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Cluster analysis in Higher Education Institutions' knowledge identification and production processes

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Abstract

The objective of this study is to describe the processes of identification and creation of knowledge in higher education institutions (HEI). The sample is composed of 7 universities in the city of Barranquila in Colombia, and is non-probabilistic. For this purpose, a survey was used to collect data from the directors and vice-rectors of research of the research departments. For its part, the research methodology is framed in the tools of cluster analysis and principal component analysis. The established approach made it possible to demonstrate that universities have two characteristics for identifying and creating knowledge in HEIs: community learning and individual learning.

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1. Introduction

Higher Education Institutions (HEI) by nature are generators of knowledge through research, these allow the creation of new explicit learning in book chapters, scientific articles, essays and degree works that enhance the teaching function through the teaching and learning process with students in classrooms [1, 2].

Research is the substantive function of HEIs that generates knowledge for the economic development of a country, however, these do not have defined processes of identification and creation of knowledge that allow generating scientific production of new knowledge through research exercises developed by researchers, and it is essential for generational replacement, another obstacle that the research departments have is that teachers do not want to share their knowledge [3].

The study conducted by Rueda-Barrios and Rodenes-Adam [4] identified that teachers and researchers do not receive economic incentives for the publication of scientific articles, thus minimizing the increase in scientific production. On the other hand, in Mexico, the Technological University of Jalisco (UTJ) identified shortcomings, such as weaknesses in the lines of research, due to the low participation of teachers in publishing articles and high impact projects with industries, in addition, there was no culture of creating knowledge, in order to be more competitive, they decided to implement management strategies, in order to train researchers in applied areas and technological development [5]. On the other hand, the study conducted by Zabaleta et al. [6], in a Colombian Caribbean university, concluded that there is a lack of a holistic and long-term perspective in knowledge management. The results showed that the policies for the dissemination of knowledge are not adequate, as well as the formal learning schemes for sharing, organizing, and implementing organizational values. The above shortcomings are overcome through a knowledge-centered culture, where the identification processes allow prioritizing critical learning and ensuring that they are continuously developed in the creation processes and take relevance in the substantive functions of HEIs [1, 7, 8, 9, 10]. This research seeks to answer the following question: How are the processes of identification and creation of knowledge related in Higher Education Institutions (HEIs)?

2. Framework

The identification processes in the research departments make it possible to visualize the existing critical knowledge gaps, as well as the sources from which they come, to which line of research they belong, to which area they belong, and the different tools of reciprocity and rules constituted in the HEIs, to carry out the process it is important to analyze the indicators of internal sources and external sources [1, 7, 8].

The processes of knowledge creation allow the development of new skills, abilities, scientific products, book chapters, improved procedures, and more effective ideas based on the interaction of knowledge identified in internal and external sources that interact with each other. They also include all the administrative activities employing which those competencies are acquired that organizations do not have or create those that do not yet exist within HEIs [7].

3. Methods

The methodological approach of the present research is composed of two stages: Principal Component Analysis (PCA) and k-means cluster analysis [18]. The objective of the first stage is to understand the relationship between variables and the relative contribution of information to a principal component (axis in the graph). The objective of the second stage is to create profiles (groups) for the creation and identification of knowledge.

For the development of the study, a Likert scale questionnaire was applied and responses were collected through surveys. The information collection process consisted of sending the questionnaire to the universities in the study, subsequently, the responses stored by the repository are structured and analyzed through a basic statistical analysis, additionally, all the initial observations were taken into account for the analysis of the results.

Finally, the execution of the research is non-experimental, as suggested by several works in the literature [13, 14, 15, 16, 17]. It should be noted that the questionnaire was evaluated and its result for Cronbach's alpha coefficient was 0.838, with which it can be concluded that the instrument is reliable. Finally, information related to the use of ICT tools was used for the development of this research (see Table 1).

Table 1: Variables of the study

Dimensions	Indicators	Item	Affirmations
Identification processes	Internal Sources	1	Expert directories are effective in finding the best researchers.
		2	Knowledge maps locate where knowledge is located.
		3	Knowledge topographies allow the identification of researchers' skills.
		4	Knowledge asset maps are stored in technological tools.
		5	Information and Communication Technologies (ICT) visualize knowledge assets geographically.
		6	Knowledge source maps identify which researcher belongs to a research group.
		7	Research departments identify the level of experience of researchers.
		8	Research departments have tools to identify the location of knowledge.
	External Sources	9	Networks of experts are used to identify the knowledge that is needed.
		10	Cooperation networks enable joint projects with other universities.
		11	Search engines are identified as a support for research.
Creation process	Individual Learning	12	Research groups have favorable spaces where they stimulate researchers.
		13	The developed creativity of the researchers helps to create new inventions.
		14	The main causes that originate problems in a specific situation are identified.
		15	The problems that arise are solved by the researchers.
	Collective Learning	16	Interaction is fundamental for the development of research projects.
		17	The communication of experiences has a positive impact on the construction of new projects.
		18	The transparency of knowledge allows the execution of new research projects.
		19	Researchers' experiences are integrated into new projects.

Finally, the research population is made up of 7 universities in the city of Barranquilla in Colombia: Universidad Simón Bolívar (USB), Universidad Atlántico (UA), Universidad de la Costa (CUC), Universidad Metropolitana (UM), Corporación Universitaria Rafael Nuñez (CURN), Corporación Universitaria Latinoamericana (CUL) and Universidad del Norte (UN).

4. Results

4.1. Principal Component Analysis

Figure 1 shows the graphical representation of the PCA in two dimensions. It is important to note that the growth of the variables is indicated by their direction. In addition, the PCA accumulates 61.2% of variability in the first two main components.

Now, the first component is called investigative skills because the greatest amount of information is generated by variables 1, 3 and 13, which are related to the skills of an investigator. On the other hand, the second component takes more information from the variables of interaction and communication among researchers, these variables are in the collective learning indicators.

Fig. 1 shows the difference between Corporación Universitaria Rafael Nuñez (CURN) and the other universities. CURN has a high result in items 4, 15, 2, 2, 1,3 12, 14, 13 11, 8, and 5m, on the other hand, the rest of the universities have a high level in items 6, 9, 17, 16, 18, 19 and 10.
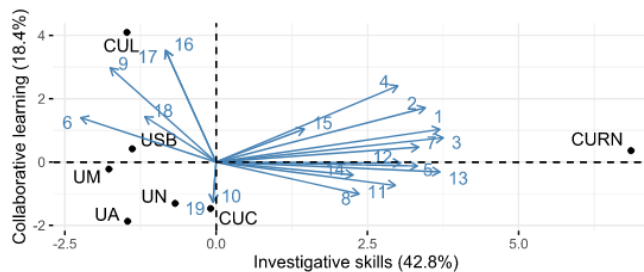

Fig. 1: Graphic representation of the PCA

4.1. Cluster analysis

Considering the previous stage, it is possible to see a difference between the universities that divides them into two groups. The k-means algorithm for group analysis yielded a Silhouette value of around 0.45 for two groups. Fig. 3 shows the characterization of the groups through the average of the variables.
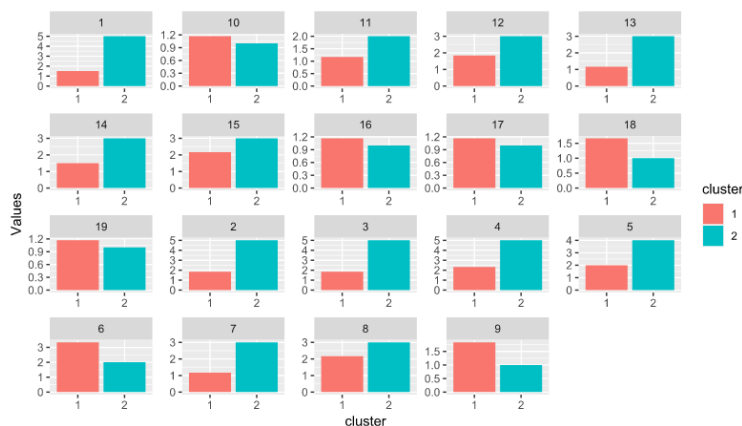

Fig. 2: Characterization of the groups

According to the cluster and PCA analysis, it can be observed that the first cluster is formed by the universities CUL, USB, UM, UA, UN, and CUC, this can be affirmed because these universities are on the left side of the PCA graph and additionally, the variables that grow in this direction of the graph correspond to the variables presented in the group characterization of Fig. 2. On the other hand, the second cluster is confirmed by the CURN university because the variables that grow towards the right side of Fig. 1 point to the CURN university and it is in agreement with what is presented in Fig. 2.

5. Discussion

In this order of ideas, the value proposition is to propose a tool for the characterization of universities and their situation with the generation of knowledge, so that they can make decisions that seek to improve or maintain this situation.

Several authors stated that knowledge in Higher Education Institutions is created by means of two dimensions, individual learning and collective learning [7, 11, 12], however, in the cluster analysis, it is evidenced that expert directories, knowledge topographies and creativity are investigative skills that members of research groups should have. The results also affirm the findings of Probst, Gilbert, et al. [7], Kettunen, P., Järvinen, J., Mikkonen, T. et al. [11] and Nisula, A. M., Blomqvist, K., Bergman, J. P., and Yrjölä, S. [12] that interaction and communication among researchers is a fundamental activity that should be developed in research departments to ensure collective learning.

6. Conclusion

This research presented a methodology composed of two tools: Principal Component Analysis and cluster analysis. The results of the research show two groups for the process of identification and creation of knowledge in Higher Education Institutions. The first cluster is characterized by having a high level in the indicators of collective learning and external sources, which highlights the importance of the execution of research in cooperation with external research groups. On the other hand, the second cluster is characterized by having a high level in the variables of individual learning and internal sources, which indicates the importance of strengthening its own research muscle. Now, this research highlights that the knowledge identified allows prioritizing critical learning in

HEIs that are the fundamental input for the solution of the different problems posed by researchers for the creation of knowledge.

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