STUDENT SUCCESS: ON THE NEED FOR A NEW STANDARD

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ABSTRACT

Engineering programs of Pontificia Universidad Javeriana have adopted the CDIO philosophy as a guideline of their curricula. The institution has made significant progress in the application of the 12 CDIO standards. However, analysis of student performance has shown weakness that are derived not only in the academic dimension, but also in other areas such as socioeconomic status and the personal features. These facts have motivated the institution to formalize a process of continuous risk monitoring and design strategies of support and accompaniment. The preliminary results show a significant impact on the students and their performance. Based on the experience of this project, a standard is proposed that guides the CDIO programs. It looks forward to articulate processes for dropout prevention and the learning assurance. This paper shows in its first section the current status of the CDIO curricula at Pontificia Javeriana University. The particular case of academic performance in first year is also analyzed. Then it is shown a dropout behavior in the school of engineering and the mechanisms for its prevention, following the STARS network guidelines. Finally, preliminary results of those strategies and the proposal of the new standard are presented.

KEYWORDS

Student Success, Drop out, Standards: 11,12.

INTRODUCTION

After three years of implementation of CDIO curriculums at Pontificia Universidad Javeriana, programs have now reached a maturity level that allows a data-driven evaluation of the process. Furthermore, from the curriculum point of view, CDIO philosophy has been adopted as context of engineering education. Learning outcomes have been also established including design experiences and introduction to engineering courses. Regarding faculty, an effort has been made to develop competences related to teaching, learning and assessment methods as well as disciplinary skills. Finally, a rigorous evaluation model, considering ABET criteria, is continuously applied. Preliminary results from this model have shown us poor performances for some of the first year students, particularly in mathematical modeling, team work and communication skills. In order to analyze the causes of these issues, focus groups and basic skill tests have been conducted. Low motivation and difficulties in the adaptation process to the university life was expressed by these students. Those behaviors cannot be identified by the evaluation program model since there is no performance indicator directly associated. An additional factor must be considered in the Colombian context: since 2015 government gives financial aids in order to improve accessibility to accredited universities. As a consequence, this public policy has increased variability in the demographic profiles for private universities. In this sense a need to characterize student population has arisen in order to establish different mechanism that could lead to the success of students.

In this paper, a new standard associated with the CDIO philosophy is proposed in order to guarantee the success of the students. Since, this success is defined as the achievement of

the student engagement, it takes into account their expectations, their reality and their psychological wellbeing. Thus, a model considering transitions is proposed based on student performances. As result, a discussion of the rationality and the standard rubric is given. Finally, an application case in the Pontificia Universidad Javeriana at Bogotá, Colombia is shown.

THE CURRICULUM CONTEXT

The Faculty of Engineering of the Pontificia Universidad Javeriana, has been in a continuous curricular reflection that has been aligned with the principles of the CDIO philosophy (Crawley, E. F., 2007). The four undergraduate programs, Civil Engineering, Electronics, Industrial and Systems, have accepted these guidelines to make reforms to their programs. Those curricula are characterized by an inclination towards an education context based on the cycle of construction of products process and systems (Al-Atabi, M., 2013). They also have integrated competences and skills to the courses at an early stage, including experiences related to the first year. The pedagogical practices are diverse and respond to the training results designed for each of the courses (Crawley, E., F., 2014). On the other hand, learning assessment processes are rigorous. They feed a program evaluation model that is part of the ABET accreditation criteria. In terms of support for teaching, the University has a center for learning, teaching and evaluation (CAE + E). It looks out the development of competences in the teaching staff. It trains also professors in teaching and learning skills and its evaluation. Thus, it is evident how the engineering school is immersed in an active process of strategic planning including curricular management as a fundamental axis to ensure quality of learning. This is complemented with infrastructure. Indeed, a building of classrooms and laboratories of the School of Engineering inspired by the standard 6 CDIO is under construction.

The first year of an engineering undergraduate program at Pontificia Universidad Javeriana is designed to articulate the physics, mathematics and primary disciplinary concepts. The goal of this is to put the student in contact with their profession. Four programs have in their structure an introductory course in engineering with a project scheme focused on solving problems. Table 1 shows the structure of each engineering program.

A review of the first year courses in the four programs allows to generalize the Syllabus CDIO competences. They have been adapted to the curricula. These competences yield the learning results that are expected of the students in this stage of their formation. In general, the first year study plans seek to develop at a first level (knowing):

1. Disciplinary knowledge and reasoning (1), focused on mathematics and science (mathematics, physics chemistry) and the core and fundamental concepts of each discipline (1.2),
2. Analytical reasoning and problem solving in engineering (2.1)
3. Knowledge construction (2.2)
4. Communication skills (3.2)
5. Team group (3.1).
6. Personal skills are a strong point, since it facilitates learning and allows the development of systemic, critical and creative thinking (2.4).

Table 1. First year structure of engineering programs.

Industrial Engineering	Civil Engineering	Electronics Engineering	Systems Engineering
• Differential Calculus • Materials Science • Product Design and Engineering • Epistemology of Engineering • Int. to Physics • Int. to Industrial Engineering	• Differential Calculus • Chemistry of Materials • Graphic Expression and Geometry • Int. to Physics • Int. to Civil Engineering	• Mathematical Tools • Mathematics I • Signals Laboratory • Int. to Physics • Int. to Electronics Engineering I	• Differential Calculus • Mathematical and Computational Logic • Algorithmic Thinking • Epistemology of Engineering • Int. to Physics • Int. to Systems Engineering
• Integral Calculus • Linear Algebra • Financ. Accounting • Mechanical Physics • Principles of Economics • Human Syst and Product • Theological sense and meaning	• Integral Calculus • Linear Algebra • Mechanical Physics • Algorithmic Thinking • Topography and Photogrammetry workshop	• Mathematics II • Electric Circuits • Int. to Electronics Engineering II • Signals and Systems	• Integral Calculus • Linear Algebra • Computer Programming • Object Oriented Analysis and Design • Theological sense and meaning • Engineering Ethics

Finally, in order to motivate students to promote a context of equity and social responsibility, courses take into account the ethical vision of the engineer. This agrees with the mission of the university.

CHALLENGE OF INTEGRATINNG COMPETENCES IN THE FIRST YEAR

The teaching-learning process of the competences requires from freshmen to have a minimum level of performance in skills and knowledge. This allows them to be successful in the transition from school to undergraduate. Although the Ministry of National Education, establishes the levels of expected achievement that students should reach after high school training (Ministerio de Educación Nacional 2006), it has been shown that there is a significant gap between these expected levels and the real abilities. This reality cannot be ignored. Thus, it is responsibility of the university institutions to measure the difference and to mitigate it. In this sense, each CDIO competence integrated into the curriculum has some entry requirements that must be guaranteed. This helps to increase the achievement of the learning results of each course in the first year.

The construction of disciplinary knowledge, reasoning and the basics in mathematics and science requires the development of: numerical thinking (natural, integer, rational and real numbers), spatial thinking, geometric systems (Cartesian representation, trigonometric functions, etc), metric thinking and measurement systems (magnitudes, precision), random thinking and data systems (statistical information, information management, conditional probability), thinking of variables and algebraic and analytical systems (derived from basic functions, trigonometric functions) (Ministerio de Educación Nacional 2006).
These requirements build the body of knowledge that will allow students to learn modeling and quantitative analysis of information (Crawley, E., F., 2011). These are indispensable skills for the formulation of numerical and analytical solutions considering orders of magnitude and trends. They should be agreed with the problem identified in real context of physical and chemical phenomena. The understanding of those phenomena of the world requires primary skills of

measurement and analysis of data focused on experimental inquiry. Skills of experimentation, research and discovery of knowledge require skills of analysis of information which are found primarily in the literature. Hence, clear strategies of classification and ordering of information based on reading and analysis of texts are needed. In general, the advanced development of communication skills, requires basic skills in textual production, understanding and interpretation, symbolic systems and media (Ministerio de Educación Nacional 2006).

Regarding the abilities and attitudes for each discipline, students are expected to arrive with sufficient autonomy and criteria to develop a culture of decision making, based on information and risk assessment. The aim is to motivate students to perseverance and adaption to changes. Also, they are encouraging to accept criticism and feedback of their training process and promote the balance between personal life and university life. It is considered that the students are able to recognize their weaknesses and strengths at their arrival to the university. Indeed, they create a framework for lifelong learning, in which the organization of time and resources are essential elements. Finally, a relevant process for the axis of articulation of the training processes is the motivation of the students to learn. This motivation requires recognizing of a life plan and a proactive vision to achieve it. In particular, the joint construction of this life plan is motivated at the university by forming learning communities based on teamwork. Thus, it is expected when students arrive at the university, they are able to recognize the need to establish networks, respecting diversity under a constructive and fair dialogue.

DROP OUT

An analysis of student academic performance of the School of Engineering, shows that approximately 25% of the students in the first semester enter into an academic risk situation. This occurs when they do not obtain the minimum GPA required by the program. Around 10% of students decide to suspend their studies, finishing the first year. 7% are excluded from the program in the third semester for not overcoming their risk status after 3 semesters of poor performance. Although the four undergraduate programs are in an advanced stage of implementation and the quality assurance model feeds the processes in a cycle of continuous improvement, academic risk indicators and dropout behaviors in the first semesters has become a concern. This is why they must be addressed as part of the operation. Ensuring student success, becomes a priority for the School of Engineering. Hence, a mapping of entry requirements to achieve the CDIO competencies in the first year has been determined.
Once the required competences have been identified, classification tests have been applied since 2016 to detect weaknesses in the entrance competences. This helps to design strategies that mitigate the gap between reality and the expected competencies (Lightbody, I., 2016). Four tests are applied:

- Basic skills in mathematics
- Basic language skills
- English level according to international classification
- Primary knowledge in physics

Focus groups have been developed with students and professors to gather perceptions about the CDIO curriculums, their operation, teaching practices, etc. As a last tool, the information generated by the evaluation model in the first year, gives indications of the real performance of the students. Several behaviours have been found that show weaknesses in the training in some high schools from which the students come. The mentioned results, give an idea of the type of weakness that could be explained in the diversity of students and in their different

contexts (public schools, private schools, regions). Additionally, 18% of the students are beneficiaries of a National Government program seeking the best students of the country with low economic resources, to access accredited institutions of Higher Education of high quality.

This program covers the total value of the tuition and also provides support throughout the study period. The program is called "*Ser pilo paga*" and by 2017 it has reached its target of 40,000 beneficiaries. The idea is to close the inequality gaps in education in the country. Of the total beneficiaries of the program, 75% comes from official high schools and 1,784 of the total are victims of the Colombian armed conflict. This diversity in the students led us to identify not only academic, but also individual, socioeconomic and institutional risks.

Table 2. Risk classification proposed by the Ministry of National Education.

INDIVIDUAL	**INSTITUTIONAL**
• Age, Gender, Civil status • Family environment • Health condition and diseases • Social integration • Scheduling conflicts • Successful expectations • Pregnancy	• Academic status • University's resources • Financial support • Politic environment • Relationship between professor and student • Academic counseling • Psychological accompaniment
ACADEMIC	**SOCIAL AND ECONOMIC**
• Academic status • School • Academic performance • Program quality • Learning and study strategies • State examination • Mathematics and Language exams • Student satisfaction level	• Socio economic level • Employment situation • Parents' employment situation • Economic dependence • Family responsibilities • Parents' educational level • Macroeconomic situation

The Ministry of National Education has as a work plan to increase its capacity in the development and implementation of policies and programs to promote student permanence and graduation. This must be agreed with strategies, teaching and learning methodologies, as well as in the training of the academic human team and administrative. Table 2 shows the risk classification proposed by this Ministry and some potential indicators for prevention and integral treatment that are hosted by the University. It is important to highlight that the risks are not only presented in the first year. For this reason, Pontificia Universidad Javeriana developed a model of transitions to describe the students' transit in their training.

The model has identified the essential institutional interventions to facilitate such transit. It leads to propose specific strategies to mitigate some risks, giving priority to academic risks. Figure 1 shows the student development model adapted to the engineering programs.

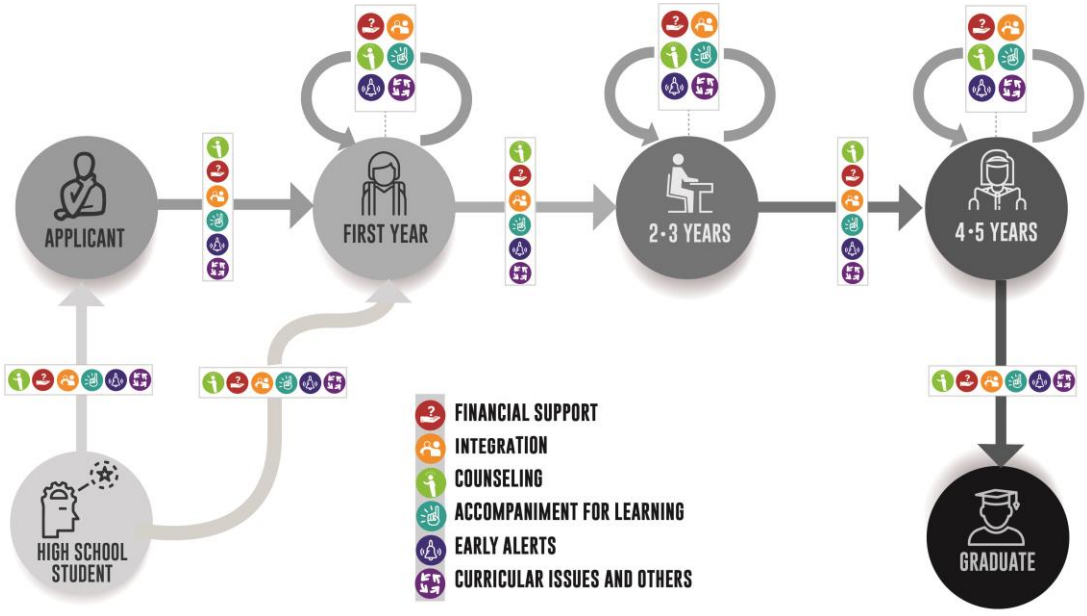

Figure 1. Student development model.

The purpose of the transitions model is to identify the accompaniment routes that will allow the student to advance in his formative process. The circles are states of a student given by their progress of their program. The arcs link these states. Those arcs are the routes that allow to pass from one state to another. The accompanying processes (circles in each arc) defining the transition routes are accumulative. Thus, each student must advance on the route and in some way complete all the conditions (processes). The proposed processes for each route coincide with the strategies, projects, policies and infrastructure that the university offers. The processes that describe the transition routes are based on the elements of Integral Formation and the accompaniment, which are elements of the Educational Project and the Mission of the University. Table 3 shows the description of each process. Four elements can be observed: a diverse student community, weaknesses in entrance competitions to the program, indicators of risks in the first year and a model of transitions that looks forward to ensure student success (McKenzie, Jo., 2017). The conjugation of these 4 elements resulted in the proposal of specific strategies for risk mitigation in the framework of an institutional program called the Student Accompaniment Program (PAE, for its acronym in Spanish).

The PAE includes four lines of work that make the transition routes of the transitions model operational:

- PAE-1: Accompaniment program for potential and enrolled students admitted to the programs.
- PAE + 1: Accompaniment program for first year students
- PAE + 2-3: Accompaniment program for students of year 2 and year 3

PAE + 4-5: Accompaniment program for students of year 4, year 5.

Table 3. Processes in the transition routes.

Institutional process	Description
Financial support	Accompanying process related to the identification of socioeconomic and academic profiles. It can be supported through the offer of scholarships, incentives, supports and financial facilities.
Integration	Engaging the students to the educational community through continuous strategies of processes and guidelines promotion. It generates the sense of belonging to the community, induction processes and transitions.
Counselling	Support for the planning of transitions in the curriculum. It deals with the choice of strategies to overcome academic risk conditions, mobility and other degree options, among other processes.
Accompaniment for learning	Support for learning and teaching, mentors, tutors, instructors and support spaces, among other to ensures learning.
Early alerts	System for the collection, analysis of data and prediction of student behavior in all the states of the model. It allows to establish student risks including drop out. This process is constituted as an articulating axis of the other processes in the transition routes. It is structured to have coverage in different dimensions of the student training.

Similar experiences in the world allowed us to validate the model of transitions and the proposed accompaniment scheme (PAE) (Lightbody, I., 2015), (McKenzie, Jo., 2014), (McKenzie, Jo., 2016) (Wilson, T., 2017). In particular, the STARS network (REFERENCE) of the Australian university academic community reinforced these support structures. Indeed, it yields to a cooperation network between the member universities of the network and Pontificia Universidad Javeriana.

STARS is an academic network that works to provide an opportunity to know and discuss research results, good practices and innovative initiatives in order to improve the learning experiences of students in each of their transitions. STARS is subdivided into specialized networks, Table 4 shows the sub-networks and the leading university that currently supports the PAE transitions model:

Table 4. STARS sub-networks.

STARS NETWORK	***University and contact***
Mentoring, accompaniment and peer learning	Queensland University of Technology – Victoria Menzies
First year experiences	University of Technology Sydney – Kathy Egea
Experiences and resources to facilitate **STEM** training	Queensland University of Technology – Ian Lightbody
Equity for students in the context of diversity	National Centre for Student Equity in Higher Education – Nadine Zacharias
First generation at the university.	University of Wollongong – Sara Oshea

During 2017, the Faculty of Engineering has chosen to focus its efforts on the design and implementation of PAE + 1 as an integral accompaniment to first-year students in different dimensions. This is described as follows:

- Ensuring learning: it assesses and supports the improvement in knowledge, skills and aptitudes of students in the areas of mathematics, critical reading, written expression and English language proficiency. The mentioned areas are consolidated as the baseline for the development of disciplinary and skills at more advanced levels of competence.
- Integration into university life: it is the accompaniment through peers, academic advisors, professor and members of the academic community that allows the student to fully assume his role as a university student. It is a vital dimension for adaptation in each transition of the model.

- Vocational support: it is the accompaniment provided by peers, academic counselors, professors, graduates (mentors), psychologists, which allow the first-year student to understand their professional choice for engineering.
- Family environment: it is about access to information and working mechanisms to provide accompaniment in particular situations in the family environment.

Figure 2 shows the structure of PAE + 1, in which the strategies are aligned. They feed an early alert system that allows the detection of risks in an anticipated manner in the context of risk prevention actions.

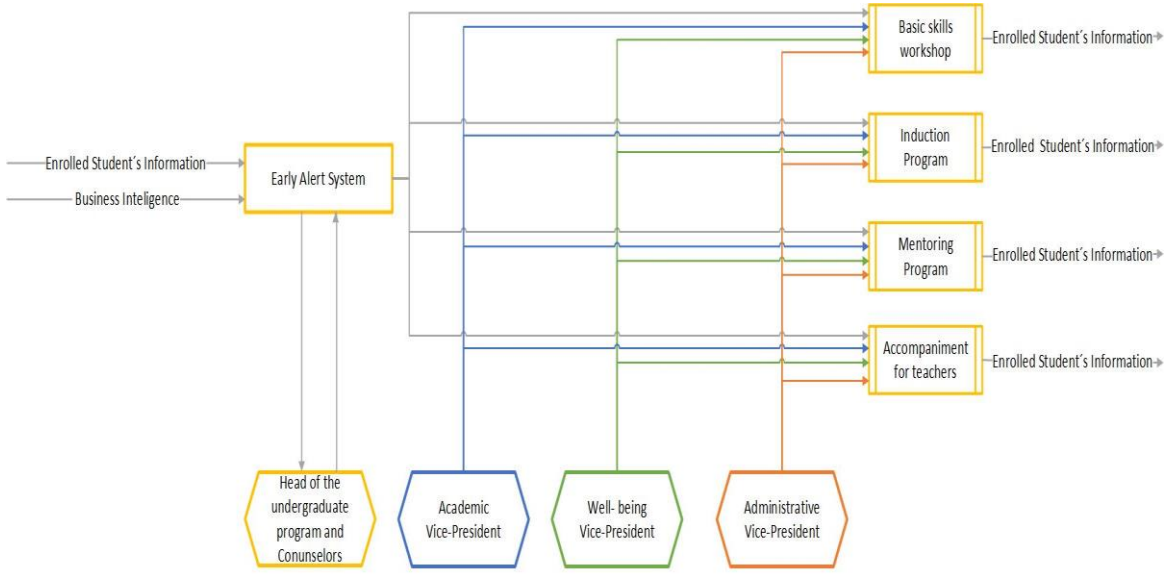

Figure 2. Structure of PAE + 1.

The early alert system

PAE + N is supported by a system for monitoring, collecting and analyzing information that supports timely decision-making in the student transitions. The system of early alerts is designed to notify the head of the program of a possible critical event related with the student permanence. This event can be at the individual, academic, socioeconomic or institutional level (Moody, H., 2015). It looks forward to reduce the vulnerability of the student population through a timely reaction. The information that feeds the scheme comes from different units and dynamics of the university. These units are the Admissions office, the academic community, the Psychological and Health Advisory Center, professors and counselors, among other actors. The primary objective of the early alert system is the creation of cause-effect models and behavior patterns of the student population.

Induction Program

Induction program seeks to impact the processes of integration into university life. It encourages the development of elements that allow students to assume their university role autonomously, responsibly and aware of the transcendence of the career within their life project. The program is oriented to a reflection about the way in which the career is integrated with this project. Additionally, the activities of the program contribute to the processes of qualitative and quantitative characterization of populations. It also motivates the appropriation

of information that allows the student a harmonic adaptation to the university. Moreover, it integrates the student with the different members of the academic community.

Accompaniment of first year professors

The objective of this strategy is to offer professors, different tools to face the particularities of their courses taking into account the population. The aim is to ensure learnings and also to give vocational support. In this program, it is searched the link among critical courses within the first year in order to provide support in the design and planning phase of these courses. The idea is to give professors orientations about their teaching practices. Finally, another objective of the strategy is to generate appropriation of the transitions model. Indeed, the first semester professor become an actor for the identification of student risks.

Mentoring program

This strategy aims to facilitate an environment of trust through peer-to-peer. The accompaniment here points out to the knowledge of the institutional processes and the understanding of the educational project. It also shows the tools and supports offered by the university for overcoming academic difficulties. Mentors facilitate the identification of risk situations associated with adaptation and integration to university life or academic performance. They promote the integration of students in the educational community and also encourage the development of transversal skills. Group mentoring is chosen as a structure, in which a group of mentors is assigned to first-year students. Subgroups of mentoring are formed to create micro-communities of accompaniment. This perspective can be extended to people with more experience, graduates and entrepreneurs.

Basic skills workshop

This strategy is an extracurricular space for all first semester students. It searches to decrease academic risks. Several strategies are developed to face the demand and complexity demanded by the university. Different from a leveling course, students are classified with diagnostic tests. This classification allows the work to be focused on the particular flaws of each student. The basic skills workshop provides accompaniment to students through the reinforcement of math and communication skills. It provides tools for an effective adaptation in the college-university transition. This is an ideal space for the detection of populations at risk of dropping out. The workshop has an intensity of 3 hours per week including three components to meet the stated objectives: mathematics, communication and adaptation to university life.

RESULTS

After a year of implementation, it is possible to measure the impact of the strategies. In particular, the percentage of the population that ends the first semester in academic risk condition. According to the national definition of drop out, the impact of the strategies on this rate requires an additional year. Figure 3 shows the percentage of first semester students in academic risk condition during the last three years. The results are divided according to the starting date of the students due to the differences in the admitted population in first and second semester. As it can be seen, for students entering the first semester of the year, three of the four programs achieved a reduction in the percentage of risks during 2017. In the second semester, this reduction occurred in two of the four programs. This is due to the characteristics

of the admission processes in Civil Engineering and Systems Engineering programs. For these two programs, the selection changed. As a result, during 2018, new strategies for classifying students at the time of admission are being implemented.

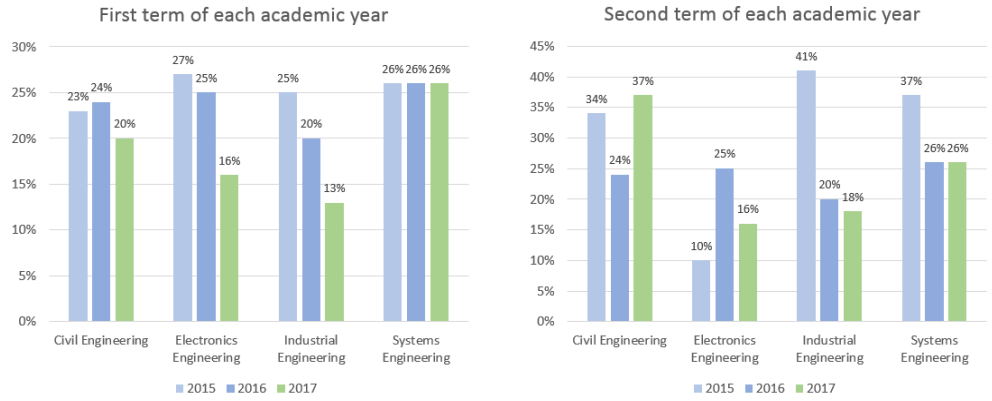

Figure 3. Percentage of first semester students in academic risk condition.

The partial results of the implementation lead to the question about the sustainability of the strategies. We argue that such sustainability is only achieved when the accompanying strategy is part of the program management. In particular, a standard associated with the maturity of this strategy must be established. In this way it will be possible to follow up the results and adjust the design of the strategies.

PROPOSED STANDARD – STUDENT SUCCESS

During the implementation of CDIO in the school of engineering of Pontificia Universidad Javeriana, we have observed benefits addressed to integrate competencies in the curricula and to the development of the same ones in the students. This philosophy together with the quality assurance system (ABET) has allowed us to find that student success not only depends on the strategies implemented in terms of curriculum. There must be a general view of the students in terms of their particular needs. Understanding the students ' context and monitoring individual needs becomes a fundamental factor in implementing strategies that ensure student success and strength the curricular and co-curricular activities to improve the program. The proposal of the student success standard is presented***.***

A curriculum supported in the analysis and synthesis of information allowing to take effective actions to mitigate the risk and vulnerability in the student population; with strategies focused on the prevention of drop out and that guarantee student success.

Description: A CDIO program seeks the integration of personal and interpersonal skills with product, process, and system building skills, as well as disciplinary concepts. Training in these competences should be gradual and start from the first semesters of the program. Student will be exposed to different experiences in order to reach proficiency levels associated with learning outcomes established by the curriculum. The achievements of each student in the process will be systematically assessed and its evaluation is associated with their performance in the program. Student success is a reflection of such performance and ideal conditions are necessary for the student to travel along the curricular route. Ensuring student success requires a continuous analysis of the academic, personal, socioeconomic and demographic information of the students. It is also necessary to propose strategies for the prevention of drop out, risks and vulnerability. The reality of each student depends on their location on the

curricular path, their strengths and weaknesses. The differences and characteristics of each stage require differentiated learning contexts and particular support to ensure their success in training.

Rationale: A CDIO curriculum is focused on the student, their realities and needs. It recognizes the transitions that occur from the first year to the stages before graduation. It seeks the assurance of learning. It also prevents student drop out and develops strategies to motivate retention. It promotes the success of its students according to their realities and is managed from the analysis of the information from the academic community.

***Rubric**:*

Scale	Criteria
5	Accompanying programs and risk models optimize the program management processes and their continuous improvement dynamics
4	There is documented evidence of the intervention and accompaniment of students in their transition
3	An accompanying program is implemented including differential strategies for transition, risk models and vulnerability.
2	There is an explicit plan to generate dropout prevention schemes and also differentiated routes in each student transition.
1	The need to adopt a culture of risk prevention and student vulnerability based on the information of the academic community is recognized and there is a plan to establish the risk model in the program.
0	There is no plan to prevent desertion and facilitate student success.

CONCLUSIONS

The implementation and operation of a curriculum inspired by the CDIO initiative is guided by the 12 standards. This route starts once the programs are addressed with the philosophy CDIO acting as context of education (Standard 1). A curriculum aimed at the integration of skills from the first year is developed. This is described through learning outcomes (Standards 2, 3 and 4), in which students are exposed to design and implementation experiences in innovative work spaces (Standards 5 and 6). Teaching and learning methods are reviewed and updated (Standards 7 and 8). Clear strategies for development of the professors are proposed (Standards 9 and 10). Finally, it is proposed clear models of assessment and evaluation of the program (Standards 11 and 12). These last standards show the academic performance of the students (Brodeur, B., 2005), which is a process that is explained not only in the curricular structure but also in the particularities of a diverse population. Knowing the characteristics of the students becomes a vital action in the process of the operation and the curricular management. The assurance of learning as a measure of student success transcends academic variables. It includes also other variables such as socioeconomic conditions, personal realities, abilities, strengths and weaknesses of students. The analysis of these variables, the culture of accompanying at each stage and risk management become processes that must be articulated in the vision of a CDIO program. This articulation has generated the need to formalize the path of action associated with student success, through a new standard. This standard takes into account the aforementioned elements and the gradualness of their application in an institution.

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BIOGRAPHICAL INFORMATION

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