑO 1
						70.00
						71.00
						72.00
						N/A
						N/A
						N/A
92	1.02. % DE PROFESORES DE TIEMPO COMPLETO Y PARCIAL CON TÍTULOS DE CUARTO NIVEL.					
GRADOS DE CONSECUCCIÓN PLANIFICADOS			GRADOS DE CONSECUCCIÓN EJECUTADOS			
AÑO 1	AÑO 2	AÑO 3	AÑO 4	AÑO 5	AÑO 6	
70.00	75.00	100.00	100.00	100.00	100.00	
						AÑO 1
						73.00
						77.00
						81.00
						N/A
						N/A
						N/A
93	1.03 . % DE PROFESORES DE TIEMPO COMPLETO CON EL GRADO DE DOCTOR (PHD).					
GRADOS DE CONSECUCCIÓN PLANIFICADOS			GRADOS DE CONSECUCCIÓN EJECUTADOS			
AÑO 1	AÑO 2	AÑO 3	AÑO 4	AÑO 5	AÑO 6	
21.00	23.00	24.00	29.00	30.00	38.00	
						AÑO 1
						20.00
						16.00
						23.00
						N/A
						N/A
						N/A

Fig. 3. Sample indicators on the MIS' dashboard

The application that supports institutional evaluation includes two sections: information and management. In the first one, the information is loaded by criteria, sub-criteria and indicators set out in the model used by the Council on Higher-Education Evaluation, Accreditation and Quality Assurance (CEAACES). Each indicator is accompanied by supporting evidence documenting its percent fulfillment. As for the UO's management (see Fig. 4), the application shows at a glance the percent fulfillment for each of the indicators, sub-criteria and criteria according to the UO's

quality targets. This supports the daily, weekly, monthly and yearly tracking by the administration, as well as strategic and operational decision-making.

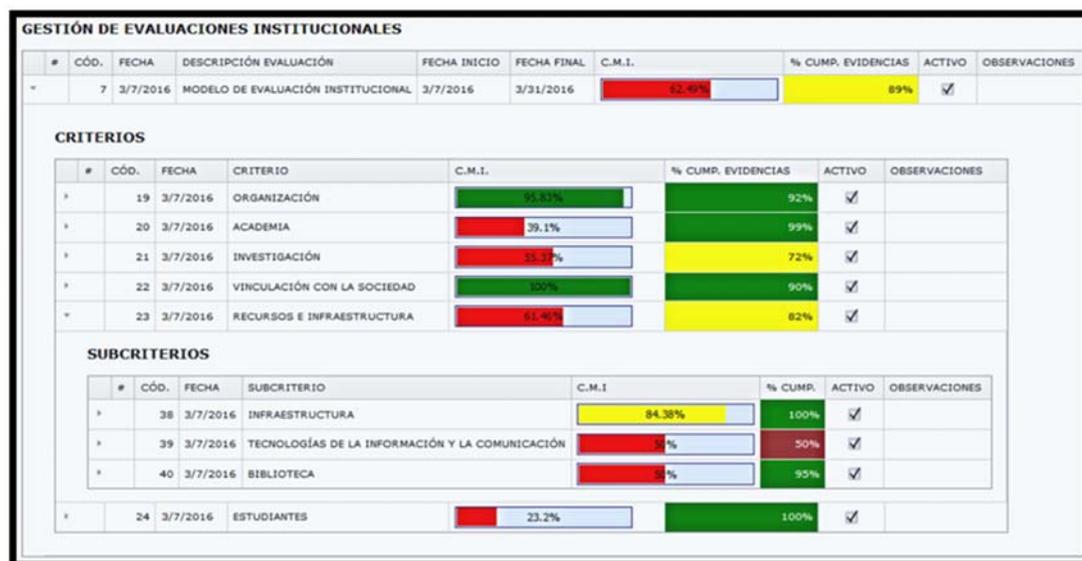


Fig. 4. Sample indicators on the MIS dashboard

The performance evaluation of part-time and full-time faculty is done via the MIS. Faculty do their own self-evaluation through the application, students evaluate their professors, professors are evaluated by their peers, and management evaluate the fulfillment of their direct reports' individual work plans. Finally, the overall evaluation is done through the system of all three areas: teaching, research, and management.

When analyzing and evaluating implementation progress with the applications in the MIS (see Table 3), we can see that all applications planned for the 2015-2020 period, except for the accounting and document management help desk applications, are fully functional. The remaining two are expected to be implemented in 2018-2020. As Fig. 5 indicates, this constitutes a progress rate of 90.4% (19 out of 21). Finally, an improvement and completion plan was prepared for the applications not yet implemented.

Table 3. Applications in the MIS

#	Applications for each module	2016	2017	2018-2020
	ACADEMICS			
1	Academic Management - AM	X		
2	Virtual Learning Environment - VLE	X		
3	Socioeconomic Card - SEC	X		
4	Digital Repository - DSPACE	X		
5	Syllabus Progress Tracking System - SPTS	X		
6	Validation System - VS	X		
7	Total Faculty Performance Evaluation System - FPES	X		
	RESEARCH			
8	Library Management System - LMS	X		

9	Research Project System - RPS	X		
LINKAGES WITH SOCIETY				
10	Psychological Test Administration System - PTAS	X		
11	Linkages Project System - LPS	X		
12	Scholarship System - SS	X		
13	Alumni System – UAS	X		
14	Free Legal Clinic System - FLCS	X		
MANAGEMENT				
15	Employee Records System - ERS		X	
16	File and Inventory System - FIS		X	
17	Accounting System - AS			X
18	Document Management System - Help Desk (DHD)			X
19	University Planning System(SPU)	X		
20	Internal Evaluation System - IES	X		
21	Driving School System - DSS	X		

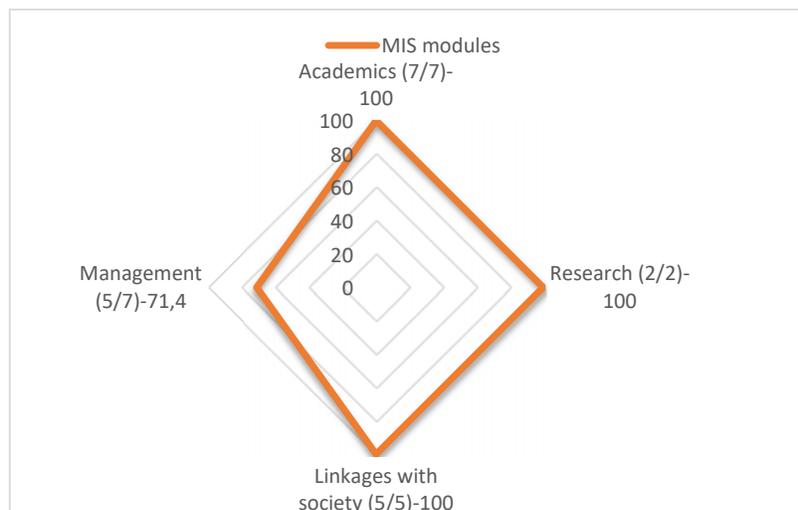


Fig. 5. Applications in the MIS implemented at the UO as of 2018

The main contributions brought forth by the creation of the MIS are the following:

- **A theoretical contribution:** A framework and architecture had to be produced that encompassed the UO's most important processes and their interrelationships
- **A methodological contribution:** A specific methodology, including the necessary stages, content, steps and structure, had to be derived to satisfy the unique requirements of the university
- **A practical contribution:** This resulted from the strategies and approach that were developed to carry out the ongoing consultation with the entire university community

Discussion

The MIS created and implemented at the university traces its roots to the Academic and Administrative Management System (AAMS), in use at the UO before 2016. The functional gaps in the AAMS made the present MIS essential to properly support operational, tactical and strategic decision-making, as well as operational and strategic planning, institutional self-evaluation, performance evaluation and other aspects of the UO's management.

The main contribution on the part of the present MIS is to provide a centralized platform for online access of information to assist in the management of the institution. Current and future threats to the UO make it imperative to firmly anchor a quality culture, required both by the challenges experienced by the university and by the higher-education regulatory bodies in Ecuador. Quality-oriented measures are being greatly facilitated by the functionality provided by the MIS.

The literature review did not uncover MIS implementations in university settings that were truly integrated. The MIS applications that were described were applications designed for specific functions, rather than covering the full breadth of the four core modules in university management in Ecuador: academics, research, linkages with society, and management.

The implementation of the MIS brought about a significant improvement in all university management functions through the automation of most processes and activities associated with institutional planning and evaluation. The MIS also greatly accelerated information processing and analysis necessary for decision-making.

Conclusions

The implementation of the applications included in the UO's MIS automate nearly all of the university's processes and activities. The MIS has 21 applications grouped into four modules, out of which 19 are fully functional, resulting in a 90.4% progress rate. The document management application is under development, and the accounting application will be next. All the applications produce reports that feed into the planning and institutional evaluation indicators, the overall dashboard, and the performance evaluation of full-time and part-time faculty. Thus, the MIS assists in strategic, tactical and operational decision making in all academic and administrative areas of university management.

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