COMPARATIVE EDUCATING/LEARNING PROCESS ANALYSIS APPLIED TO THE "PROJECT METHODOLOGY" CLASS IN A MECHANICS TECHNICAL COURSE

Henri Carlo Belan, henri@IFSC.edu.br
Cristiano Kulman, cristianokulman@IFSC.edu.br
Joni Coser, jonicoser@IFSC.edu.br
Federal Institute of Santa Catarina, IF-SC, 89.813-000, Chapecó, SC, Brazil

Abstract. *In courses of the technical level, many difficulties for the application of education methodologies exist, mainly regarding the project methodologies. These difficulties are more cumbersome when the professor has been assigned as a new discipline, what is common in the Federal Institute of Santa Catarina (Brazil), composed of several new campuses. Thus, a restrained demand of methodologies for education applied to products project in technician level courses exists. This paper performs a comparative analysis of different teaching approaches for the discipline under discussion. The main characteristic of the evaluated students is that about 90% work in companies of the metal-mechanics area in the Chapecó region and already had been involved in activities of project or production. This aspect made the students reflect on the practical projects used in the region and perceived that some aspects can be improved. The analysis of the performance and exploitation of the students was made on the basis of a specific questionnaire and subjective criteria of the professor, being evaluated through questions regarding the agreement of the project process, development of the innovation capacities, applicability of the project tools, quality of the reached results and discernment on relevant and irrelevant aspects.*

Keywords*: Technical Education, Mechanics, Education Methodology*

1. INTRODUCTION

The Federal Institute of Santa Catarina (IFSC) is a technical college/university established in Florianópolis (Southern Brazil) in 1909 and is increasingly expanding to other cities. The main purpose of IFSC is to train and qualify professionals through technological education at different levels and types of courses for varied sectors of the local economy. However, as all contemporary Federal Institutes in Brazil must agree, around 50% of the offered vacancies should be dedicated to the technical level (Presidência da República, 2008), which increases the number of courses offered in this category and creates a lack of methodologies and specific teaching techniques for it.

However, the innovative characteristic of these institutes is not easy to verify in practice because it is not easy to get on a new movement when structures and actors are already established, since the new institutions came from previous existing ones. This can be viewed similarly to the analysis presented in the reference (Bazzo and Teixeira, 2009), which states that is very difficult to change certain teaching and ordering practices already present when new students and new realities came to the an academic institution. Hence, professors and students must search for new and interesting methods, in order to improve the courses and adapt it to a very complex and demanding reality in this great moment for Brazilian economy and technologic development in history.

The campus located in Chapecó (western Santa Catarina region) was established in 2006 and is part of this plan to extend the federal institutes. Initially, it offered four courses at the technical level. An engineering course in the automation/control area is also being implemented.

Since it is a new campus, most of the disciplines are being developed for the very first time and professors are still under experience. In this sense, there are many difficulties in applying innovative methodologies for such context, especially when it concerns the "product design" and relatives area.

This article contributes to the improvement and reduction of such difficulties through a critical analysis of an innovative method applied to the "mechanical project" discipline, which is part of the regular curriculum of the course. The disciplines are currently undergoing a wide change and suitability study process. The analysis of performance and student achievements evaluation is based on a questionnaire and subjective criteria of the professors and other issues, such as understanding the process of designing, developing innovation capabilities, applicability of design tools, quality of results and several questions brought by students.

1.1. West Santa Catarina region characteristics

For a better understanding of the studied project, it is necessary to understand the socio-economic characteristics of the geographic area of the college, since the students taking this course are part of this context.

The Chapecó city gave rise to the political-administrative division that currently defines the micro-regions of the western portion of Santa Catarina state. It is the sixth largest municipality within the state, with a population of over 183,000 inhabitants (IBGE, 2011).

Chapecó is an agribusiness pole in southern Brazil and economic, political and cultural center. The city has international prestige by the exportation of processed food products of animal nature. It is also considered the capital of the Latin American poultry production and agricultural research center in Brazil.

The western Santa Catarina region has 117 municipalities with more than 1.1 million inhabitants. It has been serving as basis for the most important companies in processing and exportation of pig meat, poultry and derived products in Latin America. Its industrial park is diverse, with the sectors that stand out the metal-mechanic (who has specialized in the production of equipment for refrigeration), plastics and packaging, transportation and biotechnology. The region has great prospects derived from the central position in "Mercosul" area, high production potential, availability of powerful electric systems, favorable conditions for agricultural production and other factors.

The mechanics course has a relevant fact related to the above description: 90% of students are employed in companies engaged in agribusiness and correlated activities.

2. DESIGN PROJECT METHODOLOGY

In order to later explain the learning/teaching process, it is necessary to define the theory employed to product design. It is the composition of a methodology for product selection and another for product design. The design methodology for selecting the product determines ways to choose, delineate the requirements and available resources to be developed in the product design. The design method set tasks and tools to be used in a chronological way for further application on a real product. However, in the related experiences of this paper, the products are only virtually developed and based on simulating tools.

2.1 Project Methodology

The following methodology has been defined to facilitate the activity of product development by students, considering the school environment. This definition limits the production of tests and trials, as well as the production of physical prototypes and opted for the construction of virtual prototypes. This methodology has divided the project into three distinct product and succession of steps: informational design, conceptual design and detailed design, following design trends cited in the bibliography (Rosenfeld, et al., 2005). At the end of each stage students should document the information generated and use them in subsequent phases.

The informational design was divided into seven tasks, shown in Tab. 1, to facilitate understanding of the design process. The proposed methodology should be fully applied, being adapted according to needs that arise along the development.

Following the document named "Draft Project" generated in the process of product choice (Tab. 4), students should research the availability technique presented by the state of the art, so that the product was also innovative and feasible. Based on the state of the art, students should document the vendors and competitors and the relevant legislation in the area of product classification. Still, the patent search should be made to facilitate the informational design phase, mainly in the manufacturing of the morphological matrix. This patent search aims to increase interest in the publication and preservation of ideas generated during the professional life of the students and not to cast the projects as a new idea (when it is not the case) to avoid unintentional plagiarism. As the main customers of the selected product would not be accessible and the assessment of customer's requirements would make it impossible to finish the project within the course, we opted for the simulation of these customer requirements through a brainstorm, as well as the transformation of these requirements into product requirements.

Table 1. Informational design.

	Task	Employed Tools
1	Technical availability	State of the art (books, papers, internet, etc.)
2	Suppliers	Catalogs, stores and internet
3	Competitors	Catalogs, stores and internet
4	Product legislation	Internet, books
5	Patent search	INPI, Google patents, espacenet
6	Client requirements	Brainstorm
7	**Product requirements**	Previous research

At the end of the previous phase, the product requirements should be prepared as the main document of the informational phase. On that basis, would begin the conceptual design phase, as shown in Tab. 2, by the establishment of the global function. Following the procedure of "unfolding global function" the physical design decisions are initiated. The morphological matrix is assembled to facilitate the accomplishment of the tasks outlined in the global function. After composing the morphological matrix, which must have multiple solutions for each item of the unfolding global function, it should be chosen the most appropriate product design (considering the reality of the students and prerequisites).

Table 2. Conceptual design.

	Task	Support Tools
1	Global function	Design requirement
2	Unfolding global function	Global function, design requirements
3	Morphological matrix	Brainstorm
4	Conception table	Morphological matrix
5	**Product conception**	Decision table

At the end of the conceptual design phase, the product design strategy is fully determined and is then used in the detailed design phase, described in Tab. 3. It starts by mapping the detailed design components for the product and encoding them. After mapping the components to be acquired, they are specified. The ones that must be assembled are designed and their materials are defined for local development.

Table 3. Detailed design.

	Task	Support Tools
1	Component map	Product conception
2	Component encoding	Component map
3	**Component design**	Computer + CAD Tool
4	**Component specification**	Catalogs, stores, internet and books

3. SELECTION OF PRODUCTS TO BE DEVELOPED

To organize the work within the course, an initial choice has to be made: "Which product will be developed and how will this be defined?". Three possibilities are then cast: according to Tab. 4. Each possibility has a particular task sequence, so that similar working time is required for all groups.

When the product was designed to be chosen by the professor ("Case 1"), students should establish a fictitious company and fill in related document samples.

In Case 2, the choice of the product area (Task 1) was defined by the teacher and the other decisions were made by the students.

Finally, in Case 3 all decisions were made by the student group.

For the Task 3, a decision making tool must be employed (decision table) to avoid the product to be chosen influenced by a minority interest in a part of the group. This procedure is also part of case 2.

Table 4: Product definition options and tasks.

Task	Case 1	Case 2	Case 3
1 – Defining the focus area of the fictitious company	Consequence of the product defined by the professor	Area is defined by the professor	Area is defined by the student group
2 – Definition of the product catalog of the company	The catalog is defined by students (except the main product already defined by the professor)	All the products of the catalog are defined by the student group	All the products of the catalog are defined by the student group
3 – Definition of the product to be developed	Defined by the professor	The group defines the product to be developed within the predetermined focus-area	The group defines the product to be developed
4 – Project draft	Equal requirements for all groups		

4. DEVELOPED PROJECTS

The project methodology was applied to two classes of mechanics technician course, whose students organized in groups of four or five members, depending on the number of students in the class. Each group was free to choose their own project or accept the suggestions of the professor. The result was the formation of four groups that have opted to choose the project to be developed (Case 3, Tab. 4); one that accepted the suggestion of the development area (Case 2, Tab. 4) and one that accepted the professor's proposed project (Case 1, Tab. 4).

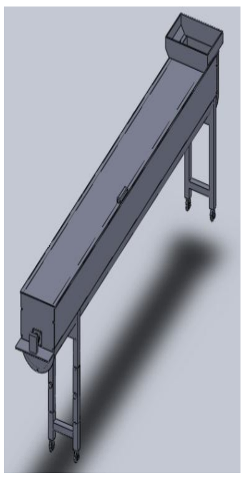
Regardless of the strategy adopted by the group, everyone should follow the same routine of activities, starting with the creation of the company and then performing the steps defined by the methodology of product design theory, as described in the previous section (2.1).

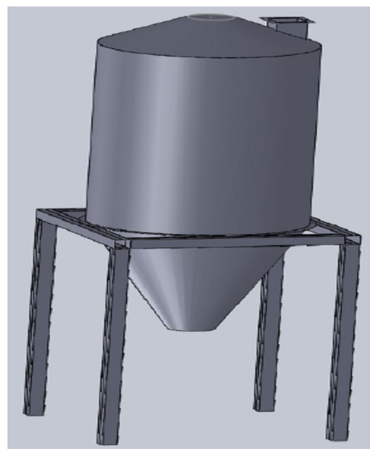
4.1 Description of the Products

Of these four groups of case 3 who have chosen to pick the area and product independently, two groups have opted to create companies to serve the agribusiness sector. One group developed a silo for grain storage (Fig. 1a), which would be used primarily for storage of feed for use on farms. Another designed a device (screw conveyor) to transport grain (Fig. 1b), whose purpose was the loading and unloading of trucks and silos.

A third group chose to develop a hydraulic giraffe (Fig. 1c), motivated in particular by working in auto mechanics, since the main purpose of the equipment was to assist the process of assembly and removal of vehicle engines.

The last group, which also chose the product to be developed, proposed to design a beater (Fig. 1d) consisting of an equipment to facilitate the production of food in small family farms. It will be used to beat and mix products derived from sugarcane, for example, brown sugar and molasses.


(a)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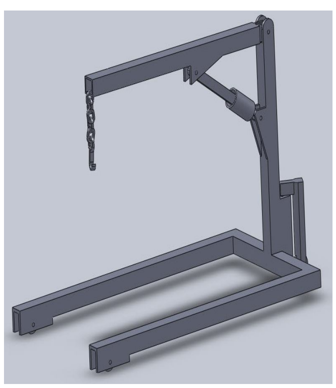
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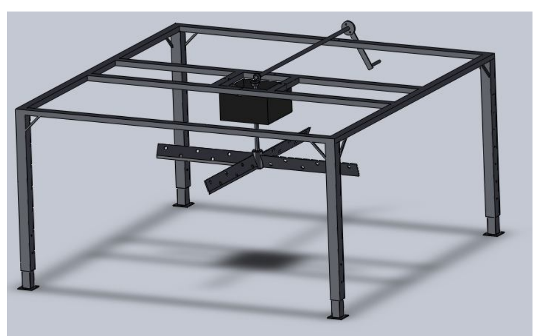

(d)

Figure 1. Developed equipment for the students of case 3. a – Screw Conveyor, b – Silo, c – Hydraulic Giraffe e d – Manual Beater.

The equipment shown in Fig. 2 resulted from work of group of students who chose to request suggestions from the professor. Figure 2 is a plastic processor designed to meet a growing demand for sustainable equipment.

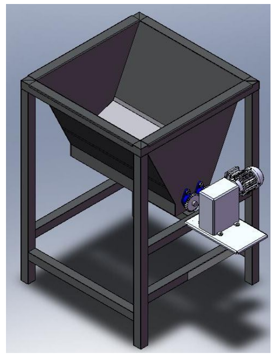


Figure 2. Developed equipment for the students of case 2 – Plastic Processor.

The Fig. 3 exposes an automatic cutting guillotine for small metal plates and fills a need for a laboratory of the mechanics department of the Campus.

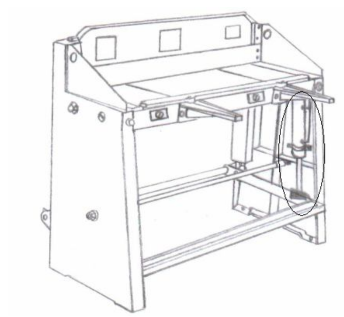


Figure 3. Developed equipment for the students of case 1 – Pneumatic Guillotine.

4.2 Critical View of the Projects

All the three systems, shown in Fig. 1 a, b and c, work with equipment for use in medium scale industry applications. Its supply is fully served by companies that are already working in the area and do not characterize an innovation, as previously said. Thus the enterprise created by the students would possibly face difficulties to establish in a real business environment.

The product shown in Fig. 1d is a proposal designed to meet a need in the region and, unlike those shown in Fig. 1 a b and c, is still not fully met. According to research by students, the currently offered similar products are electro-mechanical equipment that are usually very expensive to the potential customers.

In this way, it was observed that the groups that made the predominant option chose products that are strongly related to the context of the region, being mostly produced or acquired by companies in which students act. This, on one hand, can be seen as a surplus, because it forces the student to research technologies and products that are being applied in regional industries today. However, the products chosen and executed little differ from what exists in normal practices, i.e. it can be concluded that students tended to replicate what is already known. It is believed that the achieved factor of self-choice preference is due to students are with metalworking companies and has been involved in project or production activities. This leads to choose autonomously research, much more than follow suggestions of the professor.

The beater crusher and plastic processor (Fig. 1d and Fig. 2, respectively) are products that have similar characteristics, because can be considered regional innovations, due to the fact that according to the students there are still no devices like these being used in the region. Specifically about the beater crusher, the recycling culture is undergoing expansion in the region and the trend is that the number of companies targeting the area of conservation and recycling will increase, raising the need for such products.

The group working in design automation pneumatic cutter (Fig. 3) aimed to meet the needs created by the campus. The result of the project was an adaptation of an existing guillotine in the laboratory of mechanics, so that it make the cut sheet strength through pneumatic and non-manual procedures. The big advantages of this group is that they were able to work with real customers (teachers and technicians) and believe that the project will actually be carried forward and result in implementation.

Assessing the outcome of the projects forward to the goals of innovation that the design methodology aims to encourage, it was found that there were a few projects that can be considered innovative, so we concluded that the proposed methodology needs to be adjusted to force the student to be more creative.

However, the global project, under the educational point of view, consists not only of the final result. In this sense, it was observed that all work performed by students and presented here were consistent with quality products for the technical level, covering details and various activities that caused students to think of solutions and business strategies that might give better results.

5. METHODOLOGY ANALYSIS

At the end of the course a questionnaire was administered to students in order to collect information and analyze the result of the applied teaching method. In an attempt to get honest answers, leaving the student more comfortable and avoid a feeling of reprisal with respect to the given answers, the questionnaire was presented to students as an analysis tool that allows the professor to have mechanisms for improving the education method for future classes. Other actions towards this goal were made, for example, the questionnaire is not asked to identify the student and the professor was not in the room while filling it out.

The questionnaire consisted of eighteen questions, some open and others that require the student to choose a single alternative. The alternatives which had no vote shall not be counted in the analysis (they only indicate the number of possibilities that the student had to choose).

The questionnaire was subdivided into four parts and forced the students to reflect on the following aspects:

• Part A: The importance of the discipline within the mechanics course and the allocation of it in the fourth (last) module of the course is suitable?. Also, whether or not the student could see some link between this discipline with others in the curriculum;

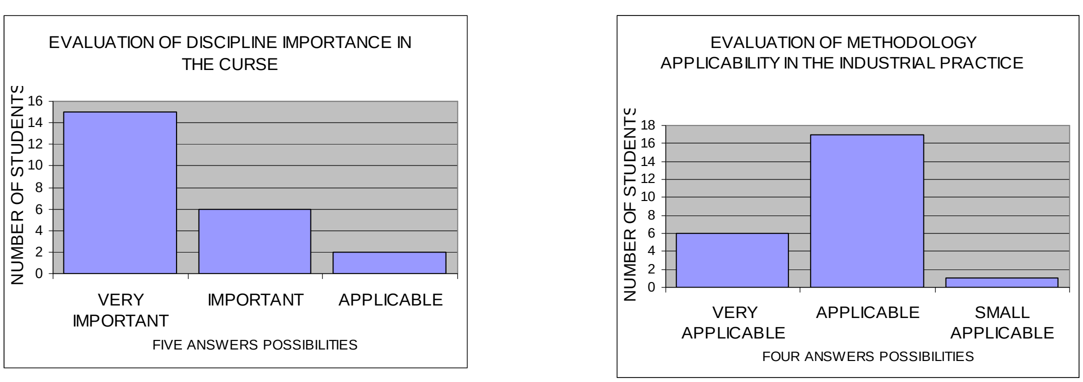
• Part B: The use of design methodologies and tools are applicable in the current industry practice? Is the use of this methodology helpful or not for the project's development in the classroom;

• Part C: The student could really understand the purpose of the methodology? Was this understanding really reached? Whether would students use this knowledge in their working lives?

• Part D: What is better? The teacher or the student to choice the project for the course and what aspects were taken into account for choosing the project, if it has been chosen by the student group.

From the results, some were within expectations, while others were somewhat surprising and contradict what was expected. Therefore, this article will present the results of relevant issues in order to build a critical idea about the answers.

Regarding the methodology applied to the students, two questions had interesting results and are illustrated by Fig. 4. Figure 4a: questions about the importance of discipline in the technical course of mechanics, while Fig. 4b questions about using the methodology learned in industrial practice. Figures suggest that students understand and believe the presented methodology, as can be seen in the number of answers saying "very important", "important", "very applicable" and "applicable". However, the fact that Fig. 4b presents an unfavorable result with regard to the methodology, compared to Fig. 4a, raises some questions. Do most students can not see that the methodology is "very applicable" because the region's industries do not use this technique? Or, they can not see any change in this attitude because they have not understood how to use the right methodology or tools? It is necessary to asses whether the technique was not introduced in an accessible way by the teacher or this methodology is not extremely necessary to the job market.



(a) (b)

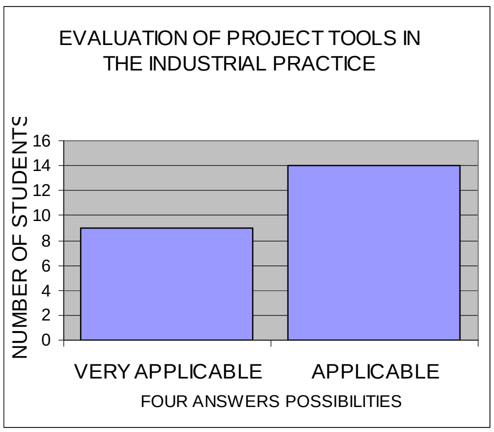
Figure 4: Methodology evaluation.

Still regarding the methodology assessment in industrial practice and student life, in the other three questions the results were totally favorable to the methodology. The answers to the questions attested that if the student opened a company, he would apply the presented design methodology and that the tools presented have really helped in the project activity.

Two questions reinforce that the discipline of design methodology should really be in the curriculum of the technical level. When students were asked how they felt able to run a product design before and after the studies, the result was that only five students initially felt confident to do it. On the other hand, at the end of the semester all twenty-three who answered the questionnaire felt able to run the project activity. Fifteen of which have come to understand the methodology during the semester and only five after project completion.

When asked in an open question whether they would change something in the design methodology presented, the responses that stood out was they will not change anything (nine students) and another group (four students) would deepen the technique for a better financial analysis, effective contact with the client and planning the plan production. So, no complaint or disappointment with the way the course was organized was registered.

Figure 5 shows the results of the assessment focused on the specific design tools. It can be seen in Fig. 5a that all students believe that the tools are applicable in the industrial area. However, the degree of applicability is viewed differently, depending on the tool in question. The coding of the components was the most criticized (a technique extremely usual in the industry). It is believed that this poor evaluation resides in the fact that projects were not developed in groups, but individually. Also, the application is relatively small in size and is not included in electronic databases, so that students did not feel the need to develop an encoding.



(a)

PROJECT TOOLS	USEFUL	UNDECIDED	USELESS
Decision table	17	6	0
Client and product requirement lists	19	3	0
Unfolding global function	17	6	0
Morphological matrix	20	3	0
Component map	17	5	1
Component encoding	13	10	0
Component specification	19	4	0

(b)

Figure 5. Project tools evaluation

Still regarding the teaching methodology and tools applied, the students, in another open question, gave different answers for greater difficulty. It is noticeable that three students relate that the great difficult it to create charts and tables, which makes us believe that some students, even studying at the fourth and final semester of the technical course, have difficulties for using basic computer tools. Six students enumerated product choice and solutions not obvious, which expresses, on one hand, the student effort in developing creativity. It also shows the difficulty faced by students to be entrepreneurs. Another interesting result with respect to the same question, was that only one student indicated the functional breakdown as the main difficulty, even though this is an activity that forces students to think of functions, which are somewhat more abstract than the component itself.

An open-ended question asked students about what part of the methodology he felt that it was more required to have creative ability. Sixteen students reported activities such as product choice and design stages of the conceptual and informational design, for example. Also they reported the definition of solution principles, definition of concepts for the product and definition of requirements and customers. This indicates that some of the students actually followed the methodology as it should be done, as it is understood that these early stages of project decision-making should be more present. However, seven students understand that the creative process was further developed in the detailed design phase, which leads us to believe that a considerable proportion of students still performed the activities of the previous phases inefficiently.

This fact can be confirmed by another question made, which indicates that fifteen students understand the methodology for the project since it has started and only eight, after the conclusion and discussion of the discipline. However, one positive aspect is that no student indicated that he had not understood the methodology.

The last part of the questionnaire was aimed at mapping student satisfaction with regard to product selection and whether the group's choice or professor's indication is better. This part was made using an open question asking the student if "a project given by the teacher would be better". The answer to this question was too divided: ten students answered "no", reporting that this diminish the student's creativity and showed some concern with the obligation to undertake the design of a product that might not be the group's interest. Another eight students responded that the group choice strategy would be better, because, with more options, they could drive a greater effort to the project itself and this alternative would not affect the development of creativity of the group. Finally, six students list the positive points for both options. Thus, it is believed that both the strategies can provide good results. However, attention is necessary with the way this decision is passed on to students.

6. IMPROVEMENTS IN THE METHODOLOGY

Considering the analysis of the process, regarding teaching and learning process used in the second half of 2010, it was noted that this methodology meets the needs of students and meet the expectations of the course, professors and learners. Thus, it is believed that the used tools, degree of design and order as the tasks are required of students can be maintained for a few semesters. However, the evaluation of this form of instruction must be continually under execution and undergo adjustments, if necessary.

But, the manner how the area of operation of the fictitious company is and the developed project is chosen yet has to be improved, since some results left much to be desired, either by the fact that some groups chose products already on the market or by the limited target-product (creating a lack of innovative ideas).

The expected outcome of this course is that, besides the students believe and understand the methodology, also to be able to develop an innovative product that meets the needs of society and have the view that this product is actually made, thus leading to the result of his work for others to admire and appreciate. However, this task is not easy, since it was observed that often students tend to choose products that are already commercially available and who may not be manufactured, given that other companies are already using this product on a consolidated and restricted market.

In order to make the outcome of the projects presented by students better, a new proposal was put together by the academics of the mechanical course and will be applied in the next semesters.

Another possible change in the design project classes is inspired in a current practice adopted in the "Machine Elements" discipline (of the same course and campus). In such classes, students were working on a product that meets a real need, which can be extended to other educational institutions and teachers of machine elements. Professors and laboratory technicians take on the role of customers. The resultant products have revealed as innovative ones and there is a clear prospect of building such equipment.

Depending on the quality of the developed product, the manufacturing equipment will be developed in the project integrator II discipline, which is also taught in the fourth module of the course. However, the class that will execute the project will be one that is currently attending the previous module, in order to students can exchange ideas and learn with each other.

7. CONCLUDING REMARKS

By evaluating the results obtained with the first application of the teaching-learning method, it is believed that this methodology is consistent with the students' ability and level of course and the sequence of activities or tools used can be maintained. However, subsequent evaluations can provide additional information and indicate what changes are needed.

Regarding the choices of projects, it was found that both strategies meet results that, at some point, did not meet initial expectations. In this sense, an innovative proposal was presented and has been put into test in the first half of 2011. The implementation of this proposal would also result in better teaching-learning process for the complex context of mechanical designs. It is also intended a much more effective integration of knowledge and a new possibility of interchanging projects and ideas.

8. ACKNOWLEDGEMENTS

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10. RESPONSIBILITY NOTICE

The authors Belan, H. C, Kulman, C and Coser, J. are the only responsible for the printed material included in this paper.