

Visualization of Data for Decision Making in a University

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Keywords: Data Visualization, Automated Systems, Interactive Graphics, Information Disclosure.

Abstract: The management of a large amount of information generated from different media is chaotic when there is no technological tool that standardizes and organizes the data provided by different users. The present work shows a web system that allows to store in a database the information of the research products that each year the researchers of the institution perform, thus simplifying and improving information management, in order to support the making decision based in the follow-up of the projects and activities of investigation of the researchers. The system records and displays the changes made by researchers and allows generating the visualization of data, providing an easier and faster way to see and understand trends, outliers and patterns in the data which is essential for analyzing information and making decisions based on the data.

1 INTRODUCTION

Automating tasks in organizations with the implementation of information systems generates benefits such as creating sustainable competitive advantages, improving the quality of service, increasing sales, reducing costs, making wise decisions, or allocating resources appropriately (Sánchez & Álvarez, 1999). But information systems also generate large volumes of data that only acquire value when they are analyzed and generate some benefit for the organization (Vázquez, 2019). Currently in various industries, organizations handle large volumes of data (Patil & Mason, 2015). The analysis and treatment of the data is carried out with the objective of providing those involved with the necessary information to make optimal decisions (Sharda, Denle & Turban, 2013).

Due to these large volumes of data, information systems are used that Andreu, Ricart & Valor (1996) define as "a formal set of processes that operating on a data collection structured according to the needs of a company collects, elaborates, and distributes part of the information necessary for the operation of that company and for the corresponding management and control activities, relying at least in part on the decision-making necessary to perform the functions and business processes of the company in accordance with its strategy". For their part, K and J Laudon

(1996) classified the information systems according to their usefulness at the levels of the business organization (operational, knowledge, administrative and strategic level), see table 1.

Table 1: Classification of information systems.

Operations Processing System (OPS)	Routine day-to-day operations required for business management (operational level)
Knowledge Work System (KWS)	In charge of contributing to the agents that handle information in the creation of new knowledge in the company (knowledge level)
Office Automation Systems (OAS)	In charge of increasing the productivity of employees at low hierarchical levels (knowledge level)
Administration Information System (AIS)	Employees in the planning, control and decision-making process at medium and high hierarchical levels (administrative level)
Decision Support Systems (DSS)	Interactive systems that help users make decisions using different data and models for solving middle management problems (strategic level).
Management Support System (MSS)	SI designed to make strategic decisions using advanced graphics and communications (strategic level)

This article focuses on the implementation of a Management Information System (MIS). Information

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system used for planning, control and decision making on the graphs and reports of the publications generated by the researchers of the Autonomous Popular University of the State of Puebla (UPAEP) and managed by the Research Directorate.

2 DELIMITATION OF THE PROBLEM

Managing all the information, product of research and dissemination of researchers in each area at the Autonomous Popular University of the State of Puebla (UPAEP) is a complex task. For this reason, systems were developed that automated repetitive tasks. The main objective of these systems is to help manage the information generated by the storage of the results by the users of the system and present it so that those in charge can focus on analyzing the information and making the pertinent decisions.

The UPAEP is interested in registering all the knowledge generated by its researchers. Therefore, UPAEP has an area dedicated exclusively to promoting and supporting teachers and students interested in developing research projects and activities. The Research Directorate created five calls: (1) Categorization, (2) Incentive to Teaching Research, (3) Editorial Fund, (4) Research Fund and (5) Support to congresses and publications in journals, to provide support to researchers for their efforts in generating knowledge.

The annually available call, called "Teaching Research Incentive", aims to grant an economic incentive corresponding to the System of Categorization and Teaching Research to professors and administrators who validate their research products. The Research Directorate oversees collecting the research products that the researchers generated during the last year. These research products (table 2) include: publications of articles in national or international journals, translations, chapters or editions of books, congress organizations, participation in projects financed by agencies outside UPAEP, prizes awarded for research, patents, utility models or plant breeders' rights, councils or appointments in which professors or administrators attached to UPAEP from any of the 14 departments:

1. Administrative
2. Research Directorate
3. Arts and Humanities
4. Centre for Research and Economic Intelligence (Postgraduate)
5. Biological Sciences

6. Health Sciences
7. Social Sciences
8. Business School
9. Engineering
10. Humanities
11. Arts and Humanities (Postgraduate)
12. Health Sciences (Postgraduate)
13. Engineering and Business (Postgraduate)
14. Study of Language and Culture (DELC)

Table 2: Order of the categories.

Categories	
Books	Publication of books
	Chapters of books
	Book Publishing
	Translation of books
Thesis direction	Master
	Doctorate
Articles in magazines	International Arbitration
	National Arbitrator
Congress	Presentations at congresses
	Organization of congresses
Intellectual Property	Patents
	Utility Models
	Plant Breeders' Rights
Project Evaluator	
Editorial Board	
External projects	
Citation in magazines	
Research Awards	

The Research Directorate organized and stored the information and then the Organizational Development and Evaluation Directorate of UPAEP will validate the research products that meet the requirements of the call and then a score was assigned to each evidence. When the call was closed, the Research Directorate developed spreadsheet reports on the results of the call manually.

There were three main problems in the process: (1) The lack of homologation of the information, due to the fact that different devices were received (in USB or CD/DVD, email or paper) and in different formats (PDF, word processors, spreadsheets, images, slide presentations, among others). (2) The amount of time invested in receiving the information, as it was necessary that one person devote himself completely to this task for approximately one month. During this month the person had to be available 8 hours a day or 160-man-hours a month from Monday to Friday exclusively to answer calls or emails and receive the researchers who attended the physical

offices to deliver their research products. (3) The personnel necessary to organize the information, a process in which up to 5 people were designated and an average of 800-man-hours per annual call.

Although the Research Directorate invested between 1000 and 1500 man hours for each call launched annually, when a researcher had doubts about his evaluation process, he went to the physical offices of the Research Directorate to request his personal report, which the Research Directorate carried out manually, increasing the man hours and the personnel used in each call.

3 DESIGN AND DEVELOPMENT

Based on the Administration Information System (AIS), the UPAEP Publications Management System for Researchers (SAPI) was developed. This system redesigned the communication process (figure 1) between the different types of users and their responsibilities (table 3).

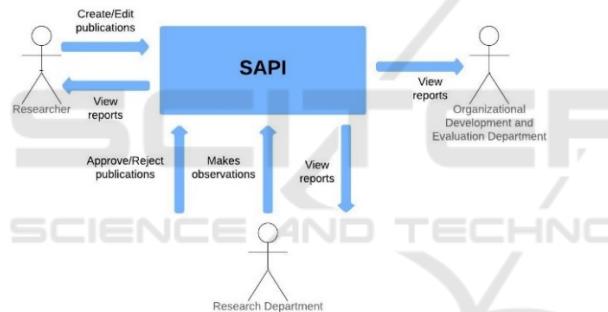


Figure 1: Communication process.

Table 3: Types of users.

Type of user	Actions
Researcher	Captures, modifies, eliminates and visualizes own information in the system, reviews comments and status of your research products, generates own reports.
Research Directorate	Query, assign scores and generate general reports.
Organizational Development and Evaluation Division	Consult general reports.

The system uses a website developed in PHP as an interface to collect and store information from UPAEP researchers' publications (figure 2) in a

database developed in MySQL (figure 3) that has 21 tables in total, each table belongs to a category of the call "Incentive to Teaching Research". There is also a table to store the academic and professional information of each researcher. Finally, another table was assigned to identify in which call each publication was approved.

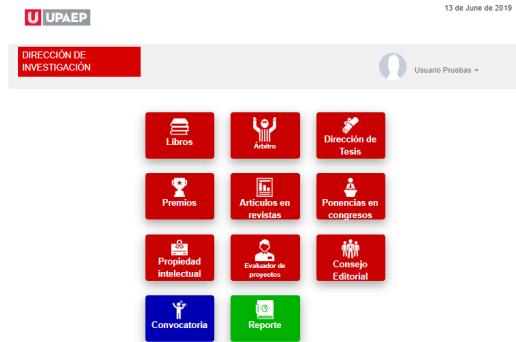


Figure 2: Main system interface.

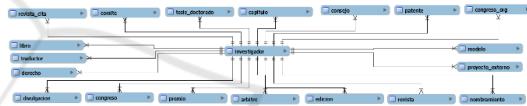


Figure 3: Database.

After researchers capture their information into the system, it is sorted, categorized, and processed for visualization by the Research Directorate through reports and interactive graphs. For its part, the Research Directorate reviews and assigns a score to each publication depending on the category and level of complexity. At the end of the review, the graphs and reports are analyzed, and the advances made in the University during the last year are presented to the academic vice rectorate. From the presentation of the data provided by the system, the Direction of Research carries out different actions such as:

- Allocation of bonuses depending on performance and research production
- Detection of growth or decrease by department, category
- Analysis of the profile of current UPAEP researchers
- Selection and implementation of performance strategies
- Analysis of the scope of short- and long-term objectives
- Design of action plans in accordance with the available economic resources of the Research Directorate.

- Changes in categories according to historical trends of previous years
- Early detection of possible technical problems in the platform based on the history of the flow of users

4 RESULTS

For a researcher to capture a publication in the system there is a different form for each category (figure 4), but in general all the forms have fields to fill in with all the information of the researcher's publication.

Libros

Si es erróneo un campo agregado y este está bloqueado, elimine el registro y cree uno nuevo.

Todos los autores:	<input type="text"/>
Autores UPAEP:	<input type="text"/> Únicamente autores UPAEP
Título del libro:	<input type="text"/>
Compiladores (todos):	<input type="text"/> En caso de que el libro sea escrito por un solo autor, el autor es el compilador
Compiladores UPAEP:	<input type="text"/> En caso de que el libro sea escrito por un solo autor, el autor es el compilador
Editorial:	<input type="text"/>
País:	<input type="text"/>
ISBN:	<input type="text"/>
Mes:	<input type="text"/>
Año:	<input type="text"/>
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Figure 4: Information capture interface.

As an identifier of the review process in which each publication is found, a color code was defined that allows researchers to quickly identify the status of each publication (table 4) when they enter their profile to consult which research products from which they captured were accepted or not and the comments of these.

Table 4: Colors assigned to the statuses that a publication can have during the validation process.

Color	Status
Grey	Research products that have not been reviewed
Green	Research products that were reviewed and approved
Red	Research products which were reviewed and rejected
Orange	Research products that were reviewed and need modification by Investigators

The main page, to access the research products captured by researchers ordered by categories, followed by users who have access to the system

ordered alphabetically, then reports, statistics, calls and, finally, access to the profile as a researcher, this option is only available if the user is registered in the system as a researcher (figure 5).



Figure 5: Main menu of the Research Directorate.

The Research Directorate can evaluate (comment, approve or reject) a publication of a researcher in an interface that shows all the necessary fields of publication with direct access to download the file of evidence that the researchers attached (figure 6).

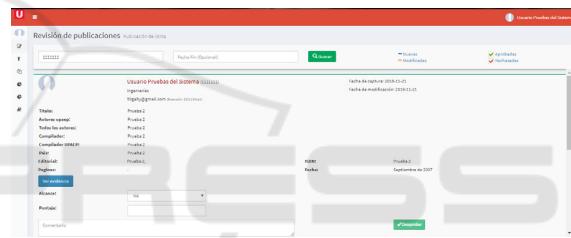


Figure 6: View in which an administrator comments on, rejects, or approves a publication.

4.1 Graphics

The system generates a considerable number of interactive graphics, fields are removed or added with a single click on any graph, which are used to see more quickly and easily the data recorded in each of the calls. The graphs are generated by the system automatically with the information that the researchers captured during the call. These were designed according to the needs of the Research Directorate who decided that they needed to be able to see one or more calls, categories or departments in the same graph and that they could be easily added or removed data. Graphs are generated on publications that were approved or rejected during the calls; a bar graph shows the general quantity of approved and rejected publications per call (Figure 7); another graph shows only approved publications (Figure 8), and another graph shows only rejected publications (Figure 9). These graphs are used to compare the total number of publications in each call, with this comparison is determined the scope that has been

achieved against the investment made in research, concluding whether the objectives of the Research Directorate have been achieved.



Figure 7: Publications approved and rejected by call.



Figure 8: Graphic of publications approved by call.



Figure 9: Graphic of publications rejected by call.

It is important to know the number of publications generated by each department of the University and validate whether the support provided is having the expected results. For this reason, a pie chart was chosen from the total number of publications in which a specific department can be selected to visualize the information of this department only (figure 10).



Figure 10: Graphic of approved publications by department.

In addition to knowing which department is more productive, it is required to know the category of publications that researchers are generating, which is why the system generates a series of line graphs of the total number of publications approved in each call per department (figure 11). A line graph of all departments can be generated to compare the number of publications per call (figure 12).

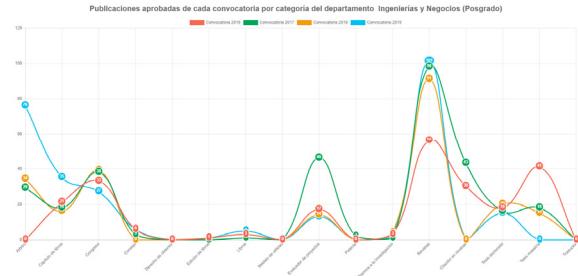


Figure 11: Graphic of approved publications by call, by category.

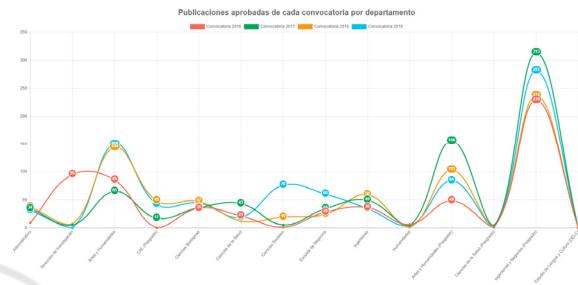


Figure 12: Graphic of approved publications for each call by department.

Another relevant aspect is the number of points obtained by department since each category has a different score, so the system generates a bar graph of the total score obtained by department (figure 13) and another linear graph of how the score was assigned by category (figure 14) and a line graph of each of the 14 departments, which shows the detail of how each department's score was assigned by each category (figure 15).



Figure 13: Graphic of the score obtained per call.

Another requirement fulfilled by the system was to note the categories in which researchers are generating the most publications. Therefore, the system generates an interactive pie chart of the total number of approved publications by category for each call (Figure 16). Another linear graph shows all the publications by category for each call allowing to compare the behavior of the researchers' contributions (figure 17).

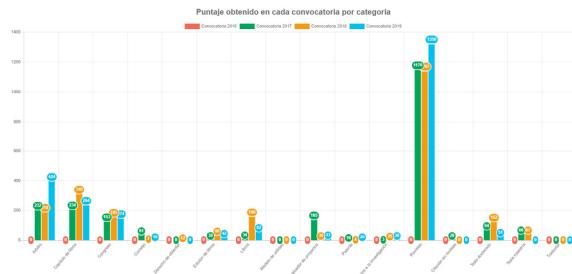


Figure 14: Graphic of the score obtained in each call for proposals by category.

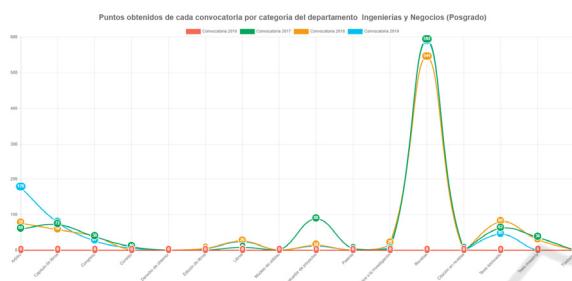


Figure 15: Graphic of the score assigned in each call by category and department.



Figure 16: Graphic of publications approved by category during the 2019 call for proposals.

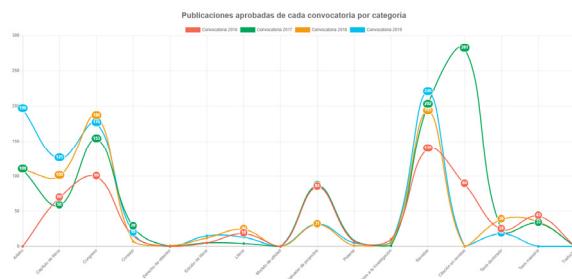


Figure 17: Graphic of publications approved for each call by category.

A general vertical bar graph of all the researchers and the score assigned during the calls is shown

(image 18). This graph is extremely important for the Direction and Research to analyze the profile of the researchers, and if the production level is low, it is investigated to determine the causes and strategies are generated to increase the levels of performance or otherwise encourage them to carry out the process of affiliation to the National System of Researchers (SNI).

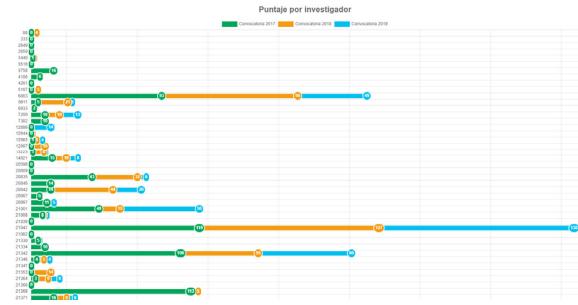


Figure 18: General graphic of the score obtained by each researcher.

In order to maintain the integrity of the system, a graph was developed that shows the use of the platform during the information capture period (figure 19), helping to develop strategies that allow for maintaining an efficient service for researchers.



Figure 19: Graphic of the flow of information captured by researchers during the call 2019.

4.2 Reports

The system allows you to generate different reports and download them in spreadsheets. Each report has different filters for combined searches. A report is shown by researcher and contains basic information about the researcher, the number of approved publications by category and the total number of points that were assigned to each publication (figure 20). The system also generates this same report, but from publications that were not approved to the researcher (figure 21).

Another report shows by department the approved publications and the score assigned to each one.

A report is generated by category of the publications that were approved where the information and evidence (archives) of all the publications that were captured is visualized in detail, organized by category (figure 23).

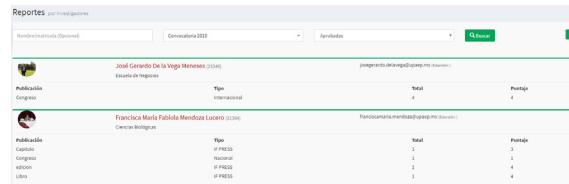


Figure 20: Report of the general summary of approved publications by category of each researcher.

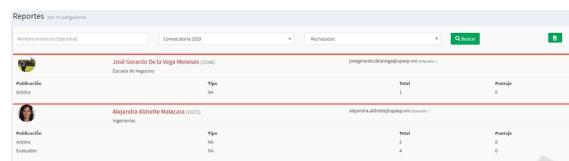


Figure 21: General summary report of rejected publications by category.

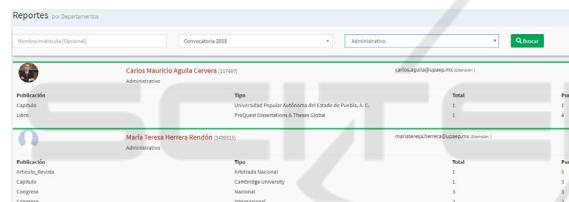


Figure 22: General summary report of approved publications by department.



Figure 23: Detailed report of approved publications by category.

5 CONCLUSIONS

The visualization of the data with diagrams and interactive graphs helped to process the information in an easier way for the end user, among the most important findings that were obtained with this system are: Finding patterns and some ambiguities that the evaluation instrument had regarding the categories into which the call was divided “Incentive to teaching research, this allowed reducing the

number of categories and defining a new score for each one of them. It was also possible to find out more easily and quickly which departments generate more research, which researcher and which type of contribution is having more participation, so that it can be determined which researchers should be followed up so that they can be proposed to carry out the process to belong to the National System of Researchers (SNI). In general, the final user of this system can provide reports on how the research is growing in the institution and how the budget allocated to the research is being distributed, adding value to identify that improvements are needed, establish which factors influence the participation of researchers, help to understand which publications should be placed in which category and predict the volume of publications to make a better budget for future calls. Another important aspect that could be detected thanks to the graphs was an important peak of information capture during specific dates of the opening of the call, if these situations persist they could compromise the system, therefore, it is necessary to generate strategies or a plan of action before possible eventualities related to this topic.

6 FUTURE WORK

The SAPI system has a great potential, it is planned to generate other interactive graphs and diagrams to complement what has been seen so far in the system. It is also planned to develop systems that automate the other calls that the Research Department has, which are: (1) Categorization, (3) Editorial Fund, (4) Research Fund and (5) Support to conferences and publications in journals, all of this will allow more efficient current return processes, since a system that centralizes the information allows a better management of the data, saves time in the generation of reports or statistics instantly, provides clearer and more organized information. In addition, due to the growth in the number of publications entered into the system and the incorporation of new researchers, a plan is being created to capture information on the platform by department, maintaining the regularity, reliability and efficiency of the service to researchers.

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