COMPETITIVE TECHNICAL INTELLIGENCE APPLYING COLLABORATIVE LEARNING: A HOLISTIC MODEL APPROACH TO IMPROVE IDENTIFICATION OF OPPORTUNITIES TO INNOVATE

Marisela Rodríguez-Salvador,
Research professor of the Quality and Manufacturing Center, ITESM
marisrod@itesm.mx, + 52 (81) 83 58 20 00 Ext. 5361

Naoko Takeda-Toda,
Research professor of the Industrial Design Department, ITESM
naoko@itesm.mx, + 52 (81) 83 58 20 00 Ext. 5362

Magaly V. Mora-Roldán,
Graduate research assistant of the Quality and Manufacturing Center, ITESM
A00774636@itesm.mx, + 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 : The purpose of this paper is to present the Holistic Model, a new education model concerning the methodology of Competitive Technical Intelligence (CTI). CTI adds key value to foster innovation and to support the strategic decision process through the analysis of the external environment. Despite the increasing amount of research concerning CTI, the teaching-learning process has been rarely analyzed. With the objective of tackling this weakness, and as a result of years of pedagogic and technical research and implementation, a course in this field and later, a Holistic Model were developed. This model integrates Collaborative Learning to enhance the teaching-learning process. It has been applied in different academic and business courses. In particular, a retrospective analysis is given of a Master's degree course. This analysis is focused on students' projects where a systematic analysis of the external environment was made aiming at identifying future trends and opportunities to innovate.

Key words : Strategic intelligence, technical intelligence, competitive intelligence, scientific and technical monitoring, creativity, innovation, collaborative learning, cooperative learning, education.

Résumé : Cet article présente le Modèle Holistique comme un nouveau modèle d'éducation de l'Intelligence Technique Concurrentielle (ITC). Pendant des années, de nombreuses études sur l'ITC se sont développées mais peu d'efforts ont été consacrés à l'amélioration du processus d'enseignement-apprentissage concernant cette méthodologie. Afin de réduire ce manque, et résultant également d'années de recherche en pédagogie et en techniques, un cours de ITC et après, un Modèle Holistique ont été développés. Ce modèle intègre l'apprentissage de collaboration pour renforcer l'assimilation et l'exécution de la connaissance. Il a été appliqué dans le cadre de programmes de formation continue au sein d'entreprises et dans l'enseignement supérieur (licence et mastère). En particulier, une analyse rétrospective d'un cours de mastère est présentée. Cette analyse est concentrée sur les projets des étudiants où une analyse systématique de l'environnement externe a été faite pour identifier les tendances futures et les opportunités à innover.

Mots clés : Intelligence stratégique, Intelligence technologique, Intelligence technique, Intelligence Concurrentielle, Veille scientifique et technologique, créativité, innovation, apprentissage collaboratif, apprentissage coopératif, apprentissage de collaboration, éducation.

Competitive Technical Intelligence applying Collaborative Learning: a Holistic Model approach to improve identification of opportunities to innovate

1 - INTRODUCTION

A new paradigm of competitiveness resulting from globalization and a knowledge-based economy has been producing noteworthy challenges for future product developers. Many challenges have occurred such as multidisciplinary teams, geographically disperse teams, and broad selection and application of Information Technologies and Telecommunications (Žavbi and Tavčar, 2005). In this sense, analyzing the competitive environment represents a key factor in detecting opportunities to make innovations with high impact on the future (Fleisher, 2004; Jaworski et al., 2002; Norling et al., 2000; Herring, 1999; Howard, 1993; Delesse, 2005). This represents new requirements for universities to prepare students. Methodologies that help to deal with challenges in the new competitive environment should be taught.

2 - COMPETITIVE TECHNICAL INTELLIGENCE AND INNOVATION

Competitive Technical Intelligence (CTI) started to gain a key role in strategic planning, especially since the mid '90s. Many successful companies have systematically adopted this methodology and have established formal units of CTI, obtaining high benefits for their innovation processes and significant improvement in their competitive position (Jaworski et al., 2002; Norling et al., 2000; Herring, 1999; Howard, 1993; Delesse, 2005).

Whereas the term Competitive Intelligence (CI) refers to the process that involves handling general information about the external business environment, the term Competitive Technical Intelligence (CTI) also concerns related scientific and technological events of research, the development and innovation process, technology acquisition policies, joint ventures, portfolios of research and development (R&D). The goal is to support decision-making- processes through a better understanding of the competitive environment and the anticipation of future changes (Fleisher, 2004). In more detail, CTI activities are usually aimed at providing early warning of external developments that could represent potential threats and opportunities, evaluating innovations and collaboration prospects and understanding science and technology shifts as a preparation for organizational planning and strategy development.

CTI methodology is developed through a systematic Intelligence Cycle which comprises five general steps: planning and direction, collection and research, processing and storage, analysis and production, and delivery of results. It is important to emphasize that this process must be developed under an ethical and legal frame (information collection is critical and must be performed in an ethical and legal manner). In fact, the diffusion and implementation of an ethical code represents main elements of this profession.

As Fleisher (2004) establishes, competitive intelligence has grown in prominence as the managerial focus on information and knowledge-based competition has increased. Education in this domain has also increased in importance in many industrial countries, gaining attention in universities. As an example we could refer to the case of France, where in a report to the Prime Minister, Deputy Carayon establishes the need of this type of education within state schools, as well as within their *«Grandes Écoles de Commerce et Grandes Écoles d'Ingénieurs»* (Carayon, 2003 in Delesse, 2005). In Latin America, education in this field is still emerging, it is necessary to increase efforts in this context. Moreover, it is necessary to apply new methodologies in order to improve the teaching-learning process where innovation is promoted. For example, courses concerning product development should involve a complex system of activities where information (inside and outside the boundaries of the company) is essential, from the identification of strategic opportunities (here CTI provides major support) to the final design of the product.

We consider that the education process can be developed through a learning strategy that involves knowledge and analysis of the

competitive environment with what is called as: Collaborative Work. In this sense, we try to enhance the students' abilities to learn and stimulate their critical thinking by facing different challenges, for example, the development of a project to help an organization in their identification of innovation opportunities.

3 - COLLABORATIVE LEARNING

Collaborative Learning is part of a broader paradigm shift that is occurring in teaching, according to Johnson, Johnson and Holubec (1998a), this includes seven key issues:

First, knowledge is constructed, discovered, transformed and extended by students. Second, students actively construct their own knowledge. Third, learning is a social enterprise in which students need to interact with the instructor and classmates. Fourth, faculty effort is aimed at developing students' competencies and talents. Fifth, education is a personal transaction among students and between the faculty and students as they work together. Sixth, all of the above best take place within a cooperative context. And seventh, teaching is assumed to be a complex application of theory and research that requires considerable instructor training and continuous refinement of skills and procedures.

The main goal of Collaborative Learning is to get students to work together maximizing each other's learning (Foote, 1997). This technique leads students to be responsible for one another's learning as well as their own (Foote, 1997; Johnson et al., 2002), and in this process they develop critical thinking through discussion, clarification of ideas, and evaluation of others' ideas (Gokhale, 1995). This is also helpful for the development and clarification of group ideas as a single entity (with common goals). Thanks to collaborative learning, the success of one student helps the rest of the students to be successful (Gokhale, 1995).

Since the first research study was published in 1898, there have been over 600 experimental and over 100 correlational studies conducted on collaborative, competitive, and individualistic efforts (see Johnson and Johnson (1989) cited in Johnson, Johnson and Holubec (1998a), for a complete review of these studies) where collaborative learning presents the advantages of:

- Greater efforts to achieve: This includes higher achievement and greater productivity by all students, long term retention, intrinsic motivation, achievement motivation, time-on-task, higher-level reasoning- and critical thinking.
- More positive relationships among students: This includes esprit-de-corps, caring and committed relationships, personal and academic social support, valuing of diversity, and cohesion.
- Greater Psychological Health: This includes general psychological adjustment, social development, social competencies, self-esteem, self-identity, and ability to cope with adversity and stress.

Johnson, Johnson and Holubec (2002, 1998a, 1998b) and Johnson and Johnson (1996) have represented a key reference in Collaborative Learning for many years. In order to develop the Holistic Model, these authors' approach has been taken into account; in particular, the accomplishment of the five essential elements of Collaborative Learning which are as follows: 1) Positive Interdependence, that exists when group members perceive that they are linked with each other in a way that one cannot succeed unless everyone succeeds. Positive interdependence creates a commitment to other people's success as well as one's own and is the hearth of collaborative learning. 2) Individual Accountability. Students learn together so that they can subsequently perform higher as individuals. The performance of each individual student is assessed and the results are given back to the group and the individual in order to ascertain who needs more assistance, support and encouragement in completing the assignment. 3) Group Processing. Group members discuss how well they are achieving their goals and maintaining effective working relationships. Continuous improvement of the process of learning results from the careful analysis of how members are working together and determining how group effectiveness can be enhanced. 4) Social Skills. In collaborative learning groups students are required to learn academic subject matter (taskwork) and also to

learn the interpersonal and small group skills required to function as part of a group (teamwork). Group members must know how to provide effective leadership, decision-making, trust-building, communication, and conflict-management, and be motivated to use the prerequisite skills. And, 5) Face-to-Face Promotive Interaction. It occurs when members share resources and help, support, encourage, and praise each other's efforts to learn. It is through promoting each other's learning face-to face that members become personally committed to each other as well as to their mutual goals (Johnson et al., 2002, 1998a). These main elements of collaborative learning were integrated into the development of the Holistic Model; details of the application in the course analyzed will be shown in subsequent sections.

4 - OVERVIEW OF THE COURSE: INTELLIGENCE SYSTEMS FOR INNOVATION

This is an elective, semester-long course that has been implemented since 2001. The target audience originates from two Master's programs: 1) Quality and Productivity and 2) Manufacturing Systems, and from a program that allows bachelor students of industrial design to complete a specialization in design with different emphasis: automotive, product and expositive. The course is given at the headquarter campus of «*Instituto Tecnológico y de Estudios Superiores de Monterrey*» (ITESM) in Mexico. It has its background in previous research (on intelligence systems, pedagogical issues…) and other courses created by the same author in Mexico and Spain.

This course was designed with the aim of enabling students to develop knowledge, abilities, attitudes and values oriented to the handling of CTI with two main purposes: 1) identifying opportunities for the development of innovations with high impact in the future, and 2) anticipating customers' future needs. The philosophy of this course is to apply CL as a global learning strategy through formal and informal activities that follow the main principles of Johnson, Johnson and Holubec (2002, 1998a, 1998b) and Johnson and Johnson (1996). During the course, interaction between students and continuous teachers' feedback is promoted by means of the work in multidisciplinary teams facing different situations (inside and outside the classroom).

The course pursues the fulfillment of four general objectives:

- To integrate a collaborative methodology that allows students to create a solid basis to transform information towards intelligence in a highly dynamic competitive environment.
- To promote future planning as a way to improve the competitiveness of the organization.
- To help students make better, more informed decisions concerning innovation management and the identification of opportunities or threats present in a competitive environment.
- To encourage students to be aware of and committed to ethical and legal norms during the development of CTI.

After some time teaching this course, the Holistic Model was created in order to enhance the teaching-learning process. For this purpose, CL was included. It is important to remark that CL is applied as the base platform but uses complementary pedagogic strategies such as discussion, research, analysis of readings, case analysis, debate, and active lectures by the professor. This approach looks to encourage learning mainly in two ways: first, by means of the development of tasks that take place each session; and second, with the elaboration of the final project. With these two elements, the students follow an evolutionary learning process during the course. Day by day they are 1) acquiring knowledge on innovation, information and Intelligence Systems; 2) developing abilities concerning information handling (planning, collecting, analyzing and diffusing); 3) stimulating values such as responsibility, respect, and honesty; and 4) reinforcing innovative, ethical, entrepreneurial, and leadership attitudes; all of which are related to the pre-established objectives of the course. Individual as well as group interaction is encouraged by facing real situations during the learning of the theory and the practice.

5 - HOLISTIC MODEL: INTEGRATING COMPETITIVE TECHNICAL INTELLIGENCE WITH COLLABORATIVE LEARNING

The Holistic Model was created for Teaching CTI in order to face the new paradigms of education, as shown in Figure 1. This model has its roots in the previous experience of the author in different Spanish and Mexican universities teaching courses and giving consultancy and training programs for companies. It comprises the following elements:

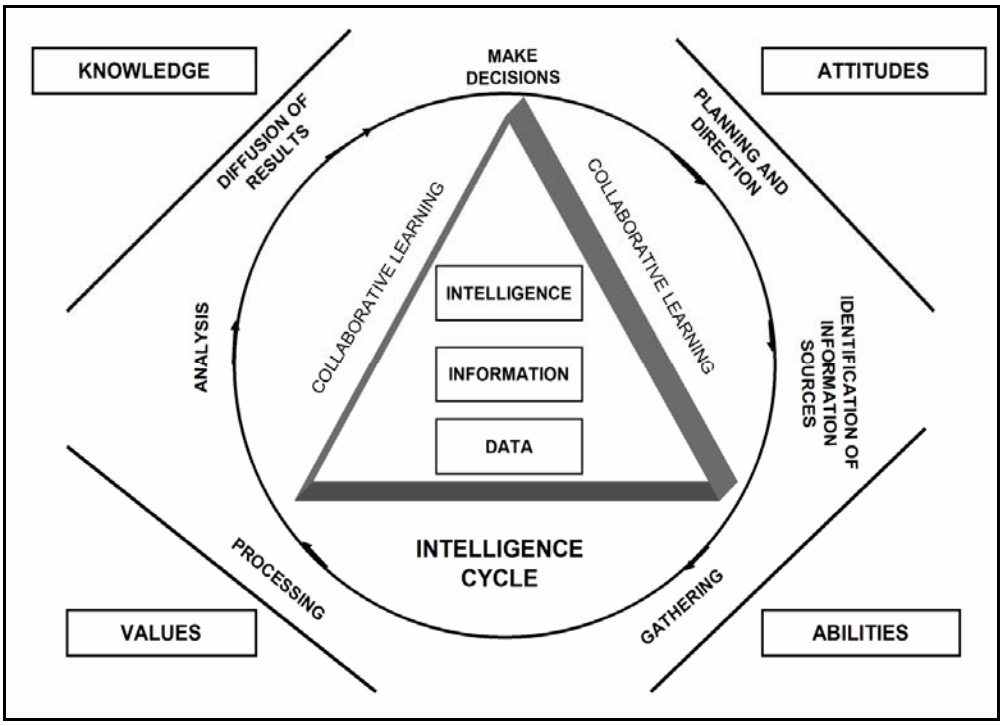

Figure 1 : The Holistic Model for Teaching Competitive Technical Intelligence

The purpose of the Holistic Model is to develop knowledge and abilities to identify opportunities to generate new products/process or improve the existing ones, facilitating strategic design course of action through the analysis of external environment. The model aims to enhance students' ability to learn and stimulate their critical thinking by means of the analysis of real situations; to accomplish this, there are different activities, such as the development of a project, where an organization is involved. This new approach integrates CL into a CTI methodology through a proactive learning system. As we pointed out previously, we considered in the model the five key elements for CL established by Johnson, Johnson and Holubec (2002, 1998a, 1998b) and Johnson and Johnson (1996) and we also included other important factors.

- Positive Interdependence. Important learning synergies are present in all teams thanks to the collaboration and commitment of each member; to accomplish this they apply specific tools, such as goal interdependence and resource interdependence to environmental interdependence. Although divergent points of view interacted at the beginning of the semester, common agreements are reached under shared goals.
- Individual Accountability. Individual responsibility is strongly encouraged. Specific activities are developed (i.e., roles assignation, simultaneous explanations, oral tests) to avoid slackers and to ensure the learning of all participants. Members of collaborative teams learn to be responsible for their own work but under a group viewpoint ("think globally, act locally").
- Group Processing. The quality of the group's teamwork is increased. The members are aware of how they are working together and how they could increase their group performance

having common goals. A continuous evaluation is made for this purpose. Groups receive feedback and reflect on their improvement areas.

- Face-to-Face Interaction. Continuous communication and direct feedback among all members are developed. The individuals promote the success of the others, motivating them to achieve their best results by sharing goals, activities and resources.
- Analysis, Synthesis and Evaluation. The students have progressive improvement in these abilities through the development of each project. These abilities are essential for the gathering and dissemination activities of intelligence methodology and have a big impact on the final result.
- Ability to Identify and Solve Problems. The students improve these abilities through projects linked to real problems, involving an organization (company, institute…) for which they identify opportunities to innovate in planning new products or processes.
- Honesty. The students are encouraged from the beginning to be aware of and to follow ethical and legal activities during the development of the intelligence cycle, as the main principles of this methodology establish.
- Efficient Use of Technology. The students are encouraged to develop this ability through the use of different resources made available to them. For example, the Model is applied in a course developed in a technological platform that allows efficient communication between students and professor. The students also have access to a digital library of their institute (ITESM), which contains dozens of databases with access to journals, magazines, theses, reports, etc. During the course they also learn to use search and meta-search engines on the Internet.
- Collaborative Work. The elements previously defined allow students to learn to work in collaborative teams (different from traditional teams). Social skills are also encouraged for improving the group performance. Successful business strategies are also dependent on the skills of the group leader as well as the company management team's ability (Herring, 1992).

While CL provides a way to maximize learning and synergic collaboration inside the team, TI fosters innovation by analyzing the external environment. The methodology, based on the intelligence cycle, is developed as shown in the Holistic Model: Planning and Direction, Identification of Information Sources, Gathering, Processing, Analysis, Diffusion of Results and Make Decisions. This cycle leads to the transformation of the data into an intelligent result focused on the identification of innovative opportunities. During this process, students are developing the knowledge, abilities, attitudes and values that we mentioned in the previous section.

Following the main objectives of each project, students develop the intelligence cycle identifying and selecting several information sources, but the objective is to selectively collect the most useful —not the largest quantity— of information needed, as cost effectively, as efficiently, and as quickly as possible. Accordingly and considering the key issues for strategic design planning, such as human aspects, competitors, providers, environment, etc., information collection is developed.

To accomplish this, students are guided by the Key Intelligence Topics methodology (KIT) (Herring, 1999). The objective is to create a cooperative environment between intelligence users and students that supports the two-way communication necessary for identifying and defining the organization's real intelligence needs.

Finally we should remark that the analysis of a large amount of information represents a great challenge for the multidisciplinary teams in CL because each member has different points of view that should be reconciled. For that purpose, in this Model, dynamics of group processing are applied.

6 - PROCESS

We will show the entire process that was followed, concluding with the analysis of the impact of the Holistic Model by applying the CL strategy. As will be noted, it was necessary to start with a reengineering of the teaching-learning process (which included specialized training in new educational strategies, research and corresponding implementation). Later, activities focused on the development of a new course and finally on the creation of this Model and its corresponding evaluation; for this specific purpose, the methodology of competitive intelligence cycle was followed. Each stage of the process will be explained in detail. The general scheme is shown in Figure 2.

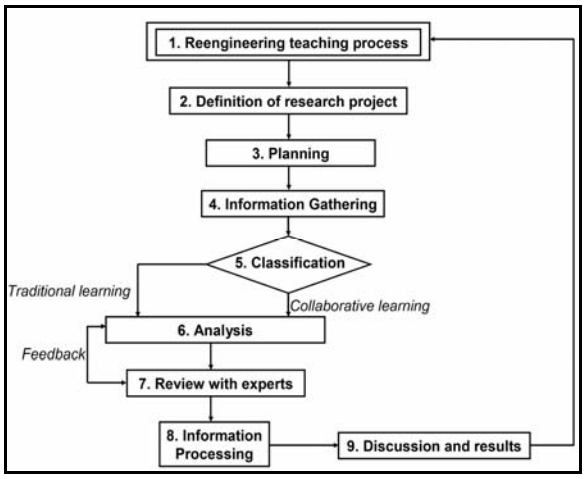

Figure 2 : Process

1. Reengineering of the teaching process. For many years, ITESM has made efforts to obtain strong qualifications for new teaching strategies and use of technological platforms. The author of the course was certified (2001) in the "teaching-learning model of ITESM", a comprehensive training system based on constructivism which is focused on a new model of education, including techniques such as: Collaborative Learning (CL), Project Oriented Learning (POL), Project Based Learning (PBL), Case Analysis (CA) and so on. This system not only demands training in those domains, but also requires the creation of a course applying these elements; moreover, an evaluation of implementation is also made. For that reason the course, Intelligence Systems for Innovation, was created following this system (Rodríguez, 2001). The implementation of the course started in the second semester of 2001; after different evaluations focused on content, use of technological resources and pedagogic issues, we obtained the final version which was approved at the end of year. After this course of action, the author of the course obtained an additional certification in CL (2003), as a consequence of training in the US and Mexico and respective implementation. The Holistic Model was implemented in the second semester of 2003 in said course. Following this model students develop different activities that include bibliographic research and case analysis to debate, in which they work individually and in collaborative teams. But the most important activity is a project where they recognize key elements to develop new products that could meet the customers' future needs. They identify competitive and technological trends and opportunities for innovation through a systematic analysis of the external environment. Through this process, students' communication is encouraged while they collaborate with different classmates facing real situations.
2. Definition of a research project. At the end of 2002, ITESM established 25 big research chairs representing multidisciplinary projects with the aim of adding value to the society in fields such as: engineering, administration, technology and communications, health, social sciences and education. Under this perspective, in 2003, we undertook the initiative called the Chair Research on Creativity, Inventiveness and Innovation in Engineering (CIII) *«Cátedra de Investigación en Creatividad, Inventiva, Innovación e Ingeniería»*. With the particular purpose of improving process innovation, CIII is focused on encouraging the development of creativity and inventiveness in engineering students. This research chair comprises lines

such as: engineering design, industrial design, CTI, quality systems, innovation, etc. After several semesters working on CIII, in 2005 we undertook this study to identify the impact of the Holistic Model's application with a CL strategy.

3. Planning. An Intelligence Cycle methodology was followed in its main steps: planning and direction, identification of information sources, collecting information, processing, analyzing and diffusing. A planning process, according to the main objectives of CIII, was made to analyze the Holistic Model application in the Intelligence Systems for Innovation course. For this purpose, it was necessary to compare the projects developed by students during different semesters where the course was taught traditionally and with Collaborative Learning. A retrospective analysis during a period of six semesters (January 2002-December 2004) was applied as follows: three semesters corresponded to traditional learning (2002 and half of 2003) and three for collaborative learning (half of 2003 and 2004). A general schedule of activities was made from the definition of the information sources (mainly related to teaching-learning techniques, strategic planning and external monitoring) to the final identification of key criteria to analyze the course (we considered intrinsic characteristics established for the CTI field).

4. Information Gathering. This step consisted of collecting information from the previously identified sources, with the purpose of defining a theoretical framework. The scope of this activity was closely related to teaching-learning techniques (such as CL), innovation, strategic planning, and competitive and technological monitoring. Information from both primary and secondary sources (books, journals, proceedings, databases, internet, and experts in each area…) was collected.

5. Classification. Once the theoretical framework was concluded, activities concerning the study of the final student projects were developed. During the six semesters 12 projects were developed, 5 projects with traditional learning: in 2002, 1st semester: 2 projects (11 students), 2nd semester: 1 project (6 students), in 2003 1st semester: 2 projects (12 students). Additionally, 7 projects with collaborative learning were completed: 2003 2nd semester: 2 projects (12 students), 2004 1st semester: 3 projects (15 students), 2nd semester: 2 projects (11 students). The number of students depended on the course registration; each team had between 5 to 6 students considering the normal size of a team focused on intelligence activities (transforming information into intelligence from: databases, patents, internet, field research, experts…). As preparation for the analysis stage, a general classification of the final projects was made. The general criterion used to classify the final projects was the application of either of these two learning strategies: Holistic Model with CL or the Traditional Learning approach.

6. Analysis. During this stage, each project was thoroughly analyzed considering structure, methodology, content as well as the final results reached by the students. A particular review was also made focused on the key issues of CTI, traditional learning and CL.

7. Review with experts. To support the analysis stage, feedback from experts was very important. In the CIII project, people with PhDs in different areas (industrial design, engineering design, education, business administration…) participate to encourage a multidisciplinary vision and to improve performance. In our case, we asked them for support during a second analysis of the projects and during the final study of the results of the Holistic Model's application. Under this context, the combined analysis of primary and secondary

sources allowed the students to manage elements present in projects concerning innovation in diverse branches of engineering. Experts in CTI, CL, Innovation, and Product/process Design were consulted for the review of: general results, recommendations, and approaches proposed by the students in their identification of opportunities for innovation.

8. Global Results Processing. After completing an individual review of each project in precedent stages, a general classification of all projects was developed in order to have a global perspective. This processing activity covered elements concerning: general information of the projects, definition of information sources used by the students, classification of the principal trends identified in each project, and a final comparative table of trends observed with the application of the Holistic Model and of traditional learning.
9. Discussion and results. The results obtained allowed the identification of the main benefits of the Holistic Model's application. Evaluation of the research was accomplished with the support of experts previously indicated.

7 - COMPARISON OF OUTCOMES APPLYING TRADITIONAL LEARNING AND CL WITH HOLISTIC MODEL

As we have established before, a retrospective analysis of projects developed during a period of six semesters was made considering a comparison of two basic methodologies: one focused on traditional learning (3 semesters) and the other, where CL was incorporated (3 semesters) through the Holistic Model. For this purpose the principles of CL established by Johnson, Johnson and Holubec (2002, 1998a, 1998b) and Johnson and Johnson (1996) were followed. The analysis of results from different semesters led to a comparison of the benefits obtained. We confirmed previous research concerning the advantages of CL strategy over traditional learning. Moreover, this model allowed the students to develop their social skills by working in collaborative teams.

General information of the projects analyzed is summarized in Table 1, which details the type of learning strategy, an identification number, the main objective, and a brief focus on the organization involved.

	Number	General objective	Main focus of organization involved
Holistic Model	1	To support strategic planning to improve domestic utensils for cleaning purposes	Company in charge of manufacturing domestic cleaning products (brooms, dusters, brushes, etc.)
	2	To identify trends in uses, materials and new applications of solar panels	Company focused on ensambling and distributing solar energy products
	3	To forecast innovation opportunities in designing ceramic dish sets	Company in charge of manufacturing mexican ceramic dish sets
	4	To find methodologies to improve creativity in executive uniforms design processes	Company in charge of manufacturing executive uniforms
	5	To support strategic planning for exporting a Mexican traditional candy to USA	Company in charge of the manufacture and distribution of a Mexican traditional candy called "cajeta" which is based on goat's and cow's milk
	6	To support the identification of innovation opportunities in designing and incorporating new materials in windows	Company focused on manufacture and installation of domestic and commercial windows
	7	To identify future trends for manufacturing processes of domestic cleaning utensils	Company in charge of manufacturing domestic cleaning products (brooms, dusters, brushes,etc)
Traditional Learning	8	To support innovation in manufacturing processes of steel for automotive applications	Company focused on manufacturing galvanized steel (flat steel sheet and corrugated steel sheet)
	9	To support detection of opportunities to improve strategic management of integral handling of municipal reminders	Organization for environmental protection focused on the integral handling of municipal reminders
	10	To identify main trends concerning steel painting for automotive applications	Company in charge of manufacturing steel, in particular for automotive industry
	11	To support strategic planning for a consulting company on Supply Chain Management (SCM)	Consulting company focused on Supply Chain Management for Small and Medium-Sized Enterprises (SMEs)
	12	To identify future trends concerning new materials for manufacturing inner tubes for automotive cables	Company in charge of manufacturing inner tubes for automotive cables

Table 1 : Comparative table of the projects analyzed

7.1 – Information gathering

To succeed in the application of the CTI methodology and obtain a real identification of opportunities and threats present in the external environment, a proper selection of information sources is essential as it impacts the information gathered and, consequently, the quality of the final results. For this reason it is important to remark results concerning this.

As was previously mentioned, students develop the CTI process through a combination of primary and secondary sources applying the Key Intelligence Topics methodology. For this purpose, students identified key players of the external environment as primary sources for monitoring and collection. Secondary sources stemmed from a well-know classification in this field that includes books, databases, news, patents, web and other resources. For this gathering activity, students used the library of the Institute (ITESM), which contains almost 4,000 books, 1,000 audio resources, 4,500 video resources and more than 4,000 journals (ITESM Biblioteca Digital, 2006). Moreover, the Institute has a digital library with over 50 different databases, which provide approximately 36,000 e-journals and 500,000 e-books. This digital library was an enormous support to students in developing their projects; databases that they used were compiled from business to science and technology. Information from both primary and secondary sources was used in the projects.

Primary sources used were labeled as:

- ACA - Academics and researchers working in related project areas.
- ORG - People from the organization involved belonging to different departments: R&D, manufacturing, design and marketing.
- EXT – People from the competitive environment (providers, suppliers, competitors, etc.).
- OTH – Others, in particular, consultants or business service providers (industry analysts, information brokers, etc.)

Concerning primary sources, results showed that the most frequent practice was to interview employees and external people (ORG and EXT are in all 12 projects). Academics and researchers were consulted in 4 of the 7 projects developed with Holistic Model and in 3 of the 5 projects developed with Traditional Learning.

Secondary sources used were labeled as:

- SB – Specialized books consulted for supporting background of technical issues.
- BD – Scientific, Technical and Business Databases (excluding patents).
- NEWS - News in electronic or paper format.
- PAT – Patent databases or official sites for searching intellectual property information in the USA, Japan and/or Europe.
- WEB – Internet: involves direct access to web sites by means of common search engines as well as the use of meta-search engines to identify new sites.
- OTH - other secondary sources such as technical manuals, bulletins, reports.

With respect to this point, a wide range of secondary sources were used. Internet and databases were the most widely applied in all projects (BD and WEB are in all 12 projects). While patents are in third place, they were consulted in each of the 7 projects developed with Holistic Model and in 3 of the 5 projects developed with Traditional Learning.

7.2 – Trends

After presenting some details of the information sources, we will focus our attention on principal results of projects' students. In this context, we analyzed the projects and classified general trends resulting from their environment analysis. This information is presented in Table 2.

		Classification of trends							
	Number	MAT	DES	MAN	FUNC	APL	SUB	OKF	STRA
Holistic Model	1	X	X	X	X	X	X	X	X
	2	X	X		X	X	X	X	X
	3	X	X	X				X	X
	4	X	X	X		X		X	X
	5		X	X	X	X	X	X	X
	6	X	X	X	X	X	X	X	X
	7	X	X	X	X		X	X	X
Traditional Learning	8	X		X	X	X		X	X
	9							X	X
	10	X	X	X	X	X	X	X	
	11					X			X
	12	X		X				X	X

Table 2 : Classification of Trends identified by the students in the projects

A classification was made based on the following eight sub-groups:

- MAT - Identification of trends concerning development of materials explicitly or implicitly related to the project products.
- DES – Identification of future customer requirements for design and/or suggestions for current improvements.
- MAN – Detection of future trends inherent to the manufacturing process.
- FUNC – Analysis of current function of products or processes including their life cycle, and identification of alternatives for improvement.
- APL – Identification of new areas of application, including the detection of new market niches or the creation of new customers' needs.
- SUB - Identification of products or process substitutes and characterization of future competitors.
- OKF - Detection of other key success factors present in the competitive environment (i.e., human aspects, suppliers, new entrants, economic forces, legislation, environment, etc.).
- STRA – This sub-group includes a long list of proposals or recommendations of management and strategic planning focused on innovation: identification or definition of new market niches, creation of departments with a CTI function, strategic alliances and other specific recommendations.

From this kind of results, students identified innovative opportunities by looking for adding value to the organizations involved. Table 2, applying the Holistic Model, shows that the scope of results was broader and more trends were identified with this Model; in fact, there was one project in which trends from each of the 8 previous sub-groups were detected. Continuing with the analysis of the results, in order to have a general perspective of the type of results obtained comparing new approach with traditional learning, Table 3, was made. This table is placed at the end of the article. All projects as a whole were analyzed, and following the previous classification of eight elements, the differences of final results by learning strategy were identified.

From Table 3, we can see that a deeper analysis of the competitive environment was made applying the Holistic Model in comparison to traditional learning, and the recognition of trends was broader, more future oriented and more strategic. These results gave more support to the identification of strategic innovative opportunities than those obtained with traditional approach. Strategic details were disseminated personally to each organization involved. As a result they asserted that uncertainty in their innovation planning process was reduced and the decision-making process was improved.

In general terms, a positive impact on innovation was evidenced in the course. Knowledge gained as well as abilities and values encouraged through the application of the Holistic Model with CL succeeded in preparing students to anticipate the challenges of the competitive environment and to improve team performance. Departing from raw data, they obtained information, processed it,

analyzed it and transformed it into an actionable result with high value for the decision process. In our case Holistic Model with CL showed important advantages not only for the students, but also for the organizations involved in projects. However, there are some gaps that need to be filled, for example to integrate more advanced analysis techniques such as data-mining, text-mining, etc. This would add key value to analyze large quantities of data.

8 - CONCLUSIONS

Accelerating challenges in science and technology have forced big shifts in education needs. Since the mid '90s concepts such as intelligent economy, knowledge-based era, and so on, have gained strong attention. In particular, conversion of information to intelligence has emerged as a strategic issue of competitiveness under both organizational and national perspectives. In this context, individuals need to face new challenges, proactively learning to monitor, analyze and anticipate future movements of the competitive environment.

We have shown some evidences of the benefits of the Holistic Model in a master's degree course for students of engineering and design. This new proposal is focused on science and technology monitoring with the particular characteristic of integrating collaborative learning as a teaching strategy. It should be mentioned that this proposal has been proven not only in academic courses but also in business courses (management) having similar results: improvement in strategic decision processes, support for product and process innovation.

As Žavbi and Tavčar (2005) affirm, the development of innovations requires appropriate education and a broad spectrum of professional abilities, concerning customer-oriented thinking, methods for systematic product development, application of information technology and communication tools, international team interaction, etc. From a retrospective analysis of six semesters, we have seen, in summary that the application of the Holistic Model has encouraged positive aspects.

Future global conditions represent great challenges that have to be taken. We consider that the Holistic Model prepares students for the future needs of a knowledge-based economy and could represent an interesting proposal to be applied in education.

	Trends identified with Traditional Learning versus Holistic Model and Collaborative Learning	
MAIN FOCUS	**Traditional Learning**	**Holistic Model**
1. Materials	Identification of future trends for current materials	Identification of future trends for current materials Detection of new materials and their future applications Recognition of the principal characteristics that the market demands for new materials (applications, environment, manufacturing, costs, etc.)
2. Design	Identification of new customers' requirements for current designs (include balance with human aspects, manufacturing, costs, etc.) Determination of competitive environment forces that could affect current designs	Identification of new customers' requirements for current designs (include balance with human aspects, manufacturing, costs, etc.) Determination of competitive environment forces that could affect current and future designs Recognition of future trends in design styles in other areas different from that of the organization
3. Process	Definition of future trends concerning infrastructure and current manufacturing processes	Definition of future trends concerning infrastructure and current manufacturing processes Determination of future trends in new manufacturing processes that reduce costs, improve quality and increase productivity Recognition of new applications of current manufacturing processes in other markets
4. Current Function	Focus on current customers' needs	Focus on current and future customers' needs
5. New Applications	Identification of new product applications in markets of the same sector	Identification of new product applications in markets of the same and other sectors Recognition of potential applications that could meet future customers' needs
6. Substitutes	Identification of current substitutes of products/processes of the organization	Identification of current and future substitutes of products/processes of the organization and potential competitors Recognition of hybrid technologies that could impact on products, materials or processes
7. Other Key Factors	Detection of current ecological trends concerning design Identification of other success elements concerning competitive environment such as: suppliers, distributors, competitors, customers, etc. that could affect competitiveness Recognition of the value that monitoring activities has on innovation and design	Detection of current and future ecological trends concerning design Identification of other success elements concerning competitive environment such as: suppliers, distributors, competitors, customers, etc. that could affect competitiveness Proposals to implement a systematic monitoring of the competitive environment to enhance innovation and design Determination of new trends concerning quality, distribution and commercialization issues Recognition of creativity and innovation measuring tools to improve product development
8. Management and Strategic Planning	Focus on current markets Recognition of potential strategic alliances in the same sector In general, identification of strategic actions focused on current management functions concerning innovation	Focus on current and new markets Recognition of potential strategic alliances in the same and other sectors Proposals to implement a systematic process of CTI as a key tool for innovation management In general, identification of strategic actions focused on current and future management functions concerning innovation

Table 3 : Trends identified with the Holistic Model and Collaborative Learning vs. Traditional Learning

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