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Presentation of the content

In the first article we present *Clustering in data mining: CJ and K-Medias applied to an opinion survey on bullying at the UTNA,* by MEDINA, Gricelda, LUNA, Francisco, TAVAREZ, Felipe and MARTÍNEZ, Rocío, in the next article we present *Labor market of the agroindustrial engineer of the BUAP and professional competences of the TSU in food processes of the UTP,* by MANJARREZ, Juanm & BERNAL, Héctor, with adscription in the Universidad Tecnológica de Puebla and Benemérita Universidad Autónoma de Puebla, in the next article we present *Determination of critical success factors for just-in-time implementation: factor analysis,* by RIVERA, Denisse, RIVERA, Lizeth, HOLTZHEIMER, Angeles and CHAVEZ, Lorena, in the next article we present *Identification of the level of industrial automation in the productive environment of the Universidad Tecnológica Fidel Velázquez: methodology and results*, by HERNÁNDEZ, Leticia, HERNÁNDEZ, Carlos, PÉREZ, Liliana and CARRILLO, Oscar, with adscription in the Universidad Tecnológica Fidel Velázquez.

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Clustering in data mining: CJ and K-Medias applied to an opinion survey on bullying at the UTNA

Clusterización en minería de datos: CJ y K-Medias aplicados a una encuesta de opinión sobre acoso escolar en la UTNA

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Abstract

In this work we applied unsupervised learning methods, to analyze the results of an opinion survey about bullying in La Universidad Tecnológica del Norte de Aguascalientes (UTNA). This study was applied to 131 students in the career of Communication Technologies at the University. We found the formation of 2 groups with different perceptions about bullying. In the first group of students they believe that bullying is mainly generated because they have family problems, and the other group, believes that bullying originates in the street, as result of, they come together with people who have a negative behavior. The objective of this study, is the use of unsupervised learning methods, applied to data analysis, specifically for this study, data from a survey on bullying perception. The methodology used to develop this study icluded, first the survey design on bullying, consulting many sources dedicates specifically on the bullying topic. After that, the data were introduced in the package data mining platform developed by R program, called R-Comander, and once the data was processed by the tool we proceeded to analyze the results.

Resumen

En este trabajo se aplican métodos de aprendizaje no supervisado de minería de datos, para analizar los resultados de una encuesta de opinión sobre el acoso escolar, en la Universidad Tecnológica del Norte de Aguascalientes (UTNA). El estudio fue aplicado a 131 estudiantes en la carrera de Tecnologías de la Información y la Comunicación. En base a los resultados obtenidos, se descubrió la formación de 2 grupos con diferentes percepciones sobre el acoso escolar. Un grupo de alumnos consideran que el acoso escolar se genera principalmente porque tienen problemas en la familia, y el otro grupo, cree que la intimidación se origina en la calle, por juntarse con amigos que tienen un comportamiento negativo. El objetivo del estudio es el uso, de métodos de aprendizaje supervisado aplicados al análisis descriptivo de datos, específicamente para este caso de estudio, los datos de una encuesta sobre percepción del acoso escolar. La metodología empleada para el desarrollo de este estudio incluyó primeramente el diseño de la encuesta, resultado de la consulta de diversas fuentes de décadas al tema del acoso escolar. Después, se ingresaron los datos de la encuesta, en el paquete desarrollado por la plataforma del programa R, llamado R-Comander, y una vez procesados los datos por esta herramienta se procedió al análisis de los resultados.

Data mining, KDD, Hierarchical clustering, K-medias, Bullying

Minería de datos, KDD, Clusterización jerárquica (CJ), K-medias, acoso escolar

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Introduction

At present there is a growing need to generate new theories and computational tools that help to extract useful information and knowledge from the large volumes of existing data, due to the constant use of technological advances in the management and generation of information. These theories and tools are topics concerning the process of knowledge discovery in databases (KDD, Knowledge Discovery in Databases), a term coined for the first time in the first KDD workshop in 1989 (Hand 01, Jiawei 06) and involving since the understanding of the application domain, going through data cleaning and knowledge extraction, to the use and application of that acquired knowledge. Data mining is one of the main stages of this process (KDD) Fig1, in which mathematical, statistical, or algorithmic methods are applied to the data, with the aim of discovering patterns and information hidden in them. This has earned data mining the attention of industry and society, due to the wide range of methods and techniques it offers for this purpose. The information and knowledge or patterns acquired through the data mining process have been used in multiple applications ranging from market analysis (customer segmentation, sales forecasting, risk analysis), fraud detection (credit cards). credit, telephone services, tax payments etc.), customer retention (study of consumption habits), to the exploration of science and medicine (Valenga 07, La Red 14, Jiawei 06) where in genetics, by analyzing changes in DNA sequences, it has been possible to determine the risk of developing diseases such as cancer, which has helped to improve the diagnosis, prevention and treatment of this type of disease (Perez 08).

This document is divided into 6 sections that contain the following: The first section talks about the results found in the application of the national survey on exclusion, intolerance and violence in upper secondary schools in Mexico. Section 2 contains a general description of the meaning of data mining and its classification, based on the type of tasks it handles. The third section describes the methodology that was used for the development of this study, detailing each technique used. In section 4 are the results obtained from the application of the survey and processed by the R-Comander program. Similar works found in the bibliography are mentioned in section 5, and finally in section 6 the final conclusions of the project are defined.
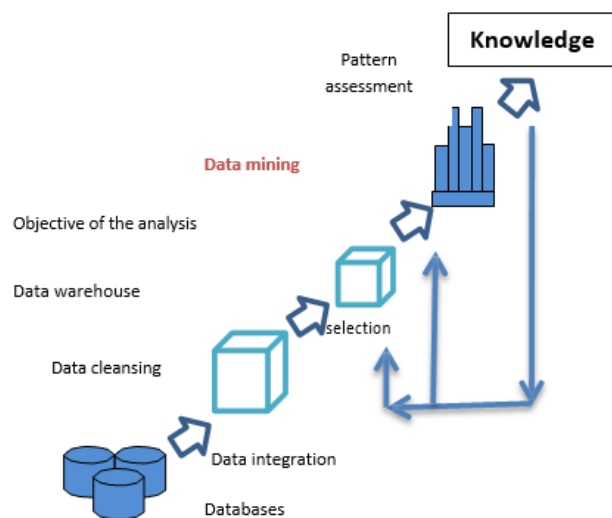
Figure 1 KDD process
Source: (Fayyad 96)

Bullying

Last year the Third National Survey on Exclusion, Intolerance and Violence in Higher Secondary Education Schools was applied by the Educational System of Mexico.

The survey was carried out with a probability sampling in 150 higher education schools, to obtain a sample size of 1,500 students.

The survey addressed issues related to interpersonal relationships in the space of the school community and provides a brief description of the social relationships between classmates, and of events that show signs of aggression or violence in these social relationships.

The data obtained allowed to establish the presence of psychological violence and situations of physical or verbal violence, to students at school, in 72% of the men and 65% of the women surveyed.

Although most of the reported cases were sporadic and only part of the students, they reported acts of violence that occur on several occasions. There are indications that students who had recurrent violence registered an increase in absenteeism, higher than 30% compared to students who have not suffered. Furthermore, 30.3% of the students surveyed do not consider school as a safe place.

That is why we consider bullying as an especially important issue in the educational field and that requires analysis tools that help us detect signs of violence in institutions, to implement actions that help us reduce acts and the consequences of these on students at any educational level.

Data mining

The purpose of applying mining techniques to data is to generally seek two types of tasks or objectives:

The description or prediction and each of these tasks are described below: (La Red 14, Shu 2012)

Descriptive or exploratory tasks (unsupervised learning)

The objective of this type of task is to partition or segment a set of data or individuals into groups. The groups are formed based on the similarity of the data or individuals in certain variables.

They are also known as unsupervised learning because they look for things in the data without guidance, they are exploratory and descriptive, and they involve looking in the data for common patterns of behavior (similar characteristics, preferences, behaviors, habits, etc.). In this type of task, the method autonomously discovers characteristics, correlations, and similar categories between them in the input data. They are techniques that start from a measure of proximity between individuals and based on a total population, seek to group the individuals most like each other, according to a series of measured variables. The characteristics to be covered are that the groups or clusters must be as tightly coupled or like the cluster (group), and the clusters as separate or different as possible from each other. There are several descriptive methods in data mining, focused on this type of task, among the most common are:

-       Hierarchical Clusterization (CJ).

-       K-means.

-       Principal Component Analysis (PCA).

-       OLAP (Online Analytical Processing).

-       Factorial methods.

Predictive Tasks (Supervised Learning)

These types of tasks are intended to predict future or unknown values of the variables (sales volumes, potential fraudulent customers, good paying customers or not, etc.). They are also called supervised learning and their objective is to create a function capable of predicting the value corresponding to a variable, after having analyzed a series of examples (the training data). There are also several predictive-type methods in data mining, among the most common are:

-       Time series.

-       Discriminant analysis.

-       Regression.

-       Decision trees.

-       Suport Vectors Machine.

-       Bootstrapping methods.

Methodology

This work has focused mainly on the study of clustering methods: Hierarchical Clusterization (CJ) and K-means, using them to analyze the results obtained from an opinion survey on bullying. The survey was applied to 131 students of the career of Technologies of the Aguascalientes, and through the clustering methods, similar groups were found in terms of their perception about the issue of bullying.

The operation of both methods used are described below:

Hierarchical Clusterization

The objective of Hierarchical Clusterization or Automatic Classification is that, from a data table, where the columns represent the variables and the lines the individuals, a dendrogram is constructed, which is cut to identify the clusters or clusters and thus find information from them. Fig 2 (Hand 01). This clustering method is based on the idea of calculating the distances or dissimilarity indices of all against all (variables or individuals) in a table.

The dissimilarity index is a mathematical function that takes two individuals and assigns them a number between 0 and more infinite (0, $+ \infty$), which has to fulfill the property of being symmetric, that is, that the distance between x and, is the same as between y and x.

$$d:IxI \rightarrow [0,+\infty] \qquad (1)$$

And

$$d(x,y) = d(y, x) \text{ for all } x, y \in I \qquad (2)$$

Symmetry property

For the calculation of these dissimilarity indices, there are several formulas, such as the Euclidean distance formula, the squared Euclidean distance, or the Manhattan distance formula, among others, but the most common is the formula for the Euclidean distance, which was used to analyze the results of the survey (Hand 01, Mirkin 05).
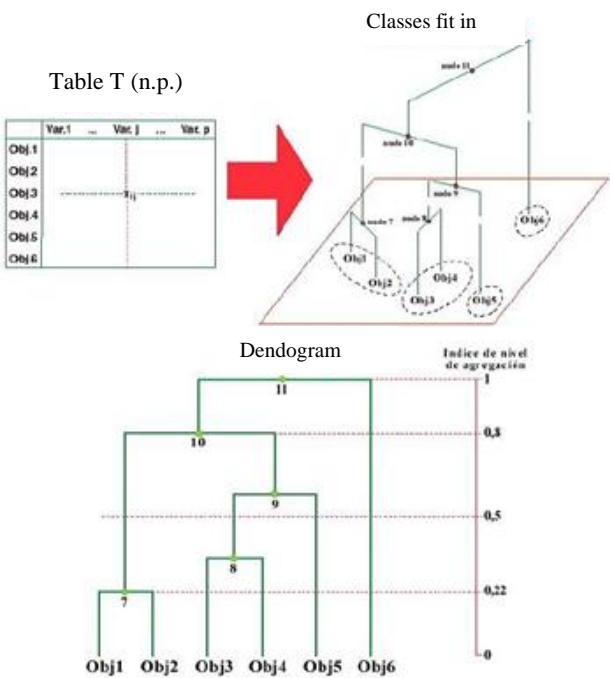

Figure 2 Scheme of the Hierarchical Clusterization (CJ) method

Euclidean Distance

$$d (X_i,X_s) = \sqrt{\sum_{j=1}(X_{ij} - X_{sj})^2} \qquad (3)$$

Once the dissimilarity indices have been calculated through the calculation of the distances of all the individuals, a symmetric matrix of distances is obtained as a result, which is used to unite in pairs, those individuals whose dissimilarity indices are lower, then join the pair with the next lowest dissimilarity indices and so on to unite all the individuals.

Once the individuals have been joined, now, through an aggregation index, groups of individuals are joined, for which, there are also several formulas, such as Ward's aggregation index, the simple link formula, the link formula half, or complete, or McQuitty's among others, but the most common is Ward's aggregation index formula (Jiawei 06, Chambers 09).

The objective of the K-means method is the same as that of the CJ method, or the Ward's aggregation.

Once the groups of individuals are united

$$\delta_w(x, y) = \frac{(x)*(y)}{(x)+(y)} \left\| g_x - g_y \right\|^2 \qquad (4)$$

The dendrogram structure is finally generated, and from this, the clusters or conglomerates of the data table can be found, to finally analyze them and find the information they provide (Valenga 07, Jiawei 06, Yakushev 14).

K-medias

It is the most used method for clustering and is generally used when considerable volumes of information are analyzed, this because the CJ method has an exponential growth problem in the calculations, since when performing the operations of the distances of all against all the individuals in a table, it can become a very computationally heavy process. For example, when analyzing a table when there are thousands of records.

ACP method, etc. Find clusters as homogeneous as possible between the individuals of each cluster and that the clusters between them are as different as possible from each other. The K-means method begins by randomly assigning each individual to a cluster, once all the individuals have been assigned, the next step is to calculate the center of gravity of each cluster, and then calculate the distances of all the individuals to their center of gravity. (Jiawei 06).

If some individuals are closer to the center of gravity of another cluster than to the center of gravity of the assigned cluster, a reallocation is made (they change clusters) and the clusters are rearranged again.

And the same procedure is carried out again, that is, the centers of gravity of each cluster are calculated again and if again there are individuals who are closer to the center of gravity of another cluster than at the assigned cluster, they are reassigned (they change clusters) rearranging the clusters. And so on, it continues to iterate, until there are no changes, or a maximum number of iterations indicated at the beginning of the process is exceeded, because, if there are, for example, a million records, the changes cannot be stabilized, so a maximum number of iterations is assigned for the algorithm to stop at a given time. Fig 3.
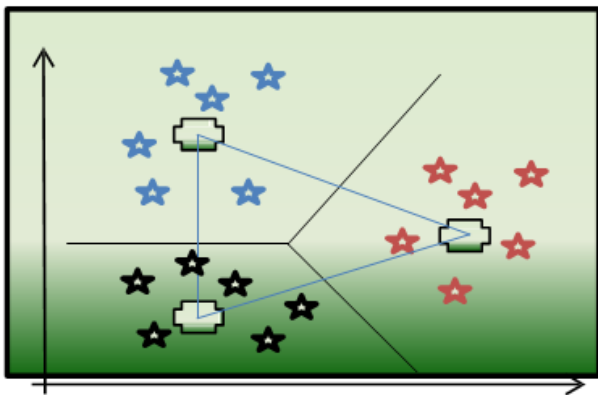

Figure 3 Scheme of the K-means method

The center of gravity of a cluster is calculated, with the vector average of the individuals that belong to the cluster, by means of the following formula.

Calculation of the total center of gravity

$$g_k = \frac{1}{[C_k]} \sum i \in C_k X_j \qquad (5)$$

Where n = amount of data in the data table.

$$g = \frac{1}{n} \sum_{i=1}^{n} X_i \qquad (6)$$

The term total inertia is a value that is calculated by averaging the distances of the vectors from the total center of gravity, which indicates the standard deviation of each vector with the general mean of inertia.

Calculation of total inertia

$$I = \frac{1}{n} \sum_{i=1}^{n} \|X_i - g\|^2 \qquad (7)$$

The inter-class inertia term is the value which indicates how distant or different the classes are from each other, and its calculation is performed by calculating the distance from the center of gravity of each class to the total center of gravity, and then make a weighted average of those distances and square it.

$$B(P) = \sum_{k}^{k} = 1 \frac{[C_k]}{n} \|g_k - g\|^2 \qquad (8)$$

Where Ck = Number of elements.

Its calculation implies the sum of the distances of the individuals that belong to a class to its center of gravity, carrying out the same procedure for the n classes, finally the averages are added and they are divided by the number of classes (Bullyinformate.org 15). Where: k = number of clusters. And gk = represents the center of gravity of each class. To calculate the total center of gravity, what is done is, average all the vectors and divide them by n, where n is the amount of data in the database (Husson 10, Mirkin 05).

$$W(P) = \sum_{K=1}^{K} I(C_k) = \frac{1}{n} \sum_{K=2}^{K} = \sum I \in \|Xi - Gk\| \qquad (9)$$

The main objective of this, is maximize the distance between classes B (P) and minimize the distance between classes W (P), to leave clusters as different from each other B (P) and for the individuals of a cluster to be as homogeneous as possible W (P). With the K-means method it is possible to solve the combinatorial problem of the hierarchical classification method (CJ), since in the latter, the calculations grow exponentially, and the k-means method reduces its calculations to a polynomial time which makes it feasible to calculate (Husson 10, Graham 11, Fayyad 96).

The R-Commander program

The analysis of both methods was processed in the R statistical program through the graphical interface of the R Commander package, designed by John Fox, of the University of Hamilton, Ontario, Canada, which covers most of the most common statistical analyzes of R, through drop-down menus (Arriaza 08, Artime 13, Cena 15, Le 08, Torsten 09).

Results obtained

The opinion survey on bullying applied to the 131 students included 7 questions handling 26 variables to consider. This survey was designed considering the approaches and proposals of some social and governmental organizations specialized in the subject of bullying (Bullyinformate.org 15, Montaño 14, Pang-Ning 06, Merino 08, OCSE 15). For each question, students could only choose a single answer. Table 1 shows the content of the survey that was applied:

1. Bullying is: p1a) A hobby p1b) Something normal happens. p1c) It is an abuse and causes pain. P1d) Show strength and leadership.
2. Select the one that you consider the main consequence of bullying. p2a) Feeling fear. p2b) Low grades, drop out of school. p2c) It has no consequences. p2d) It can cause someone to commit suicide.
3. What would have to happen to fix this problem? p3a) It can't be fixed. p3b) That the teachers and families do something. p3c) That the classmates do something.
4. Why do you think that some bully others? p4a) For playing a joke or teasing. p4b) Because they mess with them. P4c) Because they are stronger. P4d) Problems in your family.
5. Where do you think bullying mainly originates? p5a) In the house. p5b) Outside with friends. p5c) It is the personality of each person.
6. What do you think of boys or girls who bully others? p6a) Nothing, I pass the topic. p6b) It seems wrong to me. p6c) It is normal for it to happen between colleagues. p6d) They do
7. Do you know anyone or know of any case of bullying in this institution? p7a) No. p7b) Yes.

Table 1 Opinion questionnaire on bullying

Figure 4 shows the binary data matrix, generated from processing the results of the application of the surveys. For reasons of simplicity, an identification key was used for each possible answer in each question, and as the survey was anonymous, no names of students were used, only a nomenclature that identifies the group to which each student belongs and a consecutive number to control the number of students who responded to the survey per group.
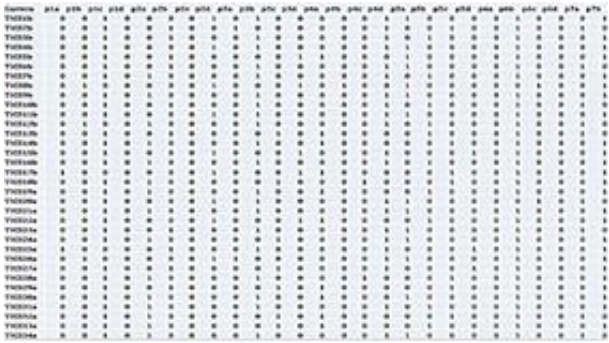
Figure 4 Binary data matrix

The results obtained by each clustering method are detailed below, which was used to analyze the information from the surveys.

Results obtained with the Hierarchical Clusterization (CJ) method

By means of the Hierarchical Clusterization method, the following was obtained: The binary data matrix was entered into the program and the dissimilarity indices of all individuals were calculated, using the Euclidean distance formula, generating as a result the symmetric matrix of distances shown in Fig. 5.
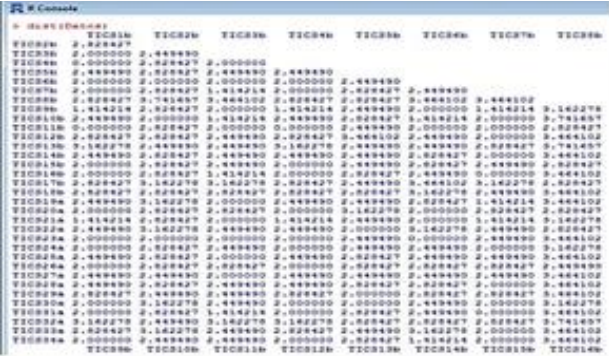
Figure 5 Symmetric matrix of distances

By using the Ward's aggregation index formula, to unite the groups of individuals, the following dendograms were obtained as a result, in 3D and 2D Fig. 6 and Fig. 7 respectively.

Figure 6 3D dendogram

MEDINA, Gricelda, LUNA, Francisco, TAVAREZ, Felipe and MARTÍNEZ, Rocío. Clustering in data mining: CJ and K-Medias applied to an opinion survey on bullying at the UTNA. Journal of Quantitative and Statistical Analysis. 2020
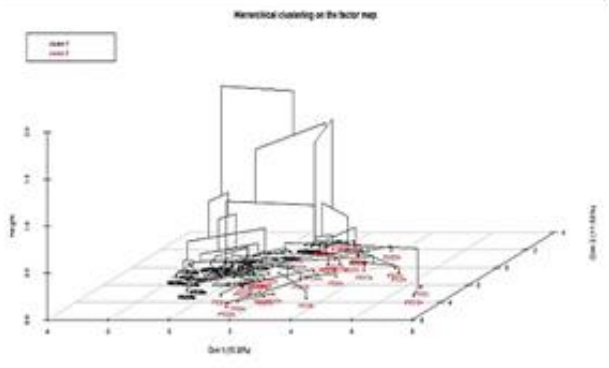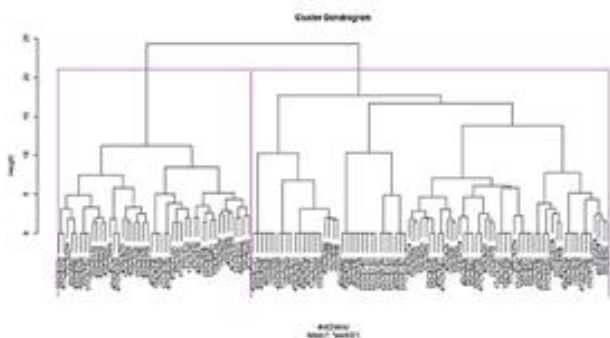
Figure 7 Dendrogram

Once the dendograms were created in the CJ method, it can be clearly seen that the system generated 2 clusters or groups, group number 1 with 86 students and number 2 with 46.
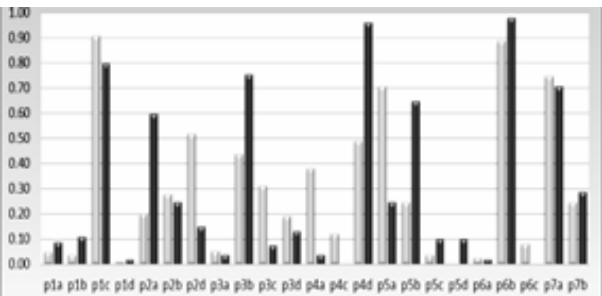
Figure 8 General graph

Fig. 8 shows the general graph where the characteristics that define each cluster are observed, finding very marked differences in questions 2, 3, 4 and 5.

Analyzing the results separately for each of these questions, it is necessary to: In question 2 (Select the one that you consider the main consequence of bullying), cluster 1 thinks that it can lead to suicide (52%) and cluster 2 considers that it causes fear mainly (60%). Fig. 9.

Question 2: Consequences of Bullying

Figure 9 Histogram from question 2

In question 3 (What would have to happen to fix the problem of bullying?), Cluster 1 thinks that teachers and families (67%), including classmates (18%), should do something, while cluster 1 2 believes that the problem can be stopped by applying legal sanctions (39%) and is more in favor of peer intervention (30% compared to 18% in cluster 1). Fig. 10.

Question 3: How to stop the problem?
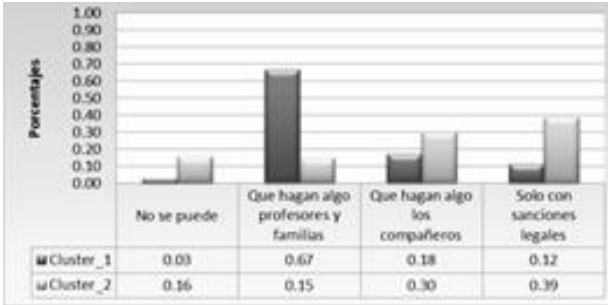
Figure 10 Histogram for question 3

Regarding the results of analyzing the answers to question 4.

(Why do you think that some bully others?), Almost 100% of cluster 1, thinks that some bully others because they have problems at home (98%), while cluster 2 thinks that they do it mainly to annoy or play a joke (71%) Fig. 11.

Question 4: Why do you think some people intimidate others?
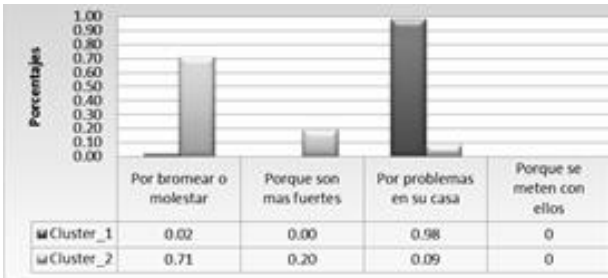
Figure 11 Histograma de la pregunta 4

Analyzing the answers to the question 5 (Where do you think bullying originates?), Cluster 1 thinks that it is at home (71%) and sometimes with friends (25%), while those in cluster 2 think the opposite, that it is mainly with friends (65%) and only some of them at home (25%). Fig. 12.

Question 4: Where do you think bullying originates?
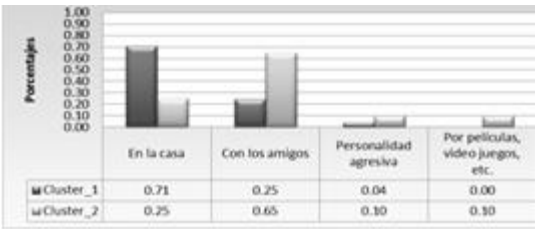
Figure 12 Histogram for question 5

Regarding the results of questions 1 (Is bullying?) And 7 (Do you know of any case of bullying in this institution), in both clusters the results are remarkably similar, as can be seen in Fig 13.

At least 80% of both clusters believe that bullying is abuse and causes pain. And 25% of all respondents in both clusters consider that they have suffered bullying at some point in the institution, which represents 32 students of the respondents.

Survey Question 1 and 7
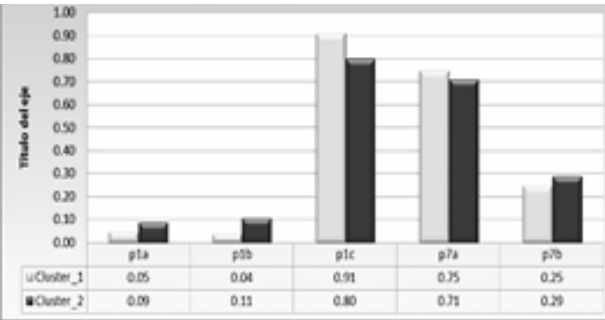
Figure 13 Histogram for question 6

Results obtained with the K-means method.

The binary matrix data was loaded, and the R-Comander program was told that by means of the K-means method, 2 clusters should be generated, just as it was generated automatically in the Hierarchical Clusterization method. In this method the clusters were formed as follows: Cluster 1 was created with 44 students and cluster 2 with 87, a result very similar to that obtained with the CJ method. For reasons of the tool and as the assignment of each individual to the cluster is random, the program inverted the number of clusters, that is, cluster 1 of the hierarchical classification method is represented by the number 2 in this method, and vice versa, the cluster 2 of the CJ method is represented by the number 1 in the K-means method.

In this method, the system generated the following biplot Fig. 14, where it indicates the trends of the responses in each question for each cluster.
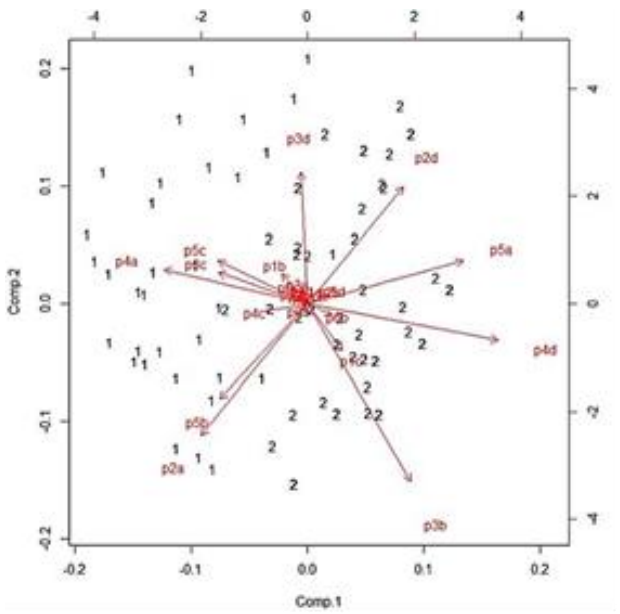
Figure 14 K-Means Biplot

The distances of the arrows on the biplot indicate the representation of the answers to each question. The closer the arrow is to the periphery of the square, it means that it was a highly selected response in the survey, and in its environment, the cluster number to which said selection belongs is found. The smaller the distance between the dates or they are closer to the center, it means that these answers were not among the most selected by the students.

Question	Cluster1 with K- means	Cluster2 with CJ
2. Main consequence of bullying	P2a) Feeling fear.	P2a) Feeling fear. P2a) Low grades.
3. What should be done to fix this problem?	P3c) The classmates must do something.	P3c) The classmates must do something. P3d) With legal sanctions.
4. Why do some bully others ?	Q4a) For playing a joke or teasing	Q4a) For playing a joke or teasing
5. Where does bullying mainly originate?	P5b) and P5c) With friends and because of the personality of each person.	P5b) With friends and because of the personality of each person.

Table 2 Cluster 1 Characteristics Comparison

As can be seen, cluster 1 chose the responses p2a, p3c, p4a, p5b and p5c, detailed in Table 2. On the other hand, in cluster 2 it can be seen that the most selected responses are: p2d, p3c, p4d and p5a, similar responses to cluster 1 of the CJ method.

Table 3 details each response, specifying the clustering method applied

Question	Cluster2 with K-Means	Cluster2 with CJ
2. Main consequence of bullying	P2d) can cause someone to commit suicide.	P2d) May cause suicide. P2c) Low qualifications.
3. What is due do to fix this problema	P3c) should do rather teachers and families.	P3c) they must do something. teachers and families.
4. Why Some intimidate others?	P4d) Because they have problems in your family.	P4d) Because they have problems in your family.
5. Where is primarily causes harassment.	P5a) It originates mainly in the house.	P5a) It originates mainly in the house.

Table 3 Cluster 2 characteristics comparison

The results of the answers in questions 1 and 7 are not visible in the biplot, which indicates that they are very close to the center, that is, that they are very similar in their answers and do not highlight considerable differences between them. Regarding the inertias obtained, the total inertia indicated a value of 2,856. The value of the inertia between classes B (P) was 0.473 and the inertia between classes W (P) was 2.383, adding both inertia gives a total of 2.856, which is the value of the total inertia. Thus proving Fisher's duality theorem, which indicates that the sums of the inter-class and intra-class inertia is equal to the total inertia of the point cloud.

Related jobs

There are several works related to the application of clustering methods used to analyze groups of individuals with similar characteristics. Among the works analyzed are the use of exploratory data mining methods to identify students at risk of dropping out or school failure (La Red 14, Márquez 12). The use of clustering to find patterns of criminal behavior, or patterns of drug use (Valenga 07), (La Red 14), (Yakushev 14).

Clustering work for Customer Segmentation (Jo-Ting 13), to support decision-making in business processes (Pérez 12, Pinzón 11, Sadat 15) and patterns for analysis of perception of corruption (Paulus 15) , or to analyze the quality of the information producers (Dinner 15).

Conclusions and future work

As can be seen, the results obtained in each question by both clustering methods are very similar, which has allowed us to obtain perception patterns on bullying that specifically define each cluster. This type of information can be extremely important for the Tutoring area or psychopedagogical counseling area within the institution. With the objective of establishing programs of talks and conferences focused on each group of students with similar characteristics. For cluster 2, awareness programs about the consequences of bullying and group integration techniques can be organized for those students who consider that bullying is generated only by making a joke or annoying, and who think that this type of behaviors, is generated mainly in the street with friends.

For the students that make up cluster 1, who think that bullying is generated mainly at home and that it occurs mainly due to family problems, family talks or guidance of special help can be focused on them when the case requires it. All this considering that, analyzing the last percentages of school dropouts, in the institution, they are not given by low academic performance, but by personal problems that affect the student to such a degree, that they decide to leave school, due to the consequences that these problems imply for them.

In relation to future work, the application of data mining supervised learning methods has an infinite field of application, since the importance of analyzing data and information to identify groups with similar characteristics or simply to describe the characteristics of the themselves, it is of utmost importance. Specifically for the issue of bullying, it is planned to analyze the issue, but now from the use of social networks, where through supervised learning methods, the comments made by students, in their publications towards other classmates, will be analyzed.

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Labor market of the agroindustrial engineer of the BUAP and professional competences of the TSU in food processes of the UTP

Mercado de trabajo del ingeniero agroindustrial de la BUAP y competencias profesionales del TSU en procesos alimentarios de la UTP

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Abstract

In this study an analysis of the requirements and expectations of the labor sector, the area of influence of the Autonomous University of Puebla (BUAP) and the Technological University of Puebla (UTP) is carried out in relation to the relevance of studies and the labor market for the agro-engineer and profesionista Superior Technical University (TSU) in food processes, respectively. For the collection of information and data of TSU, it was held in August 2014 a workshop on the UTP, in which the data collection methodology was followed for the development of curricula based on competences, adapted in 1992 by the Ministry of Education of Quebec (Ocampo, 2012). The methodology used in the workshop called "IXE Method", which has the mission to obtain the maximum information by consensus and thus to detect cognitive skills, psychomotor and affective partner necessary to establish a productive function under performance standards. This analysis allowed feedback training programs on learning objectives, a detailed and precise manner, achieving satisfying the demands of the labor market (Manjarrez, 2013).

Resumen

En el presente estudio se realiza un análisis de los requerimientos y expectativas del sector laboral, de la zona de influencia de la Benemérita Universidad Autónoma de Puebla (BUAP) y la Universidad Tecnológica de Puebla (UTP), en relación con la pertinencia de estudios y el mercado laboral para el ingeniero agroindustrial y el profesionista Técnico Superior Universitario (TSU) en procesos alimentarios respectivamente. Para el acopio de información y datos del TSU, se realizó en el mes de agosto del 2014 un taller en la UTP, en el que se siguió la metodología de recolección de información para la elaboración de planes de estudio basados en competencias, adaptada en 1992 por el Ministerio de Educación de Quebec (Ocampo, 2012). La metodología utilizada para el desarrollo del taller se conoce como "Método IXE", el cual tiene como misión obtener el máximo de información por consenso y así poder detectar las habilidades cognoscitivas, psicomotoras y socio afectivas necesarias para ejercer una función productiva bajo estándares de desempeño. Este análisis permitió retroalimentar los programas de formación sobre objetivos de aprendizaje, de una manera detallada y precisa, logrando ejecuciones satisfactorias de las demandas del mercado laboral (Manjarrez, 2013).

Agribusiness education, Labor market, Professional skills

Educación agroindustrial, mercado de trabajo, competencias profesionales

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Introduction

The Agro-industrial Engineer is a human resource with knowledge and skills to manage production systems, as well as process the industrialization of food products through new technologies for the benefit of production units. Of course, it is intended that the territorial ordering and placement of graduates impact the needs of the region and its industrialization (Bernal, et. Al. 2010). In this context of engineering training, key tasks are identified for their training with the information collection methodology, for the development of competency-based study plans (Ocampo, 2012), and their general purpose is written as follows: Manage the resources and food processes of the company based on the established standards and norms, in order to achieve their optimization, as well as the design and development of new products and / or food processes and in this way satisfy the requirements of the customers. In this way, future engineers participate in the process of recruiting graduates of the upper secondary level, where BUAP is the institution that occupies the first place in coverage among public institutions, thus contributing with an absorption rate on average of 5% and 10.5% with respect to graduates from their area of influence and the State, respectively. Basically, the potential is concentrated, and they comprise 45 municipalities, where 687 institutions are located with 24,320 graduates of which; 20 thousand 998 correspond to the general high schools, 2 thousand 536 to the technological high schools, and 786 of the Technical Professional Education Colleges (CONALEP), all of them are considered as potential demand, for 240 Higher Education Institutions and 31 Normal in the State (SEP, 2015).

At BUAP, students who manage to obtain a final average of 8.5 or more throughout their studies, receive the title automatically, without the need to present a final exam or write a thesis, and additionally, several faculties introduced additional forms , such as the preparation of a thesis, or internal and external final exams, such as the General Bachelor Exit Exam (EGEL) from CENEVAL; As a result, there are now a variety of options for titration, as reflected in the table below:

Titration forms	Women (%)	Men (%)
Thesis	27.4	33.8
Thesis	1.8	3.2
Average	48.9	33.8
Other	4.4	3.1
I do not answer	17.5	26.1
Total	100	100

Table 1 Qualification of graduates from BUAP

On the other hand, insertion into the labor market, according to the survey data, is a gradual process that begins before finishing their studies, thus, 38.8% of graduates were already working during the last year of studies (Ibid).

If you worked during your last year of studies	38.8%
You did not work during your last year of	61.3%
Did not answer	0.07%
Total	100%

Table 2 Percentage of students who worked in their last year of studies (Ibid)

Although there is evidence of a rapid insertion into the labor market for a significant part of the students, it should also be noted that this insertion complicates the degree process, since it is difficult to combine almost thirty hours of work outside the university with the completion of subjects and the preparation of a thesis.

State reference framework

The State of Puebla has a geographic location to the north 20 ° 50 ', to the south 17 ° 52' of north latitude, to the east 96 ° 43 ', to the west 99 ° 04' of longitude west. Puebla borders to the north with the states of Hidalgo and Veracruz-Llave, to the east with Veracruz-Llave and Oaxaca, to the south with Oaxaca and Guerrero, to the west with Guerrero, Morelos, Mexico, Tlaxcala and Hidalgo. It has an area of 33,902 square kilometers, equivalent to 1.7% of the country's total (INEGI, 2015). The State of Puebla has seven socioeconomic regions configured with four regions of urban predominance (Angelópolis, Tehuacán and Sierra Negra, Valle de Serdán and Valle de Atlixco-Matamoros), and three regions of rural predominance (Sierra Nororiental, Sierra Norte and Mixteca).

Figure 1 Socioeconomic regions of the state of Puebla

The total population in the State of Puebla is 5 million 779 thousand 829 inhabitants, 52% are female and 48% male, 2 million 578 thousand 612 inhabitants are concentrated in the area of influence of BUAP and the Technological University of Puebla (UTP).

474,429 are in an age range between 20 and 24 years old, 27.9% study higher education in this area, 6.3% do so in other municipalities and 65.8% are not enrolled, which means a potential for young people who require support to continue their studies (ibid).

One of the opportunities for the Benemérita Universidad Autónoma de Puebla (BUAP) and the Universidad Tecnológica de Puebla (UTP), is their geographical location, a factor that has influenced their consolidation and development respectively; by counting in the state with 1 thousand 465 Baccalaureate and 158 schools of Technical Professional (in the 2013-2014 school year) of which 50 thousand 748 students graduated in the State (SEP, planning department).
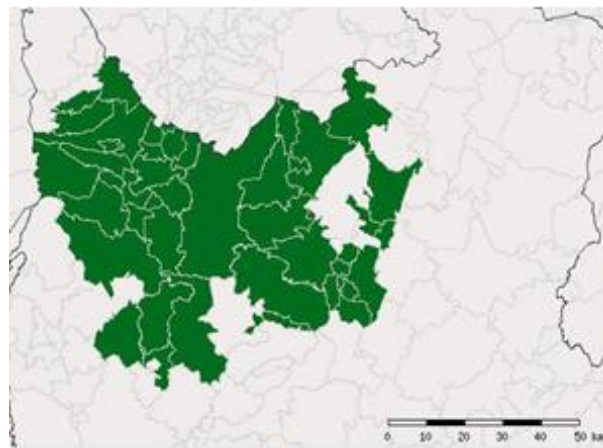
Figure 2 Influence area identifying municipalities for BUAP and UTP

In the area of influence of both Universities there are 45 municipalities, where 687 institutions are concentrated with 24,320 graduates, 20,998 correspond to general high schools, 2 thousand 536 to technological high schools, and 786 of the Technical Professional Education Colleges (CONALEP), which are considered as potential demand, for 240 Higher Education Institutions and 31 Normal in the State.

Being the UTP the institution that ranks second in coverage after the Benemérita Universidad Autónoma de Puebla (BUAP) among public institutions; thus contributing with an average absorption rate of 10.5% and 5% with respect to graduates from their area of influence and from the State, respectively. Regarding the productive sector, in the State of Puebla there are a total of 2,140 companies distributed as follows: 125 correspond to large companies, 386 to medium and 1,629 to small ones. Of these, 38.1% correspond to the industrial branch, 39.7% correspond to commerce and 22.2% to services (ibid).

Processed foods: Puebla, among the largest producers

According to information from ProMéxico, most of the large exporting companies dedicated to food processing, the state of Puebla is among the entities of the country with the largest number of food processing and exporting companies, with a total of 42 The entity is located below the Federal District which has 242 companies; Jalisco with 159, Nuevo León with 144, State of Mexico with 124, Baja California with 69, Michoacán with 62, Guanajuato with 52 and Chihuahua with 46; the list is completed by Yucatan with 40.
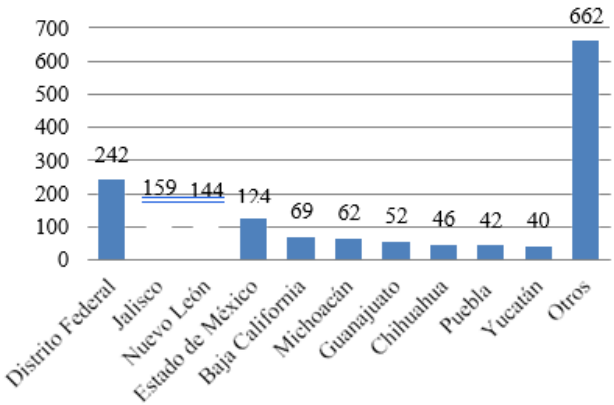
Graphic 1 Main economic units states

As has been pointed out, Puebla is one of the entities with the largest economic units in the processed food sector, with 13,494; it is located only below the State of Mexico, which has 21,386; According to figures from the Ministry of Economy, in 2012 the Foreign Direct Investment (FDI) of the industry in Mexico was concentrated in Nuevo León, Jalisco, Edomex and the DF, hence the food processing industry is one of the sectors key in the country's economy (Secretary of Economy, 2015).

In Mexico, according to the secretary of economy, the production of processed food in 2012 was 123 thousand 954 million dollars, which represented an increase of 2.3% compared to 2011. The food industry represents 23.2% of the manufacturing GDP and 4.1% of the Total GDP. Thus, Mexico is the second largest food supplier to the United States and the third largest producer of processed foods in Latin America; and worldwide, it ranks eighth. In 2012, the main export destinations were the United States, Japan, and Guatemala, with a share of 68.5%, 6.3%, and 2.4% in the total Mexican exports of the industry, respectively. (http://mim.promexico.gob.mx/work/sites/mim/ resources / LocalCo999) ntent / 72/2 / Alimentos_pr ocesados_ES.pdf).

Present and future demand for skilled labor

The economically active population of the state represents 60.24% of the total population aged 14 and over, and the inactive population 39.76%, according to the third quarter of 2014 (SEDECO, 2015). According to information from ProMéxico, most of the companies dedicated to food processing in Puebla are dedicated to food preparations and sauces.

Puebla is among the entities of the country with the largest number of food exporting processing companies, with a total of 42. The entity is located below the Federal District which has León with 144, State of Mexico with 124, Baja California with 69, Michoacán with 62, Guanajuato with 52 and Chihuahua with 46; the list is completed by Yucatán with 40 (ibid).
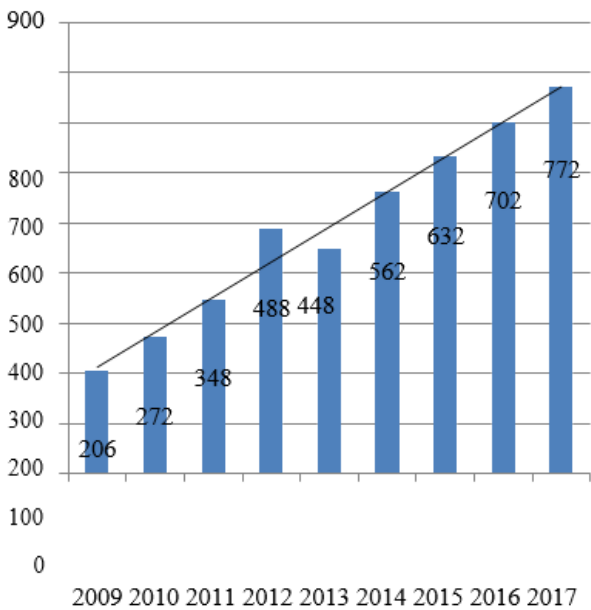
Graphic 2 UUTT enrollment projection

Regarding the projection of total enrollment of the Educational Program of TSU in Food Processes of all the UUTT of Puebla. The projection was based on the historical information provided by the UTT Puebla, Tecamachalco UT, Izúcar de Matamoros UT, Xicotepec de Juárez UT and Tehuacán UT. The following graph presents for the state of Puebla, the total number of people working in this occupation during the period 2013-2014.

| | 2013 | 10.518 |
| | 2014 | 11.145 |

Graphic 3 Annualized figures as of the fourth quarter

The growth in the number of support workers in the food, beverage and tobacco products industry in 2014 was only 5.96% compared to 2013; and the economically active population represents 60.24% of the total population aged 14 and over, and the inactive population 39.76%, according to the thi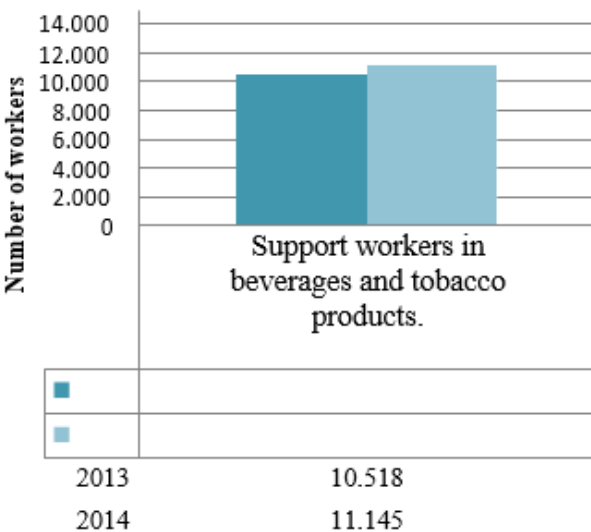rd quarter of 2014. The participation rate of the employed population is 58.0% of the total population of 14 and over. And to strengthen the University-Company link with mutual collaboration actions, the UTP offers services such as: studies and technological services, updating courses, training, professional development, and continuing education courses aimed at University graduates and workers from organizations in the same environment, likewise the university has the opportunity for students to carry out their internships-stays, make your industrial visits and join the labour market.

Thus, in the State of Puebla there are a total of 2 thousand 140 companies distributed as follows: 125 correspond to large companies, 386 to medium and 1 thousand 629 to small ones as shown in the following graphic:
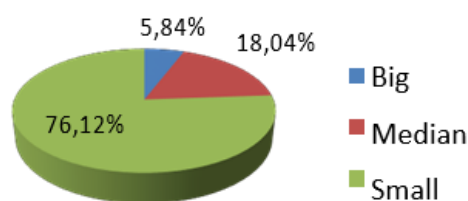
Graphic 4 Distribution of companies by size

Of these, 38.1% correspond to the industrial branch, 39.7% correspond to commerce and 22.2% to services (ibid). Where important differences between men and women begin to be seen is in the sectors where they work, for both there is a similar concentration in the sector of independent professionals, but men are more represented in agriculture, industry and government, while women are notably concentrating more on health and education, as shown in the following table.

Sector	Women (%)	Men (%)
Agricultural, Livestock	1.3	3.0
Industry	9.6	19.3
Trade	14.8	13.9
Banking, Finance	4.1	3.6
Transportation,	4.0	4.7
Health	21.0	10.2
Independent professionals	16.6	17.1
Education	17.4	11.2
government	11.3	16.9
Total	100	100

Table 3 Labor distribution by gender
Source: (Vries, et al., 2015)

Professional competences related to the functions and work tasks of the TSU

The labor market is expected to have a great capacity for change, so it is vitally important to have trained human resources that skillfully respond to the requirements that it demands.

Thus, within the area of food processes, the basic cognitive, psychomotor and affective skills that meet specific standards of a company or sector are identified by the methodology of identification of requirements and expectations of the labor sector, allowing to establish training programs on learning objectives in a detailed and precise way, achieving satisfactory execution of the demands of the labor market.

This analysis presents the requirements and expectations of the labor sector in the area of influence of the Technological University of Puebla, in relation to the relevance of studies for the professional 5B in food processes and is based on the information obtained from the workshop held in the University facilities, in March 2014. The TSU in Food Processes is a person with knowledge and skills to manage production systems as well as the industrialization of food products through new technologies for the benefit of the unit of production. Through the Analysis of the Work Situation, the specialists gathered in the workshop identified the key tasks of the sector and grouped them by productive function and based on this classification the general purpose of the sector in Agriculture was formulated, which was written as follows way: "Manage the resources and food processes of the company based on the standards and established norms, in order to achieve their optimization, as well as the design and development of new products and / or food processes and in this way satisfy the customer requirements."

During the workshop, five key functions to be developed by the professionals of this career were determined, which are mentioned below.

- Manage quality and safety management systems within the company.

- Orient the production processes according to the client's needs.

- Supervise the agricultural marketing, quality and packaging system.

- Transform food products with efficiency and high performance.

- Manage human and material resources for production.

The labor field for this professional can include agricultural, livestock, poultry and agro-industrial sectors among others, depending on the type and size of the organization, he can work in greenhouses, ranches, government agencies in relation to agriculture, among others. It also opens the possibility for the TSU in Food Processes to form its own company, where it can offer consulting services, automation, maintenance, sale of equipment and / or spare parts and marketing of agro-industrial products.

Some of the positions that a TSU in Food Processes can aspire to are mentioned below:

- Production unit manager.

- Production manager.

- Supervisor.

- Technical.

- Project leader.

- Seller.

- Independent consultor.

The above will depend on the size and business of the company where you work.

You will be able to move up in jobs as you develop and gain experience. His work environment will be very diverse, where he must coordinate and execute production processes, as well as solve problems that arise in production.

It will implement automated systems to improve the efficiency of the production process, as well as the use of natural resources, thereby seeking their sustainability. Coordinate work teams for the proper development of production activities. There is a high degree of occupational risk when carrying out activities caused by: sun exposure, breathing of toxic substances, noise, falls, bumps and cuts, among others.

In the region there is a continuous growth of the population that demands agricultural products, likewise given climate change there are fewer and fewer natural resources such as water where every day it is more scarce and its use is required to the maximum, therefore both the demand for having this profile will increase. Their perceptual faculties must be high since it requires detecting, analysing and processing information that allows them to plan and organize production processes as well as attend to the problems that arise, so it is necessary to work on the development of perceptual faculties.

Features:

- Manage quality and safety management systems within the company.

- Orient the production processes according to the client's needs.

- Supervise the agricultural marketing, quality and packaging system.

- Transform food products with efficiency and high performance.

- Manage human and material resources of production.

Tasks:

5.1 Apply quality control at the production control points.

5.2 Guarantee the safety of food products.

5.3 Apply statistical techniques in the processes.

5.4 Ensure the operability and good use of the process measurement and control equipment.

5.5   Identify the customer's needs in food products of interest.

5.6   Support the development of new food products.

5.7   Employ new technologies in the development of new products.

5.8   Investigate commercial markets in the agricultural sector.

5.9   Monitor the quality of agricultural products.

5.10   Manage environmental sustainability systems.

5.11   Add value to the primary products of the region.

5.12   Respect the environment and safety and hygiene.

5.13   Increase the effectiveness of the applied processes.

5.14   Manage cost and investment system.

5.15   Integrate and coordinate work teams.

5.16   Supervise activities of personnel in charge.

In this workshop, the information gathering methodology was followed for the development of competency-based study plans, adapted in 1992 by the Quebec Ministry of Education and adapted by the same institution. This methodology allows detecting the psychomotor, cognitive and socio-affective skills necessary to exercise a productive function under performance standards.

Prospective elements of state development

The Vision of the state of Puebla to 2020 is based on a series of trends, among which are:

-    The net growth of the state population of 100,000 inhabitants per year on average, with a higher concentration in the main municipalities of the Entity (Puebla, Tehuacán, Huauchinango, San Martín Texmelucan and Atlixco).

-    Increased capacity to attract and maintain investments, especially in the food and housing industry, as well as in health and education services.

-    The greater regional exchange of goods and services, as well as the mobility of people, fostered by the expansion and improvement of infrastructure and means of communication and transportation.

-    The industrial and commercial specialization of regions and economic zones; especially in the areas of manufacturing, commerce, restaurants and hotels, and services.

-    The greater absorption of the youth Economically Active Population (EAP) in the labor market. It should be noted that according to recent studies, 50% of the business demand of the states of Nuevo León, Mexico, Puebla and the Federal District for the knowledge of graduates of industrial engineering correspond to the areas of: production, quality systems, planning, warehouses, sales and logistics, mainly. The panorama of the Puebla entity that is expected is as follows:

1). A new demographic and family structure in urban areas, mainly.

2). Puebla: "The Capital of Knowledge" or "University City" for permanent education; and Center for Health Care Services.

3). A specialized and diversified manufacturing industry.

4). A state with regional urban development in process, pressured by the greater demand for public services, mainly water and energy.

5). Research and application of technology to improve and protect the environment, in particular, natural resources and the environment.

6). Expansion and development of infrastructure and means of transport, especially communications and telecommunications (TICS).

7). A more democratic and just government, defender of citizens' rights, and active promoter of development.

Conclusions

The labor field of the agro-industrial engineer and the TSU in food processes; It can cover agricultural, livestock, poultry and food industrial sectors in general, among others such as government institutions in the field, depending on the type and size of the organization, it can work in greenhouses, ranches, public agencies in relation to the agriculture, among others. It also opens the possibility for the graduate to form his own company, where he can offer consulting services, automation, maintenance, sale of equipment and / or spare parts and marketing of agro-industrial products.

In the region there is a continuous growth of the population that demands agricultural products, therefore the potential of the development of the agroindustrial engineering career of the BUAP and the TSU in food processes of the UTP, is high with an impact on the region and the very encouraging agro-industrial development. Of course, there are challenges that must be overcome to achieve optimal development, among them the participation of the state, industry and the University is required, thus some items where projects and / or strategies for development can be generated are:

- To form a strong and reliable State, capable of guaranteeing economic stability, food security, and leading the development of productive and social activities, with the participation of industry and the university in triple helix projects that benefit the sector. agro-industrial.

- Motivate state and foreign investment in emerging and high-technology areas, to gradually improve or replace traditional industry with cutting-edge technology.

- promote competitiveness, that is, given the scarcity of opportunities, promote sources of productivity with sustainable bases to generate wealth, increase resources and improve the level of well-being of the population, educational institutions and companies.

- Make agro-industrial education one of the main engines of development, in the poorest and most marginalized regions of the state, to guarantee food security.

Acknowledgments

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Determination of critical success factors for just-in-time implementation: factor analysis

Determinación de factores críticos de éxito para la implementación de justo a tiempo: análisis factor

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Abstract

Just in time (JIT), is one of the most investigated topics in the area of operations management, because of its success in companies and is a matter of enduring today has come to develop with great intensity, various benefits have been it reported , for example: inventory reduction , improved efficiencies of operations and a more rapid customer response, therefore, the successful implementation of JIT is vital for many companies; however, often implemented without obtaining the results expected. In this article are presented the results of a survey responsible for implementing this methodology in companies, the questionnaire was validated using Cronbach 's alpha and a factorial analysis by the principal component method was applied to 56 questions and the main key success factors making a varimax rotation.

JIT, Critical Success Factors, Factor Analysis

Resumen

Justo a tiempo (JIT), es uno de los temas más investigados en el área de gestión de operaciones, debido a su éxito en las empresas maquiladoras y es un tema de permanente actualidad que ha venido a desarrollarse con gran intensidad, diversos beneficios han sido reportados, por ejemplo reducción de inventarios, mejora en las eficiencias de las operaciones y una respuesta mas rápida al cliente, por lo tanto, el éxito de implementación de JIT es vital para muchas empresas: sin embargo, frecuentemente se implementa sin obtener los resultados esperados. En este artículo se presentan los resultados de una encuesta aplicada a responsables de ejecutar esta metodología en empresas, el cuestionario se valido mediante el índice alfa de Cronbach y se aplicó un análisis factorial por el método de componentes principales a 56 preguntas y se obtuvieron los principales factores claves de éxito realizando una rotación varimax.

JIT, Factores Criticos de Éxito, Análisis Factorial

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Introduction

Globalization has provided a new landscape for the manufacturing industry that is distinguished by competition, frequent product launches, and rapid changes in product demand (Koren, 2010). To survive in this competitive global environment, companies must make strategic changes in the manufacturing system consistent with the demands of their environment (Sandanayake et. Al., 2008) and reconfigure the supply chain (Koren, 2010), provide products of high quality and reduce delivery times.

One way to achieve a competitive advantage in manufacturing industries is to take advantage of excellent production, inventory control systems and secure the cost leadership position (Matsui, 2007). Just in Time (JIT), Advanced Manufacturing Technologies and Total Quality Management, among others, are some of the tools that should be used as part of the strategic adjustments of the manufacturing system in response to environmental requirements to improve efficiency and customer response (Yasin et. al., 2003).

Even today, important competitive advantages can be obtained with the successful implementation of JIT, so it can be said that the elements that contributed to making JIT a success are still valid, and it could even be declared that in a context like the current one , in which speed and efficiency are crucial, JIT may be even more important and effective than in the 1970s and 1980s (Machuca, 2002).

The definitions of JIT have evolved from the strict sense of just-in-time production to the concept of a general management philosophy to satisfy customers and obtain a competitive advantage in the market (Chang and Lee, 1996).

To better clarify the meaning of JIT, a series of definitions proposed by different authors is listed below:

Ohno (1982), a pioneer of JIT, defines JIT as having the right part, at the right time and quantity.

Fullerton and McWatters (2002) propose that JIT is a manufacturing philosophy that emphasizes excellence through continuous improvement of productivity and quality in all phases of the industrial cycle.

Wakchaure et. al., (2006) defines JIT as a manufacturing philosophy that aims to minimize raw materials, work in process, and finished product inventory by helping to expose other more serious deficiencies in the production cycle.

JIT leads to higher quality and productivity; In addition, it provides visible results in improving responsibility and commitment on the part of employees (Singh and Garg, 2011). According to Mackelprang and Nair (2010) JIT has maintained its popularity in practice and continues to be widely used in companies around the world.

Some researchers suggest that unsatisfactory JIT results are associated with ineffective and incomplete implementations (Clode, 1993; Milgrom and Roberts, 1995). White and Prybutok (2001) state that the benefits will not be made.

The problem identified in this study is that there is uncertainty about which are the critical success factors and the variables that make up these factors to ensure the success of the implementation of JIT in the manufacturing industry.

Given the importance of JIT among professionals and in operations management research, coupled with the scarce existing literature of studies carried out in Mexico, specifically in Cd. Juárez, is what motivates the present investigation, the objective of this The study is to build and validate a model where the Critical Success Factors of JIT and the benefits of implementation are integrated, which will serve as the basis for future research and will help companies to better plan the process of adopting this technique and achieve your benefits.

In this research, the methodology used, the results obtained, the conclusions and recommendations are presented.

Critical Success Factors in JIT Implementation (FCE)

Romero et. to the. (2009) define the FCE as variables that must be considered before and during the realization of a project, since they provide valuable information to achieve the goals and objectives of the company and emphasize the importance of analysing and determining those factors that are key to the start and development of a project; for which a comprehensive review of the literature is needed.

A body of literature has emerged as part of the efforts of academic researchers who have tried to determine the FCEs for the successful implementation of JIT.

From a methodological perspective, JIT research during the 1980s lacked reliable and valid measures (Walleigh, 1986; Voss, 1987; Wildeman, 1988; Willis; 1989). These limitations led to the development of rigorous methods to define and measure the core constructs underlying JIT (Nair & Mackelprang, 2010). Table 1. presents the dimensions proposed by some researchers.

Authors	Dimensions
Golhar and	Golhar and
	Stamm (1991)
	Elimination of waste
	Participation of workers in making
decisions	decisions
	Supplier participation
	Total Quality Control
David. et. to the. (1992) Operational structure and control	David. et. to the. (1992) Operational structure and control
	Production scheduling
	Quality implementation
	Mehra and Inman (1992) Managerial engagement
JIT production strategy	JIT production strategy
	Vendor strategy
	JIT education strategy
Sakakibara et. to the.	Sakakibara et. to the.
	(1993)
	Human resource management
	Simplification of physical flow
	Vendor management

Table 1 Authors and Dimensions on JIT Implementation

Subsequent researchers have used the JIT dimensions identified by these authors (Forza 1996; Sim and Curtola, 1999; Fullerton and McWatters, 2001; McWatters and Fullerton, 2002; Ahmad et. al., 2003; Fullerton et. al., 2003 Narasimhan et. al. 2006).

The dimensions and elements reported by Ramarapu et. to the. (1995) provided the basis for identifying the JIT dimensions and elements that were used as a guide in this research.

Table 2 shows the existing concordance between the elements related to the production factor in which 22 articles that cite more than three techniques from a literature review from 1992 to 2011 are listed.

Table 2 Elements Linked to JIT Practices Factor

Table 3 shows the existing agreement between the elements related to the supplier participation factor, in which 14 articles from a literature review from 1992 to 2011 are related.

Table 3 Elements Linked to the Suppliers Factor

Table 4 shows the existing concordance between the elements related to the quality factor, in which 14 articles are related that cite more than three techniques from a literature review from 1992 to 2008.

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	Total
Quality circles	•	•		•	•		•	•	•				•	•	9
Preventive Maintenance	•	•					•	•	•			•		•	8
Total Quality Management (TQM)				•				•	•				•	•	5
Process control (SPC)				•			•					•			3

Table 4 Elements Linked to the Quality Factor

Table 5 shows the existing concordance between the elements related to the productive force participation factor in which twelve articles of a literature review from 1992 to 2011 are related.

Practice JIT	a	b	c	d	e	f	g	h	i	j	k	l	Total
Multifunctional Employees	•	•		•		•	•			•	•	•	8
Training		•		•		•			•	•	•		6
Participation of Workers in Decision Making		•	•					•					3
Rewards Program		•								•			2
Recruitment and selection		•								•			2

Table 5 Elements linked to the productive force participation factor

Table 6 shows the existing agreement between the elements related to the managerial commitment factor in which articles from a literature review from 1992 to 2011 are related.

Practice JIT									
	a	b	c	d	e	f	g	h	Total
Management presence in the plant.	•	•	•			•	•	•	6
Senior Management Commitment in Execution by JIT.	•	•		•	•			•	5
			•				•		2
Encourage Teamwork.			•				•		2

Table 6 Elements linked to the managerial commitment factor

Methodology

The methodology used in this research has involved the design of a data collection instrument as well as the identification of activities that are important in the success of JIT, and the information was also collected and analyzed to reach a conclusion based on the results found. The different stages are described below as they have been worked.

First stage. Identification of activities and creation of the instrument

At this stage, a bibliographic review was focused on to identify the investigations related to the problem and determine the activities that must be carried out to guarantee the success of JIT, later a preliminary questionnaire was elaborated which was submitted to the evaluation of 3 research professors who extensive knowledge in the area of operations management, a quality manager and a production manager from the maquiladora industry, which determined the ability of the questionnaire to evaluate all the dimensions that are intended to be measured.

The experts were asked: (i) if the correct items had been included (ii) if the questions were easy to understand (iii) if any other item needed to be included. The necessary changes were made according to the comments and suggestions of the experts. In the final version of the questionnaire, basically three types of information were collected:

1. Information that would allow the evaluation of the degree to which the plant uses JIT techniques.

2. Information that could evaluate the benefits of JIT obtained in the plant.

3. Characteristics of the plant and of the person who answered the questionnaire.

The measurement instrument includes 47 items divided into five dimensions: managerial commitment, participation of the productive force, production techniques and elimination of waste, participation of suppliers, quality management.

In addition to eight performance indicators: manufacturing unit cost (Ahmad, 2003; White, 2001; Matsui, 2007); reduction of inventory levels (White, 2001; Nair and Mackelprang, 2010); product conformation quality (Hottenstein, 1995; Ahmad, 2003; Matsui, 2007; Nair and Mackelprang, 2010); delivery time (White, 2001; Ahmad, 2003; Matsui, 2007, Nair and Mackelprang, 2010); flexibility in the introduction of new products (Matsui, 2007) and efficiency in the use of machinery and equipment (Fullerton and McWatters, 2001).

The consistency of the questionnaire was verified through Cronbach's alpha coefficient. Good internal consistency is considered to exist when the alpha value is greater than 0.7 (Nunnally, 1970). A five-point Likert scale was used as a scoring system for the items of the activities, where 1 indicates not implemented and 5 fully implemented. The activities and benefits are illustrated in Table 7 with the abbreviation used throughout this research work.

Abbreviation	Activity
CapCruz	Training of employees to multitask.
RotEst	Rotation of operators between workstations.
OpCon	Hiring of operators for their problem solving skills and teamwork.
CirCal	Formation of work teams to solve production problems.
ProgrRec	Reward workers for learning new skills.
OpResProb	Implementation of a Suggestion System.
OpResIns	Operators' responsibility to inspect their own work.
OpAutDet	Operators have the authority to stop production.
DisSetUp	Emphasis is placed on reducing machinery setup times.
OrgCelMan	Organization of the plant in manufacturing cells.
MaqPeq	Use of small, flexible and mobile machinery.
SisKan	Use of a kanban system for production control.
RedNum	Implementation of measures to reduce the number of processes.
DispPYK	Implementation of Poka-Yoke devices.
DisPro	Close distribution of processes and machinery.
JitMrp	Use of both JIT and MRP or MRP II for production control and planning.
CumDiar	Daily compliance with the production schedule.
Ballinea	Take steps to reduce workload fluctuations through line balancing and stable cycle rates.
ProgProd	Production leveling.
DisMezSim	Within the production schedule, the product mix is designed to be similar to the forecast demand mix.
ProdManFluj	The product is manufactured in a continuous flow within the value chain.
ProEst	Standardization of processes.
ProvIntSis	Integration of suppliers to the company through a push-pull system.
EntrDiar	Deliveries are received daily from most suppliers.
ContrLarg	Long-term contracts with your suppliers.
ProvCert	Supplier certification
RedNum	Reduction in the number of suppliers
SPC	Use of statistical control to control
	and reduce process variation (SPC).
TQM	Implementation of Total Quality Management (TQM) principles and tools.
InCalOr	Guide quality initiatives to the client
TPM	Implementation of a total productive maintenance program (TPM).
BENEFITS OF JIT IMPLEMENTATION	
RedCost	Reduction of manufacturing unit cost costs.
RedNiv	Reduction of raw material inventory levels.
DisWip	Decrease in work-in-process (WIP) inventory levels.
DisInv	Reduction in finished product inventory levels.
DisTiem	Reduction of delivery time (lead time).
IncEfUt	Increased efficiency and use of machinery and equipment.
MejCal	Product quality improvement.
AumVel	Increase in the speed of introduction of new products.

Table 7 Activities and their Abbreviations

An exhaustive search of case studies and empirics published between 1992 and 2011 was carried out based on the elements reported by Ramarapu et. to the. (nineteen ninety-five).

Second stage. Questionnaire application

According to (Malhotra, 2004) a sample of four times the number of items was defined, in this case 47 resulting in 188 the sample size. Although there was a defined sample in this research, it was sought to apply the maximum number of surveys possible. In total, 300 questionnaires were distributed.

The questionnaire was applied in a sample of companies belonging to the manufacturing industry sector in Ciudad Juárez, Chihuahua, Mexico. A convenient sampling method based on personal contacts was used. The questionnaire was applied to managers, engineers, technicians, and supervisors within the organization who were considered to have sufficient knowledge of the operations to complete the questionnaire.

Third stage. Questionnaire application

The information was captured and analyzed with the software SPSS 18. (Statistical Product and Service Solutions). For the validation of the questionnaire, the Cronbach's alpha index was used before performing an analysis.

Fourth stage. Analysis of the information

The statistical analysis included the correlation of the items and the critical factors to reduce the number of variables and subsequently a factor analysis for their grouping into constructs.

Fifth stage. Exploratory Factor Analysis

In the exploratory factor analysis phase, it was determined which observable variables load into which latent variables.

To determine the feasibility of the factor analysis, the variables were correlated (Malhotra, 2004). Barlett's sphericity test was applied to verify if the factorial model is adequate (Malhotra, 2004).

The Kaiser-Meyer-Olkin (KMO) index was obtained to compare the magnitudes of the coefficients of the observed correlation with the magnitudes of the partial correlation coefficients. Establishing a value greater than 0.80 (Levy and Varela, 2004).

A factor analysis was performed using the principal components analysis method to determine the minimum number of factors that explain the greatest variance of the data for use in the subsequent multivariate analysis. The varimax rotation method was used to minimize the number of variables with large loads by one factor, which improved the ability to interpret the factors.

Results

All the questionnaires were subjected to a manual criticism stage to determine if they had been completed in their entirety or if they were answered in a correct way; Forty-one questionnaires were discarded as they did not contain reliable information. Remaining a sample of 205 valid questionnaires, which represents 68.33% of the total questionnaires sent.

Cronbach's alpha coefficient was used to determine the reliability of the instrument as a measure of internal consistency. Following the recommendations of authors such as Cortina (1993), Kamata et. to the. (2003); Levy and Varela (2003) and Streiner (2003) calculated the coefficient for each dimension.

Dimension	Cronbach's Alpha (α)
Factor Linked to Management Commitment	0.871
Factor Linked to the Participation of Productive Force	0.847
Factor Linked to JIT Practices	0.913
Factor Linked to Supplier Strategy	0.794
Factor Linked to Quality Management	0.848
Performance Factor	0.893

Table 8

Exploratory factor analysis of activities

In the first instance, the correlation matrix was analyzed and it was observed that there are a substantial number of correlations greater than 0.30 (Nunnally and Bernstein, 2005); Most of them are incredibly significant with a "p" equal to or close to zero, which shows that it is feasible to perform factor analysis.

To estimate the adequacy of the factorial model to the data, the anti-image matrix was analyzed in which most of the non-diagonal elements were small and the diagonal elements were large. In addition, the percentage of absolute residuals greater than .05 was 22%, which is why the factorial model is considered. A value of the determinant of the correlation matrix was obtained equal to 1.58E-011, which indicates that the variables are linearly related and that the correlations are extremely high.
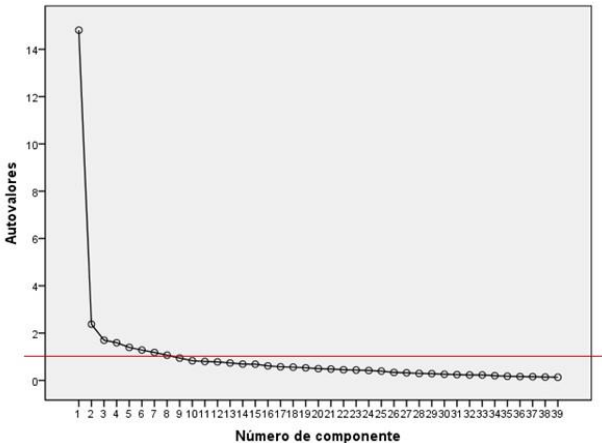

Figure 1 Sedimentation graph of activities

The KMO is equal to .917 which is considered very good and indicates that it is appropriate to use factor analysis. The principal components method was used to extract the factors. Figure 1 shows the sedimentation graph, where the number of components with an eigenvalue greater than one can be seen.

In terms of the total variance explained, there was no great difference between a 7-component structure and an 8-component structure. Based on these results, it was decided to eliminate a component in order to simplify the problem and have a simpler model. Table 3 shows the results of the total variance explained with a factorial structure of 7 factors that together explain 62.394 percent of the total variance.

eje	Autovalores Iniciales			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	14.81	37.97	37.97	4.956	12.709	12.709
2	2.374	6.087	44.057	3.996	10.247	22.956
3	1.7	4.36	48.417	3.874	9.933	32.889
4	1.592	4.082	52.499	3.249	8.331	41.22
5	1.395	3.576	56.075	3.197	8.197	49.417
6	1.283	3.29	59.366	2.964	7.601	57.018
7	1.181	3.029	62.394	2.097	5.376	62.394
8	1.067	2.736	65.131			

Table 8 Total Explained Variance with 7 components

Once the number of factors has been decided, the final solution is obtained, which is the matrix of components. Items with a value less than 0.50 were deleted (Levy and Varela, 2003). In order to obtain an easier to interpret solution, the matrix of components was rotated by the varimax method. The results are shown in table 9.

Practicas JIT		Compromiso Gerencial		Control de Calidad		Estrategia de Proveedor		Distribución de la Planta		Trabajo en equipo		Autoridad y Responsabilidad	
Item	Carga	Item	Carga	Item	Carga	Item	Carga	Item	Carga	Item	Carga	Item	Carga
ProdMan	0.71	GerIng	0.751	TQM	0.73	ProvInt	0.73	OrgCel	0.69	OpCon	0.77	OpRes	0.78
CumDiar	0.64	DifDep	0.636	SPC	0.73	EntrDiar	0.73	MaqPeq	0.63	Progr	0.66	OpAut	0.66
DisMez	0.63	ComEj	0.622	DispPYK	0.64	ProvCert	0.59	DisPro	0.57	CirCal	0.65		
ProgProd	0.62	SupFom	0.602	TPM	0.60	RedNum	0.56						
SisKan	0.58	OrgCul	0.571	SisAuto	0.55	ContrLarg	0.52						
Ballinea	0.57	MejHab	0.557										
ProEst	0.54												
JitMrp	0.53												

Table 9 Rotated Components Matrix of Activities

Exploratory Factor Analysis of JIT Benefits

A value of the determinant of the correlation matrix equal to .007 was obtained, which indicates that the correlations are high. The KMO is equal to .894 which is considered good and indicates that it is appropriate to use factor analysis. The principal components method and Kaiser's rule were used to extract the factors. The results of the total variance explained are shown in table 10, as it can be seen that the two factors explain 71.80% of the total variance.

eje	Autovalores Iniciales			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	4.596	57.446	57.446	3.249	40.608	40.608
2	1.148	14.355	71.801	2.495	31.193	71.801
3	0.609	7.607	79.408			

Table 10 Total Explained Variance of JIT Benefits

Figure 2 shows the sedimentation graph, where it can be seen that there are two components with an eigenvalue greater than one.
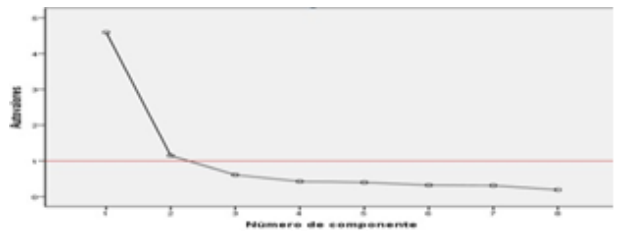
Figure 2 JIT profit sedimentation chart

Once the number of factors has been decided, the final solution is obtained, which is the matrix of components. In order to obtain an easier to interpret solution, the matrix of components was rotated by the varimax method. The results are shown in table 11.

Eje	Componente	Carga	
			Descripción
1	La implementación exitosa de JIT resulta en un aumento en la velocidad de introducción de nuevos productos.	0.839	
	Debido a la implementación de JIT disminuye el tiempo de entrega (lead time).	0.818	
	Debido a la implementación de JIT se mejora la calidad del producto.	0.759	
	La implementación exitosa de JIT incrementa la eficiencia y utilización de maquinaria y equipo.	0.735	
	La implementación exitosa de JIT resulta en una reducción de los costos de costos unitarios de manufactura.	0.708	Desempeño Operacional
2	La implementación exitosa de JIT resulta en una reducción los niveles de inventario de producto terminado	0.863	
	Debido a la implementación exitosa de JIT se reducen los niveles de inventario de materia prima	0.853	
	Debido a la implementación de JIT disminuyen los niveles de inventario de trabajo en proceso (WIP)	0.823	Reducción de los Niveles de Inventario

Table 11 Rotated Component Matrix of JIT Benefits

Conclusions

The resulting FCEs for the JIT implementation are:

Management Commitment, Plant Distribution, Quality Management, Supplier Strategy and JIT Practices. Based on the final structural equation model, we can see that JIT practices are related to other areas such as quality management, plant distribution, and managerial commitment.

The JIT production system contributes to improving performance in inventory levels. On the other hand, the layout of the plant has a significant impact on operational performance. The JIT production system indirectly impacts operational performance through other areas such as plant layout and performance in inventory levels.

The JIT production system influences some areas while others support the JIT production system. Therefore, it is recommended that companies take advantage of these synergistic effects to improve their competitiveness in the market. The results of this study also demonstrated that a successful JIT implementation requires strong managerial commitment.

One direction for future research would be to study the implementation process. That is, how JIT practices and infrastructure practices can be implemented to achieve superior competitive performance within the plant. In addition, other factors can be incorporated into the model such as the manufacturing strategy and customer-linked JIT.

The results of the impact of JIT FCEs on performance indicators deserve to be considered as part of the strategy of the manufacturing industry in order to improve competitiveness.

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Identification of the level of industrial automation in the productive environment of the Universidad Tecnológica Fidel Velázquez: methodology and results

Identificación del nivel de automatización industrial en el entorno productivo de la Universidad Tecnológica Fidel Velázquez: metodología y resultados

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Abstract

Objectives, methodology: Designing a mathematical model to estimate the time of conditioning the paper. From the information available is performed a correlation and regression analysis, we get a mathematical model, determines their validity and is shown by their use in the development of software. Contribution: Currently for the offset printers, there is no equation available, to estimate the time of conditioning the paper from the temperature difference with respect to the print room and the volume. This work contributes in the professionalization of the graphic arts industry in relation to the development of software, the administration and planning of the production, the plans and programs of study of the career of graphic arts that offer technological universities, as well as in the formation of human resources.

Graphic arts, Software, Conditioning for paper

Resumen

Objetivos, metodología: Diseñar un modelo matemático que permita estimar el tiempo de acondicionamiento del papel offset. A partir de la información disponible se realiza un análisis de correlación y regresión, se obtiene un modelo matemático, se determina su validez y se muestra su uso en el desarrollo de software. Contribución: Actualmente no hay disponible para los impresores offset una fórmula que permita estimar el tiempo de acondicionamiento del papel a partir de su temperatura con respecto a la sala de impresión y su volumen. Este trabajo contribuye en la profesionalización del sector de las artes gráficas en lo relacionado al desarrollo de software, la administración y planeación de la producción, los planes y programas de estudio de la carrera de artes gráficas que ofrecen las Universidades Tecnológicas, así como en la formación de recursos humanos.

Artes gráficas, Software, Acondicionamiento de papel

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Introduction

Industrial automation is an issue that occupies a significant number of mainly manufacturing companies, because it provides advantages that allow them to face the challenges of the currently highly competitive market; with the consequent reduction in production downtime, waste of raw material, worker safety risks and increased response speed to customers.

The study is based on the identification of technological components integrated by levels in the automation pyramid or CIM (acronym for Computer Integrated Manufacturing). To use it, the technological elements to be identified in the 5 levels were specified, with levels 3, 4 and 5 being subdivided into sublevels (there are no sublevels in the traditional pyramid). Likewise, the survey and the method to analyze the results were designed, for which there is no precedent. The terminology used is described below.

The automation pyramid is made up of 5 levels, where each one represents the gradual incorporation of technologies that allow from the automation of the physical process to the systematization of the data from it, thereby achieving total control of the company.

Level 1. There are sensors and actuators. Through the sensors, the process data (values of the physical variables to be controlled) are acquired and the actions on the process are executed by means of actuators, which is why both represent the basis for a programmable control integration (level 2).

Level 2. Different programmable control systems such as programmable logic controllers (PLCs), computerized numerical controls (CNC), robot controllers, industrial computers and microcontrollers are integrated. In it, the information from the lower level devices is prepared and the user is informed of the situation of the controllers, the processes and the variables to be controlled.

Level 3. The elements that allow communication between the machines and / or cells that make it up to control, obtain, visualize and / or process the data from the hardware defined in levels 1 and 2 are integrated into the manufacturing system. Said communication may have two purposes:

a) Obtain, visualize and store a limited set of data. In this case, the software configurable screens called Human Machine Interfaces (HMI acronym for Human Machine Interface) are used, which obtain the data from a PLC.

b) Execute actions on the process remotely, processing and storing data obtained from it for the control and quality of production. For this purpose, control and data acquisition systems are used (SCADA from the acronym for Supervisory Control And Data Acquisition).

With the first, partially integrated level 3 is obtained and with the second a fully integrated level 3, the latter being the basis for the integration of level 4.

Level 4. At this level, new computer programs are integrated to the control and data acquisition program, whose main function is planning and the requirement of materials for production (MRP, acronym for Material Requirements Planning), as well as inventory control. With these programs, the manufacturing processes and their specific sequence are designed and defined, the material and resources (machines, programs, etc.) necessary to obtain the final product are managed, maintenance work is planned, etc.

If the system has a partially integrated level 3 and has the programs described in it (level 4) or if the system has a fully integrated level 3 and has the programs described in this level (4) but less than 100% implemented of its production system, it is considered a partially integrated level 4. If the system has a fully integrated level 3 and the programs described in this level are implemented in 100% of its production system, it is considered a fully integrated level 4.

Level 5. At this level, the management and integration of the lower levels is carried out, adding computer programs to the existing ones and whose main function is global management: purchases, sales, marketing, research, strategic objectives, medium and long planning. term, which means the complete integration of the productive area with the administrative area of the company.

If the programs listed in level 4 allow the function described in the complete production system (production and administration) then it is considered to have a fully integrated level 5. If the integration percentage between productive and administrative departments is less than 100%, then it is considered to have a partially integrated level 5.

The identification of the level of automation requires extensive knowledge in this area, knowledge of the elements that characterize each level of automation, a database with specific information derived from production systems (such as the location of the company, the product to be manufactures, the threads that are carried out in it, the size of the company and others), a survey and a method that allows its identification individually. In this case, each of the characteristics was worked on and the survey was applied to the determined sample of companies, obtaining an overall result.

Through joint work with company staff, students and teachers in the development of work stays, it has been identified that a significant number of these companies carry out their production processes manually, using mechanical devices in the best of cases. and electromechanical. A significant number of them have seen the urgent need to increase the speed of their production and the quality of their product, which has led them to invest in devices or machinery that automate a part of their production system (for example, integrating a Programmable Logic Controller or acquiring machinery with Computerized Numerical Control).

This investment, from the authors' point of view, does not contemplate the possibility of integration at a higher level of automation, a situation that would lead the company in the future to have to re-invest in the same concept, if it wishes to increase it.

Likewise, a large number of personnel who carry out the implementation of partial automation solutions, commonly maintenance managers, are unaware that it is possible to integrate their processes at a higher level and those who do, do not have the technical knowledge to do so.

We must not lose sight of the fact that companies invest in the automation of their processes not only to increase their production but also to compete in an increasingly demanding market. In this sense, ignoring the level of automation that prevails in their environment could place them at a serious disadvantage compared to the competition.

Hypothesis: The largest economic units (companies) dedicated to the manufacture of products, which are located in the productive environment of the UTFV, have the highest level of automation, assessable by levels.

The article was divided into three sections: the first describes how the size of the sample of economic units to be surveyed was determined. The second explains the design of the instrument used (survey), the restrictions for its development and application, as well as the mechanism used to collect and systematize data.

The third describes the methodology for data analysis and the result of applying it with the consequent identification of the level of industrial automation in the productive environment of the UTFV.

Universe and sample determination

The source of information used for the first quantification of companies was the database that integrated the National Institute of Statistics, Geography and Informatics (INEGI) in the National Statistical Directory of Economic Units (DENUE) from the 2009 economic censuses, where groups by economic activity establishments, institutions, organizations, companies, among others (considered as economic units). Taking as a reference to classify them to the North American Industrial Classification System (NAICS). To consult the DENUE, the following variables can be used: economic activity, size of the establishment, geographical area and location. With the geographic area variable it is possible to quantify the number of companies (economic units) in the country, by states and municipalities.

The activities aimed at the manufacture of products whose processes are capable of employing automation, are in the sector identified with the name of (31-33) Manufacturing Industries.

According to the DENUE, in Mexico there are 515,562 economic units dedicated to the manufacture of products, of which 10.64% (54,861) are located in the State of Mexico. Of the state total, 15.93% (8,426) are found in the 6 municipalities of the study, distributed according to Table 1.

Number and name of the municipality (INEGI identification)	State percentage
(15104) TLALNEPANTLA DE BAZ	4.01%
(15057) NAUCALPAN DE JUÁREZ	3.98%
(15121) CUAUTITLÁN IZCALLI	2.72%
(15013) ATIZAPÁN DE ZARAGOZA	2.64%
(15060) NICOLÁS ROMERO	2.01%
(15024) CUAUTITLÁN	0.57%
Total	15.93%

Table 1. Economic units dedicated to manufacturing in 6 municipalities of the State of Mexico

As additional data, the first four municipalities are within the ten with the highest concentration of economic units in the State of Mexico.

Identification of economic activities capable of employing automation

With the information from DENUE, a database broken down into activity classes and number of economic units (8,426) was integrated, which was analyzed to identify those that could use automation, eliminating those that met the following criteria:

- Where the variety of products is very wide and the manufacturing activities are not carried out manually and / or by hand; for example: blacksmiths and carpentry.

- Where the machinery is not susceptible to increasing its level of automation and / or the product is unitary with minimal changes in its configuration; for example: tortillerías.

- Where the number of economic units was zero (although they could integrate automation into their processes).

Results

With the described criteria, 31 classes of activity were eliminated (grouping 5,116 economic units), subtracting 261 (grouping 3,310 units). See Table 2.

Determination of the universe based on the size of the establishment

The 3,310 economic units were separated by size of establishment to quantify those that could integrate the highest level of automation evaluable by levels (medium and large).

	Number of employees	MC 0 a 10	P 11 a 50	M 51 a 250	G 250 o más	Total	% MUN
Municipality	(15024) CUAUTITLÁN	118	19	5	5	147	4.5%
	(15060) NICOLÁS ROMERO	156	16	6	2	180	5.4%
	(15013) ATIZAPÁN DE ZARAGOZA	297	90	32	9	428	13.0%
		324	93	78	23	518	15.7%
	(15121) CUAUTITLÁN IZCALLI	594	186	141	33	954	28.9%
	(15057) NAUCALPAN DE JUÁREZ	717	187	136	36	1,076	32.6%
	(15104) TLALNEPANTLA DE BAZ	2,206	591	398	108	3,303	

MC = Micro
P = Small
M = Medium
G = Large

Table 2 Economic units stratified by size of establishment, susceptible to employing automation

Results

From the above, it can be deduced that the universe is identified by 506 economic units (medium and large-sized companies). The formula to be applied to determine the sample size is:

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{(N-1) \cdot e^2 + Z^2 \cdot p \cdot (1-p)} \quad (1)$$

Where:

n: is the sample size

N: is the size of the universe

Z: is the deviation from the mean value that is accepted to achieve the desired level of confidence

e: is the maximum margin of error

p: is the portion expected to be found

Data

N = 506 economic units

$Z = 62.27 \equiv 1$

$e = 10\% = 0.10$

$p = 50\% = 0.50$ *

* In this case, 50% is handled because it is unknown what to expect.

Applying the formula:

$$n = \frac{(506)(1)(0.50)(1-0.50)}{(506-1)(0.10)^2 + 1^2(0.50)(1-0.50)} \qquad (2)$$

$$n = 23.86$$

Therefore, the sample size is 24 economic units.

Development of the instrument, data collection and systematization

The instrument used was a survey, where its development was subject to the following restrictions.

- The selected personnel must know the operation of the machinery and equipment of the entire production process.

- The questions must include written aids to guide the respondent on the answer to choose, since the staff may not know or have forgotten the terminology and concepts that would be very useful to raise technical questions.

- The difficulty for companies to grant consent for its application, considering that important data for the study are confidential information.

- A single type of survey should be designed but there should be an element of it that allows differentiating between production processes organized in a linear way and those with a combined (non-linear) organization.

Results

As a result of the foregoing, a survey consisting of 11 questions was designed to be applied in economic units of the 6 municipalities in the UTFV's area of influence, dedicated to the manufacture of products, whose production process is capable of employing automation in the 5 estimated levels of the pyramid of industrial automation.

The first 4 questions place the surveyed companies within a class of economic activity (according to SCIAN) and company size (according to the number of employees). Questions 5 and 6 determine whether the economic unit has a linear or non-linear organization. From 6 to 10 allow the identification of the level of automation. Number 11 corresponds to the data of the personnel who responded to the survey.

For each selected company, a letter of presentation signed by the Rector of the UTFV was made, requesting authorization for the application of the instrument. The information gathering was carried out from its application to the personnel with the defined profile. A field coordinator was appointed, who was responsible for the implementation logistics. Likewise, two supervisors were assigned whose primary function was to corroborate the veracity of the information and to review the instruments applied.

For the grouping of the information and the elaboration of the corresponding relationships, an electronic spreadsheet was used.

Methodology for data analysis

To perform the analysis of the level of automation, a methodology was designed that consists of working data filters from combinations of possible answers, which were applied from question 5.

First filter

The first filter corresponds to question number 5, referring to the organization of the productive space. This question is very important for research because it allows the separation between companies with processes organized exclusively in a linear way, which presuppose less difficulty in technological integration due to having a greater grouping of similar sub-processes; and those that have a non-linear organization that presuppose greater difficulty in technological integration due to the diversity of their sub-processes.

The question was posed as follows:

Question 5.- How is the productive space organized? Mark with a dove. You can indicate several options.

With 5 possible answers, of which only four are quantifiable: Online, By sub-process, By by-product, By cell and others. Please specify.

Of the 4 quantifiable responses, there are 16 possible combinations that were analyzed to determine if the productive space is linear or not. Table 3 shows the possible responses and the form of interpretation for each combination, considering as linear organization the response where only the Online option had been indicated.

When selecting only one of the remaining options, a non-linear organization was considered, as well as those responses where 2 or more options had been selected.

A	B	C	D	Interpretation
0	0	0	0	No selection
1	0	0	0	Linear organization
0	0	0	1	Nonlinear organization
0	1	0	0	Nonlinear organization
0	0	1	0	Nonlinear organization
0	0	1	1	Nonlinear organization
0	1	0	1	Nonlinear organization
0	1	1	0	Nonlinear organization
0	1	1	1	Nonlinear organization
1	0	0	1	Nonlinear organization
1	0	1	0	Nonlinear organization
1	0	1	1	Nonlinear organization
1	1	0	0	Nonlinear organization
1	1	0	1	Nonlinear organization
1	1	1	0	Nonlinear organization
1	1	1	1	Nonlinear organization
A= Online				
B = Per thread				
C = By by-product				
D = Per cell				

Table 3 Possible combinations to identify the form of organization of production

Second filter

The second filter corresponds to question number 7, referring to the way in which the sub-processes (operations) that make up the production system are carried out. This question allows the separation between companies where the threads are exclusively manual and those that could integrate automation technologies that can be evaluated by levels.

Once the first filter has been applied, the second would be applied to economic units with both forms of organization of production (linear or non-linear).

The question was posed as follows:

Question 7.- What is the way in which the indicated threads are carried out? Mark with a dove. You can indicate several options.

With 5 possible answers, of which only four are quantifiable: Manual, Semiautomatic, Conventional Machinery, Programmable Machinery and Others. In each answer to this question, written aids were proposed to understand the term to be selected. See Table 4.

Handbook	Where the worker involved uses his hands to carry out the process and perhaps some manual tool such as screwdrivers, cutting pliers, etc.
Semiautomatic	Where the worker involved uses his hands to carry out the process and perhaps a motorized, pneumatic or hydraulic tool.
With conventional machinery where it is driven by a motor and / or electrical, pneumatic or hydraulic system, but it is not programmable	Where the worker involved uses their hands to operate equipment, remove, place, adjust materials and / or tools.
With programmable machinery (CNC, PLC) where the product or process configuration can be modified	Where the worker involved uses their hands to operate the equipment, remove, place, adjust materials and or tools and change the program or modify the sequence of the process.

Table 4 Written aids to guide the meaning of the answer to question 7

Of the 4 quantifiable responses, there are 16 possible combinations that are shown in Table 5, where the form of interpretation for each combination is explained below:

a) A manual production process was considered to be that response where one of the following situations had been selected: the manual option, the option with conventional machinery or the combination of the manual options and with conventional machinery. The manual option is related to the use of the hands and basic tools such as screwdrivers, hand drills, etc. The option with conventional machinery is related to the use of machinery that could have motors without programmable control devices such as conventional lathes, milling machines and drills.

b) A level 1 production system was considered to be companies where the only selection could be the semi-automatic option or combined with the manual options and / or conventional machinery. This assignment was made because the basis for automation are sensors and actuators that could be integrated in production systems with semi-automatic equipment.

c) It was considered that the production system should be evaluated for levels higher than level 1, when the selection could include the option with programmable machinery, alone or combined with any of the other options. This criterion was defined because the basis for the integration of levels 3 to 5 are programmable devices such as PLC's, CNC's, industrial controllers (that are integrated into robots), industrial computers and / or control devices with individual programming such as microcontrollers. Programmable devices are considered the essential characteristic to evaluate equipment in a level 2 of industrial automation. See Table 5.

A	B	C	D	Interpretation
0	0	0	0	No selection
0	0	1	0	Handbook
1	0	0	0	Handbook
1	0	1	0	Handbook
0	1	0	0	Level 1
0	1	1	0	Level 1
1	1	0	0	Level 1
1	1	1	0	Level 1
0	0	0	1	Evaluate next level
0	0	1	1	Evaluate next level
0	1	0	1	Evaluate next level
0	1	1	1	Evaluate next level
1	0	0	1	Evaluate next level
1	0	1	1	Evaluate next level
1	1	0	1	Evaluate next level
1	1	1	1	Evaluate next level

A= Handbook
B = Semi-automatic
C = With conventional machinery
D = With programmable machinery

Table 5 Possible combinations to identify if the process is manual or has evaluable automation by levels

Third filter

The third filter corresponds to question number 8, referring to the way in which the process is monitored and controlled in terms of quantity or quality of the product. Only those companies that, within the possible options of question 7, have chosen the option with programmable machinery, which is the basis for the evaluation of level 2 and the other levels, pass this filter. This question also provides the guideline for the evaluation of level 3, referring to the use of visualization and data acquisition systems.

The question was posed as follows:

What is the way in which the quantity or quality of the product is monitored and controlled? Mark with one. You can indicate several options.

With 3 possible answers: Manual, Online instrumented monitoring, Remote instrumented monitoring and control. In each answer to this question, written aids were proposed to understand the term to be selected. See Table 6.

Handbook	Where the worker involved uses his hands to count or verify the product in question and raises statistics that are tabulated on paper or electronic sheets.
Online instrumented monitoring	Where the worker involved takes data readings or downloads them from devices connected directly to the line or process, they can also make manual adjustments directly to the device displaying the data.
Remote instrumented monitoring and control	Where the worker involved views, monitors and / or controls the process, from a computer or similar device, in a place away from it.

Table 6 Written aids to guide the meaning of the answer to question 8

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Of the 3 responses there are 8 possible combinations that are shown in table 7, where the form of interpretation is explained below.

a) It was considered as a production process in level 2 when the only selection is the manual option, which means that it has programmable control devices, but does not have any element that associates it with level 3.

b) Level 3 was evaluated in two integration phases: full integration where a visualization and data acquisition system is found in the complete production system, remotely installed on a computer, and level 3 partially integrated when the system Productivo only has graphic or text display devices connected to programmable control equipment. The key to considering Level 3 fully integrated is that only the remote instrumented control and monitoring option has been selected. Considering that this level of complete integration is present, we proceed to indicate that it be evaluated for the following levels (4 and 5). Likewise, it is considered as partially integrated level 3 when the option of online instrumented monitoring has been selected, alone or combined with the manual option, where the following question is carried out to partially integrated Level 4 without the possibility of evaluating a level 5. See table 7.

A	B	C	Interpretation
0	0	0	No selection
0	0	1	Assess levels 3, 4 and 5
0	1	0	Level 3 partially integrated. Do not evaluate next levels
0	1	1	Level 3 partially integrated. Assess level 4 partially integrated
1	0	0	Level 2
1	0	1	Level 3 partially integrated. Assess level 4 partially integrated
1	1	0	Level 3 partially integrated. Do not evaluate next levels
1	1	1	Level 3 partially integrated. Assess level 4 partially integrated

A = Handbook
B = Online instrumented monitoring
C = Remote instrumented monitoring and control

Table 7 Possible combinations to identify if the process has level 2 or higher

Fourth filter

The fourth filter corresponds to question number 9, referring to the way in which the inputs and material requirements for the product are planned. Only those companies that, within the possible options of question 8, have chosen the remote instrumented monitoring option, pass this filter. If the selection was unique, it is evaluated for level 4 with the possibility of evaluating level 5, if the selection was combined with online instrumented monitoring and / or with the manual option then it is evaluated for partially integrated level 4.

The question was posed as follows: 9. What is the way in which the inputs and material requirements for the product are planned? Mark with one. Indicate only one option.

	Check
A person or group of people carry out the planning using data from the process that is documented only on paper and / or with an office computer program such as Excel, Access and other types of software.	
A person or group of people carry out the planning using a specialized computer program for this task where the data from the process are captured directly in the program and processed through it.	
A person or group of people carry out the planning using a specialized computer program for this task where the data from the process are obtained directly from it and transferred to the program through a computer network that interconnects the productive equipment with the computer (s) that they are in administrative areas.	

Table 8 Written aids to guide the meaning of the answer to question 9

Although of the 3 responses (see Table 8) there are 8 possible combinations (see Table 9), only three are significant, since the respondent had to choose one of three. The significant combinations are shown in table 8, where the form of interpretation was explained above.

A	B	C	Interpretation
0	0	0	No selection
0	0	1	Integrated level 4. Assess level 5
0	1	0	Level 4 partially integrated
0	1	1	Not valid
1	0	0	Level 3. Do not evaluate subsequent levels
1	0	1	Not valid
1	1	0	Not valid
1	1	1	Not valid

A = First option
B = Second option
C = Third option

Table 9 Possible combinations to identify if the process has level 3 or higher

HERNÁNDEZ, Leticia, HERNÁNDEZ, Carlos, PÉREZ, Liliana and CARRILLO, Oscar. Identification of the level of industrial automation in the productive environment of the Universidad Tecnológica Fidel Velázquez: methodology and results. Journal of Quantitative and Statistical Analysis. 2020

Fifth filter

The fifth filter corresponds to question number 10, referring to the way in which the inputs and material requirements for the product are planned. Only those companies that, within the possible options of question 9, have chosen the third option, which refers to the use of specialized software interconnected in a network for planning and material requirements, pass this filter.

The question was posed as follows:

10. Is there a computer system implemented in a computer network that allows direct interconnection between the production process and one or more administrative areas such as management, the human resources area, planning and material requirements, etc.?

Yes. ____

What approximate percentage of the departments are connected to this system? _____

Do not._____

In this question there are two possible answers: Yes or No. If the answer corresponds to Yes, then the percentage of the departments interconnected to the system is evaluated. If this is 100%, then the production system has a fully integrated level 5, and if this percentage is lower it has a partially integrated level 5.

Results

The results show that 95.8% of the companies that responded to the instrument belong to sectors 32 and 33 dedicated to the manufacture of products for human use (white goods, electronics, automobile assembly and machinery in general). In the same sense, when relating the above with the form of organization of production and the sub-processes that comprise it, it is observed that the main sub-processes carried out in a linear organization correspond to punching, cutting, molding, mixing and packaging. Said sub-processes require machinery (when carried out with it) specially dedicated to the type of sub-process, which could combine technologies such as electronics, pneumatics and hydraulics, specifically controlled by PLCs.

On the other hand, the main sub-processes carried out in a non-linear organization are cutting, assembly, extrusion and stamping, with the selection of processes not chosen in any of the companies with a linear organization, where machinery such as milling machines and lathes are used. with control technology (when it has it) different from that of a PLC, in which its programming can give rise to families of parts, such as CNC devices. This shows that there are companies that manufacture products other than those for human and animal consumption; that organize their production space in a linear way where, due to the type of sub-processes that make them up, they would apply exclusively control devices such as PLCs.

In addition to the above, companies that organize their productive space in a non-linear way (that is, combining the organization by cells with the linear form and / or by sub-process) provide a field of application for control technologies other than PLCs. s like CNC's, microcontrollers and the like.

When applying the 5 filters to each of the companies, it is observed that the predominant level of automation in medium and large companies is partially integrated level 3, which is present in 58.3% of production processes. Likewise, when combining the level of automation evaluated with the size of the company, it is observed that most of the companies with this level are medium or large. The rest of the companies have lower levels (8.3% with level and 16.7% with level 2) or even, according to the defined criteria, they do not have automation (12.5%), because their production process is completely manual (see Figure 1).
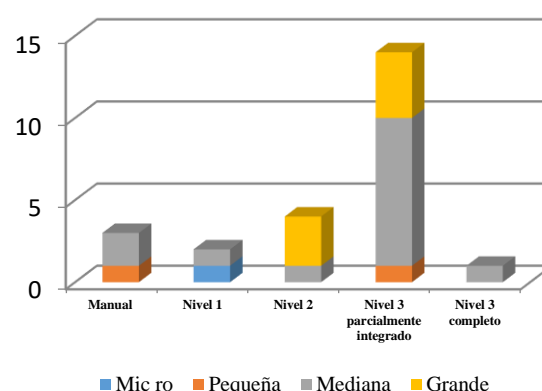

Figure 1 Relationship between economic unit size and level of automation in manufacturing companies in the UTFV production environment

HERNÁNDEZ, Leticia, HERNÁNDEZ, Carlos, PÉREZ, Liliana and CARRILLO, Oscar. Identification of the level of industrial automation in the productive environment of the Universidad Tecnológica Fidel Velázquez: methodology and results. Journal of Quantitative and Statistical Analysis. 2020

Conclusions

When analyzing the industrial manufacturing environment of the UTFV, it is concluded that the largest companies (medium and large) have levels 2 and 3 of automation integrated into their production processes, of which more than half partially use the level 3, that is, they have implemented sensors and actuators in part of their production process that are controlled by programmable devices (mainly PLC's and CNC's).

Where the data from the system can be viewed on a graphic or text screen or through monitoring and data acquisition software (SCADA) installed on a computer remotely.

It is important to consider that the results of the study reflect the level of automation present in less than 15% of all the companies that exist in the municipalities, but that could integrate the highest possible level of automation into their processes, so there is a wide field for the development of automation projects in micro and small companies, with production processes mainly related to the manufacture of parts for machinery and equipment in general, which start at level 1 and are scalable, where students and graduates of educational programs of Industrial Maintenance and Mechatronics, will continue to develop both stays and professional work. In this sense, the identification of the level of automation in conjunction with the electronic database related to the economic activities susceptible to employing automation in the 6 municipalities of the study, provide the guideline to define strategies that strengthen the study plans of these educational programs.

Likewise, any company dedicated to the manufacture of products, which intends to allocate resources to increase the level of automation of its production process, should carry out both the cost-benefit study of the investment and a scalability analysis in terms of technological integration.

In this sense, the methodology applied to a group of companies serves as a basis to identify their level of automation in a particular way to later carry out an evaluation that allows determining the compatibility and scalability of the programmable control devices integrated or to be integrated into the system, which They are the platform to climb to levels three, four and five, where the method for the individual evaluation of the production system must be proposed and developed, considering that the form of organization of the sub-processes that make it up is a very important factor in this evaluation.

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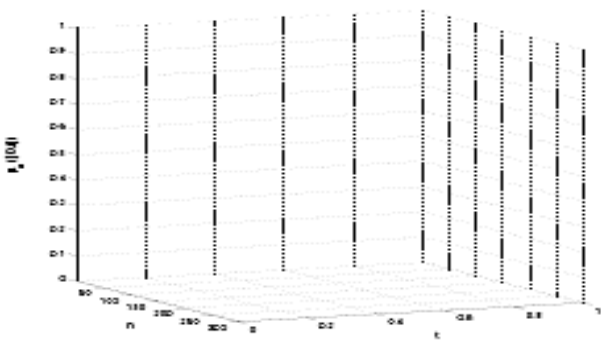
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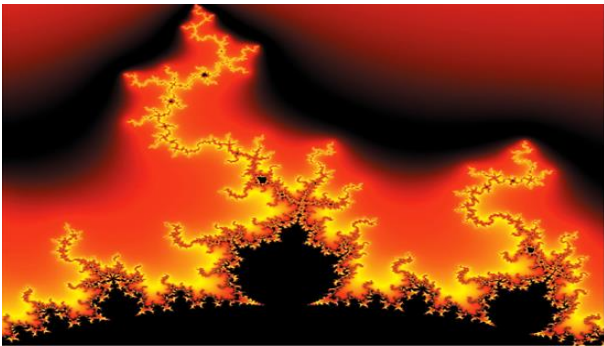
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