COMPETITIVE INTELLIGENCE PROPOSAL FOR SUPPORTING A MECHATRONIC LABORATORY IN A PRIVATE ACADEMIC INSTITUTE

Laura Yazmín Fuentes Rivera*,

Graduate Student of Master's degree in Science with a minor in Quality and Productivity, ITESM

zmyla.0@gmail.com, + 52 81 83 58 20 00 Ext. 5363

Marisela Rodríguez Salvador*,

Research professor of the Quality and Manufacturing Center, ITESM

marisrod@itesm.mx, + 52 81 83 58 20 00 Ext. 5361

José Roberto Antonio Vega Pino*,

Research Assistant

jo.rvega@gmail.com, +52 81 83 58 20 00 Ext. 5363

Address*

Centro de Calidad y Manufactura ★ Edificio CEDES 3er. Piso ★ ITESM, Campus Monterrey

Eugenio Garza Sada 2501 ★ Col. Tecnológico, Monterrey, N.L., México ★ C.P. 64849

Summary : In this paper, we propose a methodology that incorporates competitive intelligence with product design and development methodologies enhancing an active learning environment. The purpose is to successfully identify opportunities to innovate and support an entrepreneurial effort of an engineering laboratory of an academic private Institute: ITESM (Tecnológico de Monterrey) located on Mexico.

This methodology was applied for the early design of a mechatronic laboratory in the Monterrey campus of the ITESM. The aim was to support the design and development of their didactic equipment workstation of automatic logic control by creating a standard guide allowing the group involved to have a documented process to obtain a teaching guide of automatic logical control. The outcome expected was to establish a first effort concerning the stage of “understanding opportunities” to support the early design of this laboratory which model could be successfully commercialized in the future in other campuses of this Institute or in other organizations.

Keywords: Mechatronic laboratory, didactic equipment workstation, competitive intelligence, new product development (NPD).

Résumé : Dans cet article, nous proposons une méthodologie qui intègre la veille concurrentielle à la conception de produit afin d’expérimenter d’autres processus de cette méthode dans un contexte d'apprentissage actif et permanent. L'objectif de cette expérience didactique est d’identifier les innovations et de promouvoir l’esprit d’entreprise dans le laboratoire d'ingénierie d'un institut académique privé : ITESM (Tecnológico de Monterrey) situé au Mexico.

Cette méthodologie a été mise en œuvre dans un laboratoire de mécatronique situé sur le campus principal de cet institut. Le but de l’expérimentation a été de soutenir la conception et le développement d’un outil d’apprentissage automatique permettant l’élaboration d’un guide commun destiné à tout groupe incorporé dans cette formation. En effet, les objectifs du stage étaient de faire comprendre aux apprenants comment saisir les opportunités innovantes à partir de cette méthode de développement et de réaliser un guide modèle qui pourrait être réapproprié par d’autres instituts académiques et/ou organisations (institutions, entreprises et autres..)

Mots clés : Laboratoire mécatronique, station d’apprentissage, veille technologique, veille concurrentielle, développement de nouveaux produits (NPD), innovation.

Competitive Intelligence proposal for supporting a mechatronic laboratory in a private academic Institute

1 - INTRODUCTION

Universities have constantly been interested in creating a working culture based on innovation, entrepreneurship and enterprising with the creation of centers of entrepreneurship (Menzies, 1998; Trim, 2003). In the past years, universities from around the world have been working on improving their entrepreneurial activities (Wright et al., 2007) by focusing on various activities related to patents, licensing, and research joint ventures to create spin-off companies (Siegel, Wright and Lockett, 2007). Some universities have incorporated these subjects in their courses, however the results have not been the expected ones since the participants have not been able to participate in real life exercises. Given that universities also need to develop business venturing and commercialization skills (Siegel and Phan, 2005; Siegel, Wright and Lockett, 2007, Cantú et al., 2009), they have been interested in designing laboratory courses that initially are to be applied in the same campus and try to commercialize them externally.

In 2000, the mechatronics engineering undergraduate directors of the ITESM (Tecnológico de Monterrey) had the objective of designing, building and developing a new automatic logic control station in the university's main campus mechatronic laboratory for professors and instructors to teach mechatronic material to students. Currently, the mechatronic engineering students at several campus in north states of México took courses in the actual mechatronic laboratory, but the results were not the expected ones since directors and students desired more activities related to applied logical control systems. The ITESM campus Monterrey was interested in designing the new laboratory courses, however the team members would also like to identify the market opportunities of the business in order to initially create more laboratories in other campuses of the same institution and in the future to commercialize this model in companies or other organizations. Given this situation, the project presented in this article has been developed with the objective of establishing a methodology that supports the design and development of the didactic equipment workstation of logic control by creating a standard guide allowing the group to have a documented process to obtain a teaching guide of logical control. In order to develop the proposed methodology, various techniques and processes have been analyzed, including competitive intelligence, product design and development, active learning, didactic equipment workstation workstations, and concurrent engineering.

2 – IMPLEMENTATION IN A PRIVATE ACADEMIC INSTITUTE

In Latin America most of the organizations have not implemented yet a formal competitive intelligence process; as a consequence they are constantly surprised by the changes in the forces of the environment. Even though some of them have shown interest of implementing this formal process, in many cases they still solve most of their problems in the short run with minimum anticipation. In high developed countries universities, institutes and research centers support companies by providing guidelines and consulting services that allow them to formally analyze the competitive environment.

One of Mexico's main industrial areas showing interest in implementing competitive intelligence activities is Monterrey, Nuevo León where more than 13,000 manufacturing companies are present. Some of the industries that coexist in the city are related to steel, cement, household appliances, synthetic fibers and glass.

Additionally, the city of Monterrey contains the country's largest number of universities and technological institutes on a per capita basis. One of the most important private academic institutions in Latin America is ITESM (Tecnológico de Monterrey). Founded by companies in 1943, this Institute has grown into a nationwide university system of 31 campuses that has more than 8,000 professors, which educate approximately 90,000 students in its 57 undergraduate, 53 masters and 10 doctoral programs (ITESM, 2010). Given the importance of academic and business relationships, ITESM constantly offer training and consulting services to companies that wish to design and implement breakthrough methodologies to improve their performance.

The main campus of ITESM is located in Monterrey, Mexico. In July 2009, the mechatronic department of this campus, was interested in applying competitive intelligence during the early design stage of the new mechatronic laboratory courses that students are required to complete. Initially, the campus was only interested on creating the new courses, however they have shown interest in creating a documented teaching guide that can be applied in other campuses and consequently commercialized externally.

3 – BACKGROUND INFORMATION

3.1 – Competitive intelligence

Companies are constantly interested in creating competitive advantages superior than their rivals not only to attract new customers but also to react according to competitive forces movements from the environment (Heppes and du Tiot, 2009). One methodology allowing companies to monitor the external forces is competitive intelligence. One of the most leading organizations that promote competitive intelligence around the world is the Society of Competitive Intelligence Professionals (SCIP). Established in 1986 is a global nonprofit membership organization from USA that provides training and networking opportunities for business professionals interested in competitive intelligence through publications, conferences, courses, among others. (SCIP, 2010). According to the SCIP, competitive intelligence is “the process of monitoring the competitive environment and analyzing the findings in the context of internal issues, for the purpose of decision support...involving the legal and ethical collection of information, analysis that does not avoid unwelcome conclusions, and controlled dissemination of actionable intelligence to decision makers” (SCIP, 2010).

Competitive intelligence allows companies to obtain valuable knowledge from the environment to support decision process and strategic planning (Dishman and Pearson, 2003; Wright et al, 2007; Jourdan, Rainer and Marshal, 2008, Zangoueinezhad and Moshabaki, 2009).

The primary goal of using this methodology is to deliver « actionable intelligence » (Fuld, 1995; Fahey, 1999; Nolan, 1999; Fuld, 2000; Saayman et al., 2008), which includes information that has been identified, synthesized, analyzed, evaluated and contextualized (Saayman et al, 2008). This information could be obtained from primary or secondary sources according to specific key performance indicators and needs of the decison group involved. Approximately 90% of the information needed to take decisions is already public or can be developed from public and legal data (McGonagle and Vella, 1998; Teo and Choo, 2001) the main issue is how to identify it and transformed it.

Different evidences shows that competitive intelligence gives a big support on creation of competitive advantages (DeWitt, 1997; Teo and Choo, 2001) and also improves the company’s performance (Daft, Sorumunen and Parks, 1988; Teo and Choo, 2001) as a consequence of a better business planning (Gordon, 1989; Teo and Choo, 2001), new product introduction, new market developments (Ahituv, Zif and Machlin, 1998; Teo and Choo, 2001) and other initiatives concerning this methodology.

Moreover, it is important to stress that competitive intelligence improves risk awareness by identifying weak signals concerning synergies and movements coming from the external environment (competitors, suppliers, customers, economic forces, etc), as a consequence companies could be aware of what happen or could happen and react proactively (Zha and Chen, 2009). This methodology also has a prospective focus, if companies know in advance future changes in the environment; they would be able to take better decisions at the right time.

To develop an initiative of Competitive Intelligence the following methodology

(Ashton and Klavans, 1997; Norling et al., 2000; Rodríguez and Gaitán, 2004) has been proposed:

- -Planning and direction: to develop a plan according to the organization's needs by identifying goals and strategic actions that should be accomplished
- -Selection of sources: an evaluation should be developed to select those primary and secondary sources of information that could allow the company to obtain critical and trustworthy data
- -Process and collection of information: to define a strategy to: identify right information, collect it, and organize it to posterior analysis. Information could be registered by keywords or affinity groups (categories, years or relevance)
- -Analysis of information: only pertinent and relevant information should be taken into consideration, there are many kinds of tools that can be applied (scientometrics, swot, porter, etc.) that depend on the objective and focus of each project
- -Diffusion of results: it should be taken into consideration the persons who will take decisions (Güemes and Rodríguez, 2007), disseminating results should be in the right time, at the right way and the right person (final client). A disseminate format easily to understand and useful to improve decision making process

This methodology is not a lineal process it is like a cycle with interdependent stages, where all activities are focused on getting a final outcome that would have an impact on identifying opportunities to innovate improving the competitive position of the organization.

2.2 – Product design and development

As a consequence of economical crisis and highly evolution of environment, industries have an increasingly effort focusing on the design stage during the product development process. They look to obtain cheaper and faster manufacturing processes, add value from new material choices, respect environment applying more sustainable and efficient systems, and in general enhance their strengths to compete more effectively and efficiently. (Ward, Runcie and Morris, 2009). The design stage plays an important role when developing a product since it defines the physical form of the product to adapt it accordingly to the client's needs (Ulrich and Eppinger, 2004). In order to personalize a product, companies should design based on user insights allowing it to specify its properties by defining the actual and future requirements for its use (Randall, Ulrich and Terwiesch, 2003; Kimita, Shimomura and Arai, 2009). Using external collaboration could make companies have faster development-to-market time (Johnson and Filippini, 2009) since customer and supplier insights are transferred more efficiently to key decision makers building a more effective relationship with customers (Kimita, Shimomura and Arai, 2009). These external collaborations allow companies to focus on problem definition, inter-firm information sharing, and problem-solving among the actors involved (Andersen and Munksgaard, 2009) by designing a product that meets each one of the participant's requirements. An interesting tool that allows companies to minimize the product's time-to-market is called "concurrent engineering" which is based on changing activities from a lengthy sequential system into a more compact process (Kincade, Regan and Gibson, 2007). Its objective is to reduce the total time of the process by concurrently executing the different activities related to design and production (Barba, 2000). Companies apply concurrent engineering in their production by analyzing multiple aspects of a product and multiple stages of product development and production (Carter and Baker, 1992; Chase and Aquilano, 1992; Kincade, Regan and Gibson, 2007). This initiative allows them to formulate a detailed concept of how the product should be designed by determining the internal and external specifications in each stage covered.

Innovative companies involved in developing new products also apply new products development (NPD) methodologies to improve process concerning development of ideas into products that can be successfully commercialized. These methodologies are similar, as we can see. Ulrich and Eppinger's

NPD approach (2004) covers six stages (planning, concept development, design at system level, detailed design, trials, and initial production). Rosenthal (1998) also presents a NPD process having almost the same stages (planning, design at system level, detailed design, and initial production). The NPD process proposed by Otto and Wood (2001) contains three stages (understanding the opportunity, concept development and concept implementation). Each one of these NPD processes could allows companies to effectively develop an idea in order to create a new product that with the help of stakeholders will meet their requirements and will be considered a market success.

2.3 Active learning and didactic equipment workstations

Given advances in technologies, students are developing multi-tasking techniques, are interested in multimedia entertainment, interactivity and have a minor tolerance of traditional teaching techniques like lectures (Prensky, 2001; Blouin et al, 2009). In order to communicate the best ideas to the students, instructor's techniques like question and answer sessions, provocative statements or arguments, case studies and scenarios, and group exercises can be applied (Price, 2010). These techniques make students to develop abilities and knowledge concerned their subjects of interest, for this purpose it's also important to implement active learning situations where students can solve problems in real life situations. More effective long-term learning can be obtained if active learning considers discussions and practicing by doing (DiPiro, 2009). In order to simulate the real life situations, teaching courses can use didactic equipment workstations to build a similar working environment where real problems could be analyzed and students could propose real solutions. In this case the learning process is based on experiences that allow students to learn by themselves (Rebollo, 2009).

It is also important to consider teaching web technology as it adds a high value to the teaching and learning process considering powerful information, managing tools and efficient diffusion ways (Ogunleye, 2010). However all teaching tools should be constantly evaluated to monitor its impact in active learning (Ogunleye, 2010) for this purpose it could be taken into account opinions of all people involved (students, instructors, and course designers). Finally we can say that incorporating these techniques in the courses allows students to be able to reason, reflect, debate, examine and explore different subjects of interest (Price, 2010) where each one of their decisions could create a real life outcome that can be evaluated.

3 – DESCRIPTION OF THE PROPOSED MODEL

In order to design and develop a didactic equipment workstation in a mechatronics laboratory of the ITESM campus Monterrey a methodology incorporating tools such as competitive intelligence, and product design and development was developed. The methodology is shown in Figure 1, the following considerations should be taken into account:

- The process used for the design should be integrated in a concurrent way in each of the steps and the group workers will work in teams having constant communication
- Since this design is focused on teaching, the intelligence process should be based on internal and external clients.
- The methodology is designed for an organization in our case an Institute but could be applied in other entity
- A general methodology covering all stages of product development was designed but given the big dimension of this project only the first stage concerning understanding opportunities was applied in this case.

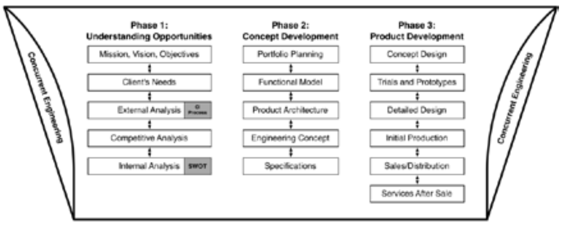

Figure 1 Representation of Model Proposed

3.1 – Understanding opportunities

The first phase of the proposed methodology is « Understanding Opportunities » were all the aspects related to the conception of an idea for development will be known by understanding the market opportunities related to the client's needs, and the strengths and weaknesses the organization has. The steps that should be completed in this initial phase are:

- Mission, Vision, and Objectives: It starts by stating the mission showing why the organization exists or why it is in its actual industry. Some of the questions that can be used as a guide to this step are:

  During how much time the organization will be satisfying this mission?
  What does the organization offer?
  To whom is the product offered?
  What market segment is being targeted? (Collins and Porras, 1996)

  The vision of the organization should be developed considering the following two aspects: the reason of being and the long-term future aspirations of the organization (Collins and Porras, 1996). By stating the objectives, the organization could try to accomplish its own goals that will be transformed into action plans.

- Client's Needs: Know who about the client and their requirements', the organization can apply interviews, questionnaires, polls, and other means to obtain all the information directly from the client. It is important to collect the client's data, interpret it according to their needs, organize their needs in affinity diagrams and establish priorities or importance (Ulrich and Eppinger, 2004).

- External Analysis: This step allows the organization to determine new developments, techniques, products or in general opportunities to innovate. For this purpose contribution of competitive intelligence is fundamental. The approach proposed by Dishman & Calof (2008) covers the following steps: planning and direction, collection, analysis, communication and decisions. This process is similar to the competitive intelligence process described before; however a difference exists in the communication step where it tries to create awareness and an organizational culture tailored to distribution needs.

- -Competitive Analysis: There are many possibilities to develop this stage. The important issue is to choose a tool to help the organization to determine their current competitive position and prospection of its future at different levels: market, technical, logistic, etc.

  Benchmarking for example is a good tool to compare the organization's products with the ones of the competition (Ulrich and Eppinger, 2004) or related companies.

- -Internal Analysis: This step and the previous one are closely related, in this case is well known the application of SWOT (Strengths, Weaknesses, Opportunities, Threats) matrix (Arroyo, 2005). This matrix could be developed with the input from the previous analysis.

3.2 – Concept development

It takes into account the functional and design aspects of the product in order to define its structure and finally its production and distribution. It involves the following steps:

- Portfolio Planning: This step consists on the definition of the different products offered by the organization, including an initial drawing and brief description of each one of them. These drawings can be organized by market segments, type of need or by another aspect related to strategy.

- Functional Model: To clarify and design the architecture of the product it's necessary to create a model to see how the product should work. Initially, it's necessary to determine the principal functions and sub-functions the products will have, and its relationships to create a logical sequence according to the inputs, interconnections and outputs (Otto and Wood, 2001).

- Product Architecture: This step takes into account the critical decisions related to the physical operation of the product (Otto and Wood, 2001) in order to see if the concept can really be developed. This step also creates a solid base to organize and manage the following activities related to the product's development, where the team in charge of the project should define optimal solutions for its design.

- Engineering Concept: During this step, designers apply their creativity to generate innovative concepts according to their demands. It is necessary to repeatedly refine and sketch the solutions with respect to the customer's demand, technical specifications and other critical issues.
- Specifications: Once the work team defines the quantitative specifications of the product, they should be transformed into production requirements in order to define each detail of its structure to be considered in the posterior activities.

3.3 Product Development

It takes into account the previous steps needed to create the product, starting with its design and finalizing with the development of the physical product. The steps included are the following:

- Trials and Prototypes: Initial and non-working models are created allowing clients to offer feedback and consequently refine the final concept. Prototypes should constantly be modified to effectively meet the client's needs.
- Detailed Design: During this step, the product's characteristics are specifically defined by designing the functional part of the product and decisions are taken according to the geometry, the materials used and the unique parts of the concept. With the help of Computer Assisted Design (CAD) software, the work group can generate, visualize and rapidly modify the tridimensional design.
- Initial Production: Once accomplished the production plan, the available resources and the assembly process are developed, an initial production of the product is made. This step has the objective of verifying the production control of the process by obtaining the clients approval and making final modifications in the product or production process.
- Sales/Distribution: Since the production has already been controlled in the previous step, it's now necessary to synchronize the work related to the other areas of the organization: sales, marketing, advertizing, inventories and distribution. It's important to state that marketing and advertizing play a critical role in the client's decision since the product is shown to the public and the buyer is motivated to search for it directly or through a supplier. The organization should also consider the distribution of the product by taking decisions according to how they should deliver the product to the client.
- Services After Sales: The organization needs to continually monitor the clients' needs and requirements. The greatest benefit of this step is to maintain communication with the client to improve and lengthen the relationship that could allow them to know new preferences or needs that may be required by the product.

4 – APPLICATION

The previous approach is a general methodology that could be applied to design and develop products. For the specific purpose of this article the initial stage (understanding opportunities) will be applied to the design and development of the new mechatronics laboratory at the campus Monterrey of ITESM. It should be taken into consideration that:

- The application will be related to the teaching environment, in particular with a didactic equipment workstation used for the student's learning
- Even though the case study was developed at the Campus Monterrey of ITESM, the development of the new mechatronic laboratory will be managed as an external organization by taking into account the competitors involved in the same subject teaching industry.

The results of each step in the initial phase of our methodology are shown as follows:

- Mission, Vision, Objectives: According to the model developed by Collins & Porras (1996) the mission, vision, and objectives where established as:

    Mission 2009-2012: We are an organization that offers didactic workstations of automatic logic controls to universities, academic institutions and industrial training facilities in Monterrey, N.L. (México), having the competitive advantage of its didactic design for active learning.

    Vision 2010-2015: We offer didactic workstations of automatic logic controls trying to be the principal suppliers of the service to universities, academic institutions and industrial training facilities of the country.

    Objectives: Design didactic equipment workstation for active learning, improve the design of the actual equipment, commercialize the didactic equipment workstation, and establish an advertizing strategy based on the identified benefits for universities, academic institutions and industrial training facilities.

- Client's Needs: The client's identified for the case study are the following: the organization in study (board of directors); universities, academic institutions and industrial training facilities (ITESM campus Monterrey, Mexico; Universidad Regiomontana in Monterrey, Mexico; Universidad Autónoma de Nuevo León in Monterrey, Mexico; Universidad de Monterrey in Monterrey, Mexico; Tec Milenio in Monterrey, Mexico); instructors of the logic control lab (3 instructors at ITESM); and the students using the logic control lab (approximately 100). After making various interviews with the potential clients, the following needs where identified as critical: design based on active learning, improve the financial status of the organization and improve the teaching methods.

- External Analysis: Using the Competitive Intelligence process proposed by Dishman & Calof (2008), the results in each of the steps are the following:

    Planning and Direction: This stage included a planning process based on previous stages, description of the competitive environment, and objectives to accomplish.

    Collection: A determination of databases useful was made combined with interviews of experts in this field. Databases like IEEE Xplore, ProQuest Science Journals, and EBSCO Business Source Premier were analyzed, finally 22 articles were collected, in most of the cases their main issue concerned the implementation of virtual laboratories to improve the student's learning capabilities through the use of web tools.

    The following competitors were identified: FESTO, ARMFIELD, FEEDBACK, AMATROL, and ECP (Education Control Products). An analysis of them based on its focus on innovation and research and development led us to identify that FESTO is the leading competitor in the industry. FESTO has strong research areas including electrical processes, fluid processes, motors, chamber devices and electrical connections.

    Analysis: The outcome of this step is to define the competitor's characteristics and determine the necessary adjustments in the actual design. In this case a comparison of different didactic equipment workstations were performed. According to the comparative results, the following information was obtained from each competitor:

        FESTO: Its workstations are much more structured having more than one system (distribution, storage, classification and separation). Its learning system gives the participants theoretical and practical insights related to design, assembly, detection of mistakes, and maintenance of industrial automated systems.

ARMFIELD: They offer multifunctional didactic training systems to control processes, which give access the students to complete stations to experiment. It focuses on the application of process control systems by having teams configured to make these activities.

FEEDBACK: They offer training teams depending on the course subjects allowing the student to experiment in the typical learning environment to control industrial processes. Its portability allows students to only focus on one methodology at a time.

AMATROL: Its advantage of offering mobile workstations allows it to be used independently and in combination with other workstations. The equipment is complemented by an integral mechatronic system with the use of sensors, valves, pneumatics, robots and PLC.

- Internal Analysis: Using the information gathered and analyzed in the prior stages, a SWOT analysis was developed and is presented in Figure 2.

Strengths	Weaknesses
- Considering active learning to design the didactic equipment - Equipment focused on didactics - Station that integrates the industry's application control (PLC, pneumatic, electric, electronic) - The exercises allows interactions with students that have similar problems - The didactic doesn't only focus on the use of the equipment	- Low relationship between the design department and the final user - Low integration in the organizational structure in the development process - There is no detailed definition in the organizational structure by functions and specific activities - Lack of development process control throughout the supply chain
Opportunities	**Threats**
- The application of active learning can be made in virtual labs - Use of virtual interaction in the teaching method - An improvement in the definition of functions and corresponding roles in the design and development process - Competitors define their own courses - Competitors design their didactic allowing the student to see and learn the industrial applications	- FESTO currently has more patent applications - AMATROL is focused in developing mechatronic stations - ARMFIELD offers stations for process control stations

Figure 2 SWOT Analysis

Once the information was analyzed the following conclusions were defined:

The current trend to take courses in didactic workstations of automatic logic controls is through virtual laboratories (with help of remote access).

The competitors offer various didactics for the technical training of people in the academic and industrial sectors by developing their personal teaching systems and designing the courses, materials and software used.

The majority of the patents registered by FESTO are related to the fluid process control.

- Communication: The key decision makers participated in any one of the steps defined previously so they could check the progress of the system through a web page. They also used periodic meetings to give feedback about the expected and delivered results.
- Decisions: The following considerations should be considered:

Design an interactive equipment workstation that offers virtual opportunities of development having a friendly software

The didactic equipment workstation should allow students to build their industrial processes

Design a course that doesn't omit the didactic part where the student is supposed to learn in an active way

A prominent focus towards the industrial processes related to the management of fluids

5 - CONCLUSIONS

With respect to the case study, recent publications have shown that tools with remote access have been used in virtual labs, as well as for the design of the courses related to the didactic teaching taking into account the application of activities that prepare the students for the industry processes. After analyzing the competitors, it was found that FESTO has the majority of registered patents showing that the organization currently focuses on fluid process controls. The other competitors also develop their own teaching courses where they only focus on the industrial teachings and not on the active learning. After taking into consideration the results from the SWOT analysis, the following concept definition has been made: improve the teaching method by modifying its design in a compact way to be combined with other equipments allowing it to diversify its activities to improve the active participation of the student.

With respect to the proposed methodology, only the first stage was applied since the other phases cover similar activities to the existing development processes. This approach is useful to design and develop a didactic equipment workstation by combining competitive intelligence with product design methodologies to determine the relevant aspects taking into account an internal/external analysis of the organization.

For future research, it is recommended to apply the following stages of the proposed methodology to finally develop the desired concept. Another recommendation is to develop studies for different laboratory didactic equipment workstations, where the student could experiment with the results of the exercise. The final recommendation is to design academic programs that use the didactic equipment workstations considering active learning allowing students to experiment with real cases in the laboratory.

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