Introducing CDIO at The Military Institute of Engineering in Brazil

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Abstract
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Final Report

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Introducing CDIO at the Military Institute of Engineering in Brazil

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1. INTRODUCTION

The Military Engineering Institute (IME) is a Brazilian Army higher education institution, located in Rio de Janeiro – Brazil. IME was created in 1972 with the designation of "Royal Academy of Artillery, Fortification and Design". In 1959, the designation changed to the current name. The Institute has a history of pioneering in Brazilian engineering education and participated in some of the most important national engineering projects.

The institute has ten programs leading to the bachelor’s degree in engineering (Figure 1) with the main objective that graduated engineers will work in the Science and Technology System of Brazilian Army. The engineering curriculum structure has ten semesters, with the courses in series form and all mandatories.

IME admits about one hundred students per year. The IME admissions exams are considered to be one of the most difficult among Brazilian engineering universities, with approximately five thousand applicants, requiring a solid basic knowledge of mathematics, physics and chemistry. About 70% of the students of the Institute are military and the others are civilian student. The military students will work in Brazilian Army engineering organizations, after their graduation.
Since 2012, a project to transform the Brazilian Army's Science and Technology System has been running, involving and introducing new aspects, such as the innovation and triple helix concept. This transformation project won’t be addressed in this report, but it created an opportunity for IME to initiate a reflection about how to improve and adapt the formation of the engineer to the new scientific and technological system.

In parallel to that, in the last years, there has been an increase in student dissatisfaction. This dissatisfaction is mainly related to the great number of theoretical activities in IME. In the words of the students: “only lectures, blackboards, books and exams”. The students have put in their feedbacks the desire to “build” and to “practice” something. Actually, in the past, the IME’s student had more activities that are practical. However, during the last years, the education has been based most in scientific foundation without or almost without practical activities. This kind of feedback was received, in a certain way, from some engineering institutions of the Brazilian Army.

In 2010, a new activity was included in the IME programs, which increased this demand. The students of IME in the fourth year started to participate in international exchanges, created directly by IME or by Brazilian government educational programs, such as Science Without Border (Brazilian Government, 2016a). These exchanges allowed students from IME to attend six months of courses at some renowned engineering international institutions,
such as, West Point United State Academic, Texas Tech, Massachusetts Institute of Technology, Michigan Technological University, University of Cambridge and ParisTech. The feedback about the student performance, of all this universities, have been excellent.

This activity, in addition to provide an excellent learning experience to the students, produced one modification in the perception of the IME student relation with what they saw during their exchanged and what they experience at IME. The students that return from the international exchange are very motivated but start to compare this with the IME structure. This comparison in relation to learning and teaching methodology, curriculum structure and teaching activities contribute to increase the dissatisfaction among the students. The students now have the perception that the learning and teaching process could change and could be improved at the Military Institute of Engineering.

So, basically, the students forced IME to start an improvement process in its engineering education, despite its excellent results. Based on why and how to change, and after visit some universities and analyze some possibilities, the introduction of CDIO framework in the programs of IME was chosen, at the end of 2014, as the kernel of this improvement process. As will be seen in this report, the CDIO framework is the one that most suited to IME culture and demands.

2. ENGINEERING EDUCATION IN BRAZILIAN MILITARY INSTITUTE

The IME is, at the same time, an engineering college and a military academy (Figure 2). As an engineering college, it must comply with, like all engineering bachelor’s degree programs in Brazil, the rules established by the Brazilian government. In a few words, all engineering undergraduate programs must have at least 3600 hours of academic activities and five years to be graduated (Brazilian Government, 2002) and (Brazilian Government, 2007).

Figure 2. Academic scheme of the IME.
At IME, the engineering curriculum structure has ten semesters. The four initials semesters, called the basics years, are the same for all the ten programs. Only after the fourth semester the student chose the respective engineering program. The programs have between 3.800 and 4.000 hours of activities in engineering education. Despite this number, the most part of the activities are theoretical activities, mainly a great number of lectures.

In 2004 the Brazilian government created a national exam named ENADE, in substitution of an older similar exam. The ENADE is a Brazilian Performance National Examination Students (Brazilian Government, 2016b), and it has the objective to measure and monitor the process of learning and the academic performance of undergraduate students. The exam is one of the assessment procedures of the National Higher Education Evaluation System, applied periodically to students from all undergraduate programs during the first and last year of the program. The engineering programs are evaluated every three years, and the first was in 2005, and the exam is in relation to the knowledge, skills and competences acquired during their graduation.

The students of IME always have exceptional results in national examination replaced by ENADE in 2005, 2008, 2011 and 2014. The result always puts IME in the first positions. For example, IME was the first in five of six engineering programs evaluated by ENADE 2014.

Beyond the education in engineering, as a military academy, the military student has more than about 1.700 hours of activities related to military education. These activities are scattered by the five years, even though more concentrated in the two first years, and they must comply with the Brazilian Army orientations. The Figure 3 shows the curriculum’s structure of IME.

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**Figure 3. Curriculum structure at the Military Institute of Engineering.**
3. CDIO CONCEPTS

The CDIO Initiative is an international collaboration with the aim of developing and improving engineering education. The Initiative started in 2000, and from the beginning three universities in Sweden (Royal Institute of Technology - KTH, Chalmers Institute of Technology - Chalmers, and Linköping University - LiU) and MIT from the USA were involved. Over the years a number of universities have joined the Initiative, and currently there are more than 120 collaborating universities from all over the world. The CDIO Initiative is a community that share experience and learn together. An overview of the CDIO Initiative can be found via the web site (CDIO Initiative, 2016).

A thorough presentation of the CDIO framework for engineering education and the main results from the activities within the Initiative is given in (Crawley et al, 2014). The CDIO framework is based on two fundamental documents, the CDIO Syllabus and the CDIO Standards respectively. The first document, the CDIO Syllabus, can be seen as a specification of the desired knowledge and skills of a graduating engineer, and it is structured in four main sections:

1. Disciplinary knowledge and reasoning;
2. Personal and professional skills and attributes;
3. Interpersonal skills: teamwork and communication;
4. Conceiving, designing, implementing and operating systems in the enterprise, societal, and environmental context – The innovation process.

The main efforts within the Initiative have been spent on finding ways to develop and improve engineering education with respect to the three last sections of the Syllabus. The organization of the CDIO Syllabus in its four main sections, and subsections is also useful as a framework for specifying learning objectives for both individual courses as well as entire programs.

The second document, the CDIO Standard, specifies the desired properties of an engineering program, and it consists of twelve points that define the desired features from different viewpoints. The first standard states the fundamental philosophy behind the CDIO Initiative by saying: Adoption of the principle that product and system life-cycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education. The statement implies that the entire engineering education should be designed and run within this context, and various aspects are then highlighted in the other standards. For example, Standard 5 stresses the importance of including DBT experiences in the curriculum, and Standard 6 emphasizes the necessity of having workspaces for such learning activities.

4. WHY AND HOW IMPROVE THE IME’s EDUCATION PROCESS

The first question that emerged was why an institution that obtains excellent results in the national exams and is recognized as one of the best engineering colleges in Brazil should change. The reasons were soon raised as written in an earlier section. It was directly connected with the students' motivation, their desire to practice engineer during the under-graduation, and the change in the manner of performing R & D in the Brazilian Army.
After this, the question was how to improve. Due to this scenario, in the beginning of 2014, a program was started with the objective to improvement the engineering education process in IME and the CDIO framework was chosen, at the end of 2014, as a way to achieve the program’s objectives.

This choice was based on the alignment between the intended IME changes and the CDIO concepts, as shown below by some examples:

- The concept that the engineer education should be based on fundamentals but with a context of Conceive-Designing-Implementing-operating systems and products – CDIO Vision and CDIO Standard 1;

- Creation of new opportunities for students to perform more engineering practice in the academic activities, as elaboration of engineering systems, well-designed work and design-build-test courses – CDIO Standard 4, 5 and 8;

- Implementation of teacher training and improvement in new teaching methodologies, encouraging the use of more active learning activities – CDIO Standard 8, 9 and 10;

- Inclusion of integrated learning, which means learning experience where the theoretical knowledge and professional skills are obtained simultaneously – CDIO Standard 3;

- Implementation of the constructive alignment concept (Biggs, 1996) as a model for courses design, as also executing a revision of the intended learning outcomes and the curriculum of the programs – CDIO Syllabus, CDIO Standard 2,3 and 12.

- Introduction the concepts of innovation and triple helix (Ranga & Etzkowitz, 2013) as part of the knowledge, skills and attitudes of the student – CDIO Syllabus.

Another important point is that the educational improvement process has some challenges:

- How do IME change without losing the excellence already achieved?

- How do IME change and, in the same time, comply with the rules of Brazilian Ministry Education and Brazilian Army?

The answers to these questions are found in CDIO framework to. The CDIO framework is a reference model and not a rigid standard (Crawley et al., 2014). Thus, the CDIO framework can be adapted to the Brazilian higher education law and to the Institute’s academic and military rules.

5. PROCESS OF INTRODUCTION CDIO FRAMEWORK

Some steps of the improvement process have been taken in accordance with the suggestion that is in the “to get started” section of CDIO Initiative (CDIO Initiative, 2016), as example, the reading of the initial sections of CDIO Initiative and the Rethinking Engineering Education book (Crawley et al., 2014).
On the other hand, others steps related to specificities of IME were taken too. This section will present some of the steps of the process at IME until March 2016. It should be noted, for better understanding, that IME’s Commander is also the principal responsible for the educational process in IME, exercising the role of the university president too.

In November 2014, the high direction of IME, including the IME’s Commander visited two of the Swedish universities that started the development and implementation of the CDIO: Linköping University (LiU) and Royal Institute of Technology (KTH), respectively, in Linköping and Stockholm. The objective of this visit was to have a first vision about the CDIO framework and its implementation and see some of CDIO’s results. At the return from this visit, the CDIO framework was confirmed as the methodology for the improvement process of IME’s education.

At the beginning of 2015 professor Svante Gunnarsson, Linköping University (LiU), was invited to give a CDIO workshop at IME. Figure 4 shows the workshop. This workshop was in May 2015 and had the objective to show the CDIO vision to a group of teachers and students. This workshop presented, beyond the CDIO concepts, some tools, examples and experiences related the CDIO implementation at the LiU.

As a result of the direct contact with the LiU, after the workshop in Brazil, it was planned an exchange of two IME professors for six months at Swedish universities. This exchange had the objective to give more experience and knowledge to the IME professors concerning the CDIO implementation and in methodologies of Teaching and Learning in High Education. This exchange of two professors from IME occurred from September 2015 to March 2016. The activities of this part of process will be more explained in the next section.

In October 2015 the high direction of IME, including the commander of IME, made a visit, similar to Sweden in 2014, but now they visited the Aeronautics and Astronautics Department of Massachusetts Institute of Technology (MIT) in Massachusetts, United States of America, which was one of the original founders of the CDIO Initiative. The visit had objective to see additional implementations of CDIO.

Last but not least, IME sent three professors in 2014 and three more in 2015 to attend the “CISB Executive Innovation Management Course (EIMC)”. CISB is the Swedish-Brazilian
Research and Innovation Centre (CISB, 2016) and this course has been offered to Brazilian Army since 2013. This is a joint initiative between Linköping University, the Swedish Armed Forces and SAAB Corporate to explain and teach the Swedish way of doing innovation, with focus in Innovation Management. It is part of the project to transform the Brazilian Army's Science and Technology System.

Even though this course isn’t directly connected with the CDIO, it will be useful in the improvement process of education in IME and in the introduction of the triple helix concept. The professors that attended this course have the responsibility to think about the connection between the CDIO implementation and the innovation concept, need by Brazilian Army transformation project.

As a consequence of this course, it was organized in November 2015 the “1st Integration Seminar between IME and Brazilian Defense Industry”. Some of the objectives of this seminar are connected with the education improvement. As example, the definition of themes for Undergraduate Final Projects that could fit the industry interests. At the end of this 2015 seminar, 26 themes were jointly defined by IME and the industry. The second seminar is scheduled for 2016.

6. EXCHANGE OF PROFESSOR BY SIX MONTHS IN SWEDISH UNIVERSITIES

As mentioned, one of the results of the direct contact with the Linköping University was the creation of an exchange of two IME professors for six months at Swedish Universities. This exchange, that occurred from September 2015 to march 2016, had the objective to give more experience and knowledge to the IME’s professors. The activities were related to the CDIO concept and implementation that occurred at LiU and activities in the Teaching and Learning in High Education area, which are realized by a course at Royal Institute of Technology (KTH).

The methodologies and tools used in the process of CDIO implementation and in the benchmarking of engineering curricula were analyzed at LiU. The study of the curriculum was carried out via interviews and discussions with the teachers responsible for the courses and by participation in various learning activities.

During the stay at Linköping University two five-year engineering programs were studied in some detail. These were the Applied Physics and Electrical Engineering program and the Mechanical Engineering program respectively. As mentioned, Linköping University was one of the four original collaborators of the CDIO Initiative and the university was represented by the Applied Physics and Electrical Engineering program. The redesign of the program is documented in (Berggren et al, 2005a) and (Berggren et al, 2005b).

Complementarily, The Teaching and Learning in Higher Education course (LV231V) was attended at Royal Institute of Technology (KTH) from September 2015 to January 2016 (KTH, 2015). The objective of introduction this activity in the exchange was to obtain more knowledge in the Teaching and Learning in High Education, mainly in engineering education.

Among several activities during the exchange, some observations were considered more important in relation with the IME process. These observations will be based of the transformation planning. So, some points will be highlights in this section.

6.1. Projects Course
One of the main outcomes of the CDIO implementation within the Applied Physics and Electrical Engineering Program at LiU was that a sequence of project courses was introduced according to Figure 5. This are three projects course in the Engineering Program.

The Introductory course was introduced in 2002 in order to comply with Standard 4 of the CDIO Standards. Two of the overall aims of the course are to provide an introduction to engineering and give rise to motivation for future studies. The aims are also to provide training in written and oral communication and to give an introduction to team work and project management. At Linköping University the project model LIPS is used in several of this kind of courses.

The LIPS project model is used in all courses

Figure 5: Sequence of project courses within the Applied Physics and Electrical Engineering program.

The course is hosted by the Department of Physics, Chemistry, and Biology, and the course is managed by Associate Professor Urban Forsberg. The size of the course is six ECTS credits, and it consists of three main parts.

The first part is a series of lectures dealing with the engineering profession, team work and group dynamics, the LIPS project model, and communication. The second part of the course is the project, and there are approximately seventeen project tasks offered by five departments. The students are organized in groups of six students. The third part of the course is a project conference, organized with parallel sessions similar to a scientific conference, where the project groups present their results.

The starting point for the project work is a requirement specification stating the technical results that are requested. The first step of the group is to distribute the different roles like project leader, documentation, external relations, etc., among the group members. After having formed the project group the next step is to write a project and time plan. When the project and time plan have been accepted the project work starts. The technical result is evaluated by checking that the delivered results fulfil the requirement specification. After the result has been accepted the group writes, as a mandatory part of the project work, a
reflection document. Figure 6 shows an example of the lectures dealing with the engineering profession, team work and group dynamics realized in 2015.

![Image of lectures](image1.jpg)

Figure 6: Introductory course – Example of Lectures.

The second stage in the sequence of project courses is the project course in electronics, which was introduced in 2003. It is given by the Department of Electrical Engineering and managed by Associate Professor Tomas Svensson. A detailed description of the course is given in (Svensson and Gunnarsson, 2012). The brief description here is mainly taken from (Berggren et al, 2005b).

The students are organized in groups of six students. One of the students is appointed to be project manager, and the other students in the group also have special tasks such as responsible for the documentation, responsible for software design, responsible for hardware design etc. Each project group has a supervisor, and all groups have access to a number of technical experts.

The starting point for the project work is a project directive written by the sponsor. This includes a description of project task and the number of hours allowed to be used. After having formed the project group and selected a project task, the next step is to write a requirement specification. This document must be negotiated with the sponsor. Requirements are given different priorities. When the sponsor has approved the document, the project enters the preparation phase. The group makes a system drawing, a project plan and a time plan. When the project and time plan have been accepted the execution of the project starts. The first step is to produce a more detailed description of the design, a design specification. This document must be discussed and approved by the sponsor at a tollgate meeting. Now the group is given access to the workspace. Figure 7 show example of the workspace labs used in this course.
During the execution phase, the students must do individual time reporting. The group will be warned if too little (or too much) time is used by the group or by individuals in the group. The sponsor will also ask for status reports, where the group has to report about finalized activities, problems, changed planning etc. At the end of the execution phase the technical results are evaluated by checking that the project outcomes fulfil the requirement specifications. The evaluation is done by the sponsor at other tollgate meeting. If this is approved the group is allowed to deliver. The delivery is done by presenting the project outcome at a small conference and by demonstrating the result.

There is often a competition between the delivered products. The result must also be described in a technical documentation. After the delivery has been accepted the group writes, as a mandatory part of the project work, a reflection document. Figure 8 show an example of students projects presentation, realized in December 2015.
The third and last stage in the sequence is a set of project courses connected to the different specializations of the program. These courses cover a wide range of subjects from Applied mathematics, Computational physics, Electronics, and Automatic Control to Biomedical Engineering. The courses encompass 12 ECTS credits, and of those 3 ECTS credits belong to a module about entrepreneurship. The project course in Automatic Control is described in some detail in (Karlsson et al, 2006). Another point observed in this course, that is considered important in IME’s process, is the use of student projects connects with the industry task.

6.2. Project Model

A project model is used by the student throughout the sequence of project courses. The project model LIPS is used to support the development process. This project model was developed within Linköping University during the initial years of the CDIO Initiative, and has now been used in hundreds of projects and by thousands of students. The model is thoroughly described in (Svensson and Krysander, 2011). The model provides a structured way of carrying out a project with clearly defined toll gates and decision points. The model provides templates for the various project documents created during the project, like requirement specification, design specification, etc.

The LIPS model can be used for any kind of academic engineering project, regardless of course or content. Figure 9 shows the structure of the LIPS model. The tasks described in the model are used to guide the work in the direction of pre-defined objectives and to facilitate their control. The model provides an efficient flow of activities and decisions necessary for the implementation of a project. The three steps of the LIPS model describe the preparation and project planning, execution and completion and evaluation. The model also includes descriptions of activities, functions and forms of communication in a project.
A project template provides a useful tool to develop and evaluate the required professional skills of students. The skills provided in Section 3 of CDIO Syllabus are present in the context of the project course, and the ideas proposed by the CDIO Syllabus, in Sections 3.1 and 3.2 (teamwork and communication, respectively) are central to long the entire course. The evaluation of teamwork is present in the project template, either directly or indirectly.

6.3. Program Management

The education programs within the Institute of Technology at Linköping University are managed by five different program boards, where each program board is responsible for a set of education programs within a particular area of related subjects. The program boards manage programs within:

- Electrical engineering, physics and mathematics;
- Computer engineering and media technology;
- Industrial engineering, management and logistics;
- Mechanical engineering and design;
- Chemistry, biology and bio engineering.

A board consist of three categories of people; teachers, students and representatives from industry. It is important to stress the broad teacher representation in the board, and e.g. the board for programs within Electrical engineering, physics and mathematics encompasses teachers from the departments of Electrical engineering, Computer science, Mathematics, Physics, and Biomedical engineering. Similarly, the board members from industry represent different types of industries in terms of size and technical area.
The board takes decisions about the curricula for the programs as well as the course plans for each individual course. The course plan includes a description of the learning outcomes, the organization and the type of examination used in the course. The teacher representatives are elected for a three year periods, with the option of re-election. For each of the program boards there is also an administrative team, located at the Dean’s office, consisting of a Director of studies, Student counsellor, and a Coordinator e.g. responsible for the scheduling of the various courses in the programs.

6.4. Machine Design Course

The Machine Design Course is another course that was observed during the exchange at LiU. This course is one of the implementation of CDIO framework in Mechanical Engineering undergraduate program, in order to comply with CDIO Standard 5. This course is managed by Associate Professor Peter Hallberg.

Briefly, this course uses a CAD tool and provides the student an efficient way to create a mechanical design. Classes consist of theory and practice in laboratories of computer and mechanical construction. The course is divided into two stages, showed in Figure 10.

The first involves learning with the CAD tool, the reading and production of mechanical technical drawing, 3D modelling and optimization technique of machine design. The second stage is a project in groups of 4 or 5 students, where students explore the connection between the digital developing CAD and physical knowledge of the model. Currently this project is about the design and construction of a catapult for an object to be launched to reach a certain height and distance.

Figure 10: Machine Design Course - Course stages.
The course assessments are carried out through the delivery of individual technical drawings in CAD and the group project. This course provides an engineering practice environment, Figure 11, through well-designed laboratories, leading to active and integrated learning. Through the proposed activities, students have the opportunity to share many recommended skills and attitudes in the CDIO Syllabus, as engineering knowledge, system design, teamwork and communication. In this way, this kind of course also comply with the CDIO Standard 6, 7 and 8.

Figure 11: Machine Design Course - Course development environments.

Another activity of this course is a student competition. In this activity the student groups, who wish to, can compete with their catapults. Figure 12 shows one of the course activity, where is realized one student’s competitions.
6.5. Teaching and Learning Course at Royal Institute of Technology (KTH)

The Teaching and Learning in Higher Education course, attended at Royal Institute of Technology (KTH), has the purpose of develop the knowledge, skills, abilities and attitudes that the teacher need in order to best support and facilitate the students’ learning in higher education. It gives the participants the opportunity to experience and explore different aspects of learning and teaching to develop and reinforce their identity as a university teacher and educator.

This paper highlights some of the course’s objectives, between the course intended learning outcomes (KTH, 2015):

- choose, design and analyse learning outcomes, teaching activities, forms of assessment and examination that support and test your students' learning;
- evaluate your students' experiences, learning strategies and learning and develop your teaching and teaching skills;
- discuss, analyse and utilise experiences and relevant research results, and thereby contribute to the knowledge development in the subject area;
- identify obstacles to a desirable development of the education and develop strategies to meet these in a constructive way.

In the course meeting, the participants work with some form of educational development, through of the explorations and discussions of each topic. Figure 13 shows some of the course activities in 2015. The course is designed with five Learning Cycles and some workshops related with the subject.
The learning cycles were: learning and learning environments, the students, the role of the teacher, designing course to facilitate meaningful learning and pedagogical and professional development.

The workshops available in 2015 and attended in the exchange were: designing courses for motivation, flipped classroom, intended learning outcomes and the course syllabus, formative feedback for learning, assessment methods, pedagogical portfolio and educational development with “Learning Experience Questionnaire” (LEQ).

In 2015, this course was managed by Professor Dan Borglund, with a dozen of other teachers in the course’s team. The Academic Teaching was based on book (Elmgren and Henriksson, 2014) and there were a large number of available references in the course webpage that could be use in the IME’s process implementation.

7. FURTHER ACTIONS

IME hopes, as mentioned at Crawley et al. (2014), that the adoption and implementation of the CDIO framework could be of great value to the undergraduate programs and the students they serve. The previous sections presented the steps taken until March 2016 and now, in this section, we will show the intended projects related with the improvement process. Most of these projects are based in the Adoption Process Diagram, Figure 14, that is in the Implement Section at the webpage of CDIO Initiative (CDIO Initiative, 2016).
The new actions will start with the return of the two professors that were in the exchange at Sweden universities. The first step is the definition of a team, a “task force”, that will be responsible by the coordinate the implementation of the improvement educational process in IME. This task force will plan the further actions, create a vision of change, coordinate the projects, create team groups responsible for each project, and support all the staff that will work to adopt and implement the CDIO framework and aim at consolidating and stimulating the educational transformation.

All the university has an environment that is resistant to changes (Crawley et al., 2014), so, even though the IME leadership is involved and committed to the process, one point that is fundamental will be in creation of environment of conviction and commitment between the faculties, students and staff in IME.

Taking this context into account, it is planning the promotion of seminars that will introduce and show some concepts for faculty, staff and students. These seminars have the objectives to create an environment conducive to changes, a sense of commitment among the IME members and communicate the vision of change, in the way to comply with CDIO Standard 1.
The intended subjects that will be addressed in these seminars:

- Why should the educational process in IME change?

- Establish an urgency sense to the necessary academic changes at the Institute, whose focus is the motivation to learn and the new context of the Brazilian Army engineering;

- The CDIO Concepts (How change?);

- The exemplified some “Early Success”, “Best Practices” and “Innovation” to motivate the change.

The faculty involvement in the CDIO implementation within IME’s engineering undergraduate programs is very important. The teachers will be encouraged to development and increase their own competence in teaching skills and attitudes of the professional engineering specified in the CDIO framework. They must adapt their teaching styles to student focus and to comply with the new context. So, it will the faculty development must be supported and planned with one of the projects (CDIO Standards 9 and 10).

In this way, this project will start with some seminars/workshop about the “Learning and Teaching in High Education”. The objective is to show new methodologies and concepts in engineering education. At IME, there is an annual preparation course to the faculty called ESTAPAE, and it will be completely redesigned in form and contents to answer that demand of teacher development.

Even in relation to this subject of faculty development, another intention is the creation of a department of engineering education. This department has the objective to create and motivate an environment of education in engineering research at IME and to support the improvement of the faculty. This new department will be important during and after the implementation process of improvement. Another aspect is that it will be, together with the educational departments, responsible for program evaluation and continuous program improvement, complying with the CDIO Standard 12.

To comply with the CDIO Standard 4, it planned for an introduction of a first-year engineering course in all IME’s programs. This course will have the objective to create a first environment for engineering practice, beginning the introduction of personal and interpersonal skills and the implementation of a project model concept in the programs. This first step of this project will be modifying an exist second-year course that has similar objectives but isn’t still aligned with the CDIO outcomes.

Even though the introduction of a first-year engineering course affects all the programs, the plan is to start the implementation of CDIO framework within the Mechanical and Automobile Engineering Program and Mechanical and Armament Engineering Program, both at the Mechanical and Materials Educational Department.

The first step of implementation of CDIO in these programs must be a complete benchmarking with objective to:

- evaluate the programs in relation to their alignment with the CDIO Standard, in the way to know the actual status and to possibly identify areas for improvements and prioritize the process of changes;
• establish an inventory about the current situation of these program curricula using some tools, such as black-box exercises and ITU-matrices, and to evaluate the programs based on CDIO Syllabus;

• analyze the current situation about the methodologies and teaching activities implemented and used in these programs of IME, to make it possible to obtain the necessities of improvement and some cases of “best practices”.

• get information about the workspace use in the Mechanicals Programs to verify the necessities of improvement.

After curriculum benchmarking, it will be the definition of the learning outcomes associated with the skills (outlined in the CDIO Syllabus), the knowledge expected from a mechanical engineer and the skills associates with the innovate concept of Brazilian Army Transformation (CDIO Standard 2).

Each benchmarking process will be preceded by one process of improvement. The intended process, connected with the items listed previously, is:

• the program curriculum improvement, that will be started after finishing the benchmarking of the Mechanicals Engineering Programs Curriculum and the definition of the intended Learning Outcomes. The objective of this project is to modify, create or delete some course in order to introduce the concept of Integrated Curriculum in the program and realized a program-course mapping in relation of all the learning outcomes (CDIO Standard 3). Is important to highlight that initially it will be tried to use the resources of time and teaching that exist;

• the improvement of teaching activities and methodologies. It will be started after finishing the benchmarking of the teaching activates and methods. This project has the objective to introduce new methodologies in the learning process, as more activities learning, just like, the concept of integrated learning experience and constructive alignment in the Program (CDIO Standard 7and 8) (McKeachie and Svinnicki, 2014). In this project the new kinds of assessment and the alignment of this with the Brazilian rules must be realized (CDIO Standard 11).

• the workspace improvement. This project will be started after finishing the benchmarking in Program Workspace. This project has objective to improve the workspace but, initially with two aspects: It will be tried to use the space that exist and it will be prioritized the changes that could produce effectiveness, reliability and visibility in the transformation process (CDIO Standard 6).

Other important point in improvement of the Mechanical Engineering Curriculum, in the same way to that used by LiU’s implementation, it will be introduction of two project courses in the Mechanical programs (Svensson & Gunnarsson, 2005) (Svensson & Gunnarsson, 2012). These courses, in the third and fifth year will be responsible to complement the first-year engineer course in the experiences of design-implement and in the solidify the project model as a program outcome (CDIO Standard 5).

In this kind of course, mainly in the last year, it is also intended to increase academic agreements with companies and industries to establish partnerships on research and education projects.
It is intended to create a study group to analyze which project model that will be used at IME. The initial intention is to use the LIPS model in the first years of the implementation and then adapt it in order to become closer to the Brazilian Army project model.

Lastly, as consequence of the process, it is intended to introduce the Military Institute of Engineering in the CDIO community. This will be based in promote some meetings/workshop in IME to divulgate the CDIO concepts, encourage the participation of the faculty in the CDIO meeting and in the future, after to adapt the educational process at IME, to became a collaborator of the CDIO Initiative.

8. OPEN QUESTIONS

The improvement process in IME education still has some open questions that should be discussed and analyzed in more details during the process in order to take a correct decision. This report highlights some of them:

- Who must be the member of the task force?
- The seminars about CDIO and new methodologies must begin with all faculty members or only with a selective group?
- The others programs must wait the implementation in Mechanical Programs or can start their implementation together? And in the case of benchmarking?
- The three intended projects courses should be new courses or a modification of the existing courses?
- In the case of engineering education department, is it necessary to create a new department, modify one of the existing or distributed the functions by some departments? What are the responsibility and function of this department?
- In the case of new assessment methods, how will implement changes that comply with the Brazilian rules and the constructive alignment concept?

9. CONCLUSION

This report described the motivation of the Military Engineering Institute (IME) to implement an improvement process in their engineering education, through the adoption of the CDIO framework and new methodologies of teaching and learning.

Currently, the IME is inserted in the Science and Technology System of Brazilian Army, which undergoes a process of transformation and innovation, where the engineer must have sufficient theoretical and practical knowledge to solve engineering problems and have interpersonal skills to lead teamwork.

In addition to the changes of the Brazilian Army, many students of the IME have been participating in international exchanges in recent years, reporting through feedback the
necessity to have more motivating academic activities involving active learning, academic projects and workgroup.

In this transformation context, the CDIO framework was chosen as the kernel of the process, in order to meet the Brazilian Army and student demands. The engineering education at the Brazilian Military Institute, the CDIO concepts and the reasons for CDIO chosen were explored in this report.

The steps that were taken until March 2016 were discussed, with the emphasis on the exchange of professor by six months in Swedish Universities. This activity that occurred from September 2015 to March 2016 had the objective to obtain more experience and knowledge in this kind of implementation.

The analyzes of methodologies and tools used in in CDIO implementation, the studied and observation of the projects course and machine design course, among other things, were realized at Linköping University during this exchange and explored in this report. The Teaching and learning course at KTH attended was explored too. The principal points that will be used in the base of the intended project were highlighted.

The further actions and the open questions related to adapting and implementing CDIO at IME were presented. This report highlights some of them that have the objective to comply with the CDIO Syllabus and CDIO Standards.

It is expected with these new actions that an implementation of the CDIO framework will be successful at IME and that it will permit, gradually, the improvement of all engineering education program and the graduation of engineers more capable in the practical work of engineering.

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