Introduction to the industry 4.0, through predictive maintenance, integrating IMAI case of the Technological University of Jalisco

Introducción al tema industria 4.0, a través del mantenimiento predictivo, caso integradora IMAI de la Universidad Tecnológica de Jalisco

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DOI: 10.35429/JSTA.2019.16.5.19.26

Received July 30, 2019; Accepted September 28, 2019

Abstract

At present, Technological Universities present their quality through the affinity of their teaching methods with the needs of the productive sector, although the competences that the graduated students acquire are not always the expected, due to the constant evolution of technologies. Given this problem, the present work has the purpose of increasing the capacities and positioning of the University through the development of predictive maintenance projects with students from the engineering to industrial maintenance majors, focused on the industry 4.0, through a program for developing predictive maintenance applications in order to increase professional skills, brand positioning and the sense of belonging of students with the University. The methodology consists of gathering a group of students of the IMAI major (29 students and 3 teachers), identifying the initial status for each of them during the 4 phases of the program; the first phase seeks the development of human capital; the second an application development predictive maintenance approach; the third, a development of research and brand positioning; and the fourth, a final product.

Industry 4.0, IOT, Predictive maintenance, Professional competences

Resumen

En la actualidad las Universidades Tecnológicas presentan su calidad mediante la afinidad de sus métodos de enseñanza con las necesidades del sector productivo, si bien, las competencias que los alumnos egresados adquieren no siempre son lo esperado, debido a la evolucion constante en las tecnologías. Ante dicha problemática, el presente trabajo tiene el propósito de aumentar las capacidades y posicionamiento de la Universidad a través del desarrollo de proyectos de mantenimiento predictivo, con los alumnos de la carrera de ingeniería a mantenimiento industrial, enfocados al tema industria 4.0. A través de un programa de desarrollo de aplicaciones de mantenimiento predictivo con la finalidad de acrecentar las competencias profesionales, el posicionamiento de marca y el sentido de pertenencia de los alumnos con la Universidad. La metodología consiste en reunir un grupo de alumnos de la carrera de IMAI (29 alumnos y 3 profesores), identificando el estado inicial para cada uno de ellos durante las 4 fases del programa; en donde la primera fase busca el desarrollo de capital humano, en la segunda un desarrollo de aplicaciones enfoque mantenimiento predictivo, en la tercera un desarrollo de trabajos de investigación y posicionamiento de marca, y por último un producto final.

Industria 4.0, IOT, Mantenimiento predictivo, Competencias profesionales

Citation: BARRÓN-BALDERAS, Juan José, FAUSTO-LEPE, Gabriela Margarita, ORTIZ-CORNEJO, Julio Cesar and RAMÍREZ-ULLOA, Sergio. Introduction to the industry 4.0, through predictive maintenance, integrating IMAI case of the Technological University of Jalisco. Journal of Scientific and Technical Applications. 2019, 5-16: 19-26

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Introduction

In recent years, the situation experienced not only in Jalisco, but the whole country does not guarantee getting a job for all graduates, since the industry increasingly requires an endless amount of professional competencies in the maintenance area in order to achieve optimal functioning.

Hence, the primary objective in Technological Universities is to teach applicable competencies with the 30% Theory 70% practical model, to help students face the labor world when they leave university.

With this background, it is very important to link the industry with the academy, so that the students of the different maintenance majors at the Technological University of Jalisco can be up to date, knowing the scope, applications and potential of unmanned vehicles, as an emerging work tool in the maintenance area.

Taking this into account, this paper contributes to the scientific and academic fields by implementing a drone workshop with the aim of involving employees and students of the Technological University of Jalisco in the subject of the Industry 4.0, in order to seek the enrichment of new professional skills to achieve predictive maintenance of inspection tools for the detection and monitoring of variables (concentrations of carbon monoxide, temperature, and thermographic images) through low-cost technology available to everyone.

Likewise, a particular objective is to improve the sense of organizational belonging within the University, because the students share interdepartmental communication, becoming the direct contact with potential candidates for the Engineering in Industrial Maintenance major.

To break this paradigm and demonstrate that the IMAI major is not far from concepts such as:

Industry 4.0, Internet of things, robotic integration of processes, among others and that these projects can be developed, in which the students are involved, acquiring in the process greater skills for when they graduate.

It is worth mentioning that the project was carried out at the end of the quarter so as not to hinder the academic performance of the students.

Definition of the problem

Currently, the Technological University of Jalisco (UTJ), has a student population of 350 students for both shifts in the IMAI major, and as in any educational offer, continuous improvement is sought. In the case of the Industrial Maintenance students, we want them to obtain new knowledge which can give them a competitive advantage when they graduate; likewise, the subject of the industry 4.0 has never been addressed, much less the development of support tools for predictive maintenance, so it represents an opportunity to contribute with the learning and teaching of new professional skills for both students and teachers.

Figure 1 IMAI students with whom the project started
Source: Prepared by the authors, taken in the electricity laboratory of the IMAI major

Hypothesis

The implementation of the predictive maintenance application development program will help to improve the perception of the Technological University of Jalisco, considering that the association of image and quality criteria is positioned, not only over the years, but with the development of projects that influence the university community, resulting in a better positioning of the brand inside and outside the metropolitan area of Guadalajara.

Justification

At the moment, the study programs of the maintenance majors of the Technological University of Jalisco (UTJ), do not present a subject focused towards the development and implementation of applications in the maintenance area, although there are some investigations and advances in this field.

Therefore, we found an opportunity to carry out this work, using “low cost” technology accessible to students. With the help of this project we expect to lay the groundwork for the UTJ, in order to develop further research and place the University within the many study and research centers which explore the concept of the industry 4.0.

The development of this project would consist of several modules, thus enabling students to develop new professional skills and putting into practice concepts learnt throughout the maintenance majors, coupled with the development of the project.

This will allow the improvement and positioning of the perception that students and professors of the UTJ brand have, considering the association of image and quality of new educational offers, taking into account that the brand is positioned over the years.

Objective

- To propose a program model for the development of predictive maintenance applications, as a strategy for the development of new professional competencies for students of the Engineering in Industrial Maintenance major of the Technological University of Jalisco.
- To develop knowledge, skills and attitudes in the participants, to generate new competences not only in predictive maintenance, but also in the whole industry 4.0 subject.
- To develop new tools to facilitate predictive maintenance tasks in places of difficult access, in order to anticipate failures before they occur, performing inspection tasks.

Importance

The conservation and mitigation of negative impacts caused by various factors that influence predictive maintenance; to develop technical and operational capabilities, promoting scientific and technological research within the students of the IMAI major.

Relevance of the investigation

The rise of new emerging technologies requires being at the forefront in learning and teaching students new professional skills, so it is necessary to give them a plus as part of their study in the maintenance majors offered by the university. We give this a specific application as an alternative tool for predictive maintenance, by collecting and sending data quickly and timely in inspection tasks via the Internet or MSN message, thus avoiding risks or dangers difficult to discover and in consequence, injuries and accidents, which imply time and money. In addition, we encounter two types of phenomena: one of them is the little interest in the development of research projects, especially multidisciplinary ones, by professors of the institution.

To what degree is it possible to solve the problem?

The problem with the realization of this project will be solved in the medium and long term. Since the implementation of the program, a small percentage of the student population of the IMAI major has been reached. Given that it is a current topic, it was contemplated to have a good audience, hoping to increase as the program is repeated and renewed every four months.

Waiting the end of the project, the increase, in the scientific-technological field of the percentage of training with new skills in a positive way, this is also reflected in the social sphere, with the increase of the sense of belonging, work environment, and satisfaction of the students within the university.

Theoretical framework

The Industry 4.0 concept can be defined as the digitization of the industry and all the services it carries.

This is due to the need for globalization in a development process which is fast accelerating in recent times.

That is to say, that the virtual and real worlds are merged in the industries, applying new information technologies in all the productive processes. Now, facilities self-manage autonomously, easing responses and market demands.

There are certain aspects that characterize the new Industry 4.0 and that differentiate it from the industries of other historical revolutionary moments of vital importance in the past.

A basic question is found in automation and intercommunication. It has a special impact on an industrial scale, since it interconnects productive units, creates digital production networks and allows the acceleration of all kinds of resources in a much more efficient manner. So, we can find four basic aspects:

- Automation
- Digital access to the client and many more users in less time.
- Connectivity
- Digital information

These four aspects of the new industry show the degree of transformation that we face today.

Now, the new Industry 4.0 is able to provide new responses to customer requirements. That is, at the level of products, processes and business models, the impact is decisive in a value chain, since it brings new benefits. But we must also emphasize that there are certain threats, as many factors may be left out, such as unskilled labor.

At the same time, the new industry incorporates great quality in its production, which is coupled with a significant reduction in costs.

Of course, digitalization drastically affects all social factors, and the industry is exception.

So, just as we talk about Industry 4.0 as something revolutionary and historical, we could also refer to a new Society 4.0 which goes hand in hand with it through elements such as electronic administration, specialized training, globalization, and, ultimately, a new world formed by *Smart cities*, where everything is more intelligent, refined, constructive and beneficial.

Advantages of the Industry 4.0

According to information retrieved from <http://www.aldakin.com/industria-4-0-que-es-ventajas-e-inconvenientes/>.

More purified, repetitive processes are obtained without errors or alterations. Thus, an uninterrupted production is available 24 hours a day, which is a notable advantage for highly seasonal companies, for example:

Quality levels are optimized. Process automation allows greater precision in weights, measurements and mixtures. Moreover, dead times and interruptions are prevented.

Obviously, the greater the efficiency are, the greater the cost savings. Automated processes require fewer personnel, fewer errors and greater energy efficiency, raw materials, etc.

Production times are drastically cut.

Greater security is ensured for the personnel involved in each process. This point is especially important for labor at high temperatures, with heavy weights or in hazardous environments.

The production is much more flexible, since the product adapts to the requirements of each particular company.

Data flow is now much more efficient due to communication networks. Reaction times and decision making are reduced.

Naturally, business competitiveness is much higher. The needs of the markets are better approached, high quality products are offered and quicker and more flexible reactions to change are possible.

It ensures great potential to connect millions of people through digital networks.

Thanks to the new industry, asset management is more sustainable and can even regenerate the natural environment.

The performance of organizations improves in efficiency.

Regarding predictive maintenance, Robert C. Rosaler (2002) mentions it as the technique to predict the future point of breakage or breakdown of a machine component, so that said component can be replaced, based on a plan, just before its failure; Santiago García Garrido (2009) mentions in his book that the predictive techniques usually employed in the industry are the following:

- Vibration analysis
- Borescopes
- Thermographs
- Oil analysis
- Thickness control in static equipment
- Visual inspections
- Indicator reading

Taking these applications into account, they can be part of the implementation using drones such as visual inspections. However, others can be added to complement the drones as tools not only for predictive maintenance, but also as tools that generate knowledge and skills in young people studying maintenance majors in the industrial or heavy machinery field. That is why we can implement what G. P. Bunk (1994) mentions in his work on professional competencies, referred to as a set of knowledge skills and aptitudes needed when exercising a profession, solving problems of the profession in an autonomous and flexible manner, as well as having the ability to assist in the professional context and in the organization of work.

By developing a program within the institution in which the subjects of drones and predictive maintenance are exploited, the increase of the concept of professional capacities can be achieved in the teaching staff and in the students, which will increase the basic competences which facilitates access to training or a job.

The basic knowledge that enables access to a job are: Ability to innovate, Ability to work rigorously, Analytical ability, Ability to lead, Ability to communicate, Ability to interact, Ability to work as a team, Ability to manage stress, Ability to adapt, Ability to organize, Ability to reach a goal, Ability to specialize.

Furthermore, with the approach of a program for the development of drones, not only would it serve to obtain as a result the development of professional competences, it can also serve to reaffirm the internal marketing term, according to Ruiz de Alba (2010). This was created with the purpose of improving customer service.

Since then and until now, this concept has not been posed as a strategy in educational institutions to generate a sense of belonging and communication which satisfies the internal customer.

So it would be very important to add this concept to the drone development project for predictive maintenance within the institution, because it would provide added value necessary for the institution, teaching staff and students of other educational programs to stand out in the metropolitan area of Guadalajara.

Methodology

To identify opportunities for improvement, the cause-effect diagram was used (Figure 2) as a support tool to look for the potential (or real) causes of the possible performance problem, since it allows to look for the main causes of the presented problem and to establish the priority of solutions for the yield improvements in the project development.

Figure 2 Block diagram used to monitor the operation of the project “Implementation of a temperature and humidity sensor network for controlled environments in the industry”

Source: Prepared by students from the 10th quarter period of the IMAI major at the UTJ

Once the opportunities for improvement were identified, the Gantt chart tool was used to organize this research project, in order to plan and schedule the activities throughout the period between January and June, 2019; so that participants rely on the knowledge acquired in the areas of analog and digital electronics, machines and mechanisms.

To obtain a good result at the end of the four-month period, the program of the integrative subject was divided into 4 phases which consisted of:

Phase 1 Human Capital Development

Phase Description

In this phase, basic concepts of the industry 4.0, its history, types and applications were addressed.

We took 2 hours of class, Development of new Professional competences, skills and attitudes in the participants in order to facilitate and improve personal communication skills in the internal environment as an opportunity to motivate the work teams and enhance the productivity of IMAI students.

Within the subject of the industry 4.0, the topic of predictive maintenance was addressed, as it contributes to having less down time in any process, large expenses are avoided, and less human capital is required. The following projects were carried out by the student teams of the 10 IMAI group:

Design and implementation of a wireless sensor network to monitor temperature and humidity in electric motors.

Implementation of a temperature and humidity sensor network for controlled environments in the industry. In these projects several topics of engineering 4.0 are covered, such as cloud data management, IoT, automation and predictive maintenance.

Phase 2 Application development with predictive maintenance approach

Phase Description

Developing new tools to facilitate the predictive maintenance tasks within the industry 4.0 field.

The use of the app inventor program for Android was discussed as part of the application development tool, which benefited from the fact that the participants developed new professional skills such as assembly, programming, c, operation and manipulation of the variables through the application developed. Likewise, they developed the communication of the project to the cloud, to send the acquired data and be able to process them, applying one of the topics of the I 4.0, which is the IoT.

Phase 4 Final product

Description of the Phase

Presentation of the final products, based on collaborative work with the professors and students of the IMAI major of the UTJ, to promote cohesion among professors, students and the university with this type of programs.

It is worth mentioning that it is not only the presentation of the works, but also the follow up with the entrepreneurship program of the UTJ, since the vast majority is subject to have a business, application and employment plan in companies in Jalisco.

Results

The feasibility or cost-benefit of the proposed solution

With the completion of the project, we consider that the cost benefit feasibility is very high, due to the particularity of the program, which is the development of tools applicable in the subject of low-cost industry 4.0; hence, the participants will not waste on unnecessary expenses. The expected result is greater than the invested, since it is increasing and developing new professional skills of the student population of the maintenance division, especially in the industrial maintenance major.

Conclusions

This investigation enabled the documentation of indispensable evidence for the validation of the objective.

At the beginning of the project, internal communication was effective in calling and confirming the participation of a sector of the UTJ, where the evaluated participants lacked the scientific and technological knowledge on the subject of the industry 4.0.

The presentation of the final product developed by the participants before the university community was used to promote cohesion among professors, students and the university; as it resulted from the workshop an increase in the capacities and positioning of the University through the project, as an emerging tool of predictive maintenance.

Likewise, by spreading the results obtained from the program through the institution’s social networks, among other means, in order to position our UTJ brand with the university community, to enhance the current image that we want as leaders in the new education offers in the development of applications for predictive maintenance in the Guadalajara metropolitan area.

The projects are still being refined as part of the search to place them within the incubation project of the university. Therefore, it can be concluded that the result presented before the UTJ community was satisfactory.

Figure 3 Lesson on the industry 4.0 subject with students in the 10th quarter of the IMAI major
Source: Prepared by the authors during the lesson of industry 4.0 issues

Figure 4 Arduino and hc 06 card, configuration for sending data to mobile devices
Source: Prepared by students of the 10 IMAI group with the project “System for monitoring and forecasting failures of a storage room”

Graph 1 Environmental measurement temperature dispersion
Source: Prepared by students of the 10 IMAI group with the project “System for monitoring and forecasting failures of a storage room”

Considerations

There is still room for improvement, hoping that in the coming months the projects can be completed and in the future they could be developed with a new hardware platform, the Raspberry card. With it, the spectrum of operational functions could be increased, including real time access to the needs of the industries, since we will have information of the monitored variables within our reach, so it will be easier and faster to access it through the internet of things (IoT.)

We would link the system to the Internet, so that the monitored variables and images can be incorporated into a database, as well as collected data to help when they are required.

Taking advantage of the fact that this concept may sooner or later reach our daily lives, according to official studies, in 2020 our digital universe will be 44 times larger (in collected data or stored information) than in 2010.

All this will make society as it is today very different. We will be overflowing with information and all this will also be a business opportunity for many. Meanwhile, this will continue to be part of the student's motivation at the Technological University of Jalisco to study the topic of the Industry 4.0.

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