

## **Impacting engineering students' academic trajectories through a learning outcomes enhancement cycle**

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## Introduction

The way quality is defined in higher education (HE) depends on whether the object of assessment is outcomes or processes. For Harvey & Green [1], the notion of quality can be understood as exceptional (special, very high standard), as perfection (no-defects), as fitness for purpose (meets requirements, fulfills objectives), as value for money (efficiency), and as transformative (qualitative change). Furthermore, quality in HE is linked to regulatory frameworks and monitoring processes [2]. In the last few decades, quality assurance in higher education, particularly in engineering education, has gradually shifted its focus toward external accountability [3]. In the literature on quality in engineering education, accreditation is the predominant theme [4]–[8]. Engineering has been a pioneer in a discipline-specific accreditation process, which serves as a model for other professional disciplines [6].

The Accreditation Board for Engineering and Technology (ABET) implemented in 1997 a new set of accreditation standards (Engineering Criteria 2000, EC2000), after which a learning outcomes assessment protocol became central for quality assurance models in undergraduate engineering programs [9] [10] [11]. Different international accreditation agencies for engineering programs have since agreed to define comparable learning outcomes that shape the current quality standards in the discipline [12][13]. The latter has impacted the way different countries understand quality, quality assurance, and quality enhancement in engineering education. Engineering education and quality assurance in Chile are no exception. The National Agency for Quality Assurance (CNA in Spanish) implemented mandatory learning outcomes assessment for undergraduate programs more than 15 years ago [14]. Likewise, some Chilean accreditation agencies for engineering programs have subscribed to international agreements such as the Washington Accord, and several institutions have accredited their engineering programs in ABET [15].

This paper reports partial results from implementing a quality assurance model in the School of Industrial Engineering at a Chilean regional university. The holistic quality assurance model integrates traditional definitions of quality when assessing curricular and course elements, and it takes a *quality-as-transformation* view to assess engineering learning outcomes at the student level. We present six cases of students who participated in different evaluations and interventions as part of a *competency training cycle*. To gather data our team used a qualitative approach and interviewed students regarding their academic trajectories and their participation in the quality assurance model. In this paper, we draw on these six cases to highlight students' transformation in becoming industrial engineers when engaging in interventions at the student level. The interventions are based on two Quality Assurance Mechanisms for the undergraduate engineering program: internal learning outcomes evaluations (by professors) and external learning outcomes evaluations (by employers in internships).

## Background

### *Quality Assurance in Engineering Education*

Defining guidelines to implement accreditation standards [7] and searching for consistency of standards between different registering bodies [8] are relevant to the successful mobility of

engineers in a global labor market. The perspectives on quality from the different stakeholders [16] seems to be of interest when defining quality standards that allow graduates to assume relevant roles in the job market [6], [7]. Due to the importance of accreditation systems, quality in engineering education takes mainly the perspective of ‘fitness for purpose’[4]. The latter means that the focus is on how successful graduates are upon their entry to professional practice, which not only refers to high employability rates but also to the attainment of higher-level learning outcomes, both cognitive and interpersonal [5].

The dominant literature on HE quality points to the tension between quality accountability and quality enhancement [17], [18]. However, this dichotomy is only apparent for some authors, and they propose models for filling the current gap between quality assurance and quality enhancement in higher education [5], [19]. Moreover, the tension between quality assessment and quality enhancement in higher education is expressed as an imbalance between both components. Nonetheless, in quality assurance processes, efforts tend to be focused on program assessment and external accountability [19], limiting the transformation of the main actors of the teaching/learning process: students and lecturers.

### ***Quality assurance model***

The quality assurance model presented in this work was created at the School of Industrial Engineering at a regional university in Chile. Our quality assurance model considers international and national tendencies in engineering education, such as ABET standards, Washington Accord standards, and the Chilean law on quality assurance [20][15][14]. Furthermore, the holistic model considers three levels of assessment: curricular, course, and student. To evaluate the course and curricular levels, we consider Lattuca and Stark’s curriculum model as an academic plan [21]. However, to assess student learning during their undergraduate studies, we decided to incorporate the concept of quality as transformation. Using a transformation view to promote quality enhancement in our quality assurance model does not only have the purpose of evaluating students’ advancement during their academic trajectory, but also of improving or boosting their advancement when necessary. What we present in this section is the students’ learning assessment element from our holistic quality assurance model. For purposes of this paper, we will call the beforementioned evaluation section as “*learning outcomes enhancement cycle*”.

***Quality as transformation.*** Harvey & Green explain that “the transformative view of quality is rooted in the notion of ‘qualitative change’, a fundamental change of form” [1, p.18]. For the authors, the student is not only a customer receiving a service, as the student is being transformed by the reception of that service (education). For the authors, the transformative element of education is more qualitative than quantitative, which is aligned with constructivism and radical constructivist paradigms of learning, as expressed by Vygotsky, Feuerstein, and the Chilean biologist Humberto Maturana [22][23][24]. For transformation to happen, institutions need to empower and enhance students. Furthermore, as mentioned by Cheng, Harvey further developed their initial definition of quality as transformation, explaining that quality as transformation can be applied in higher educational settings. Additionally, the transformation is bidirectional: the process of transformation happens to the students, but also requires changes within the institutions [25].

The reasoning to incorporate quality as transformation in our quality assurance model, particularly in our learning outcomes enhancement cycle is that students must achieve specific learning outcomes during their college trajectory. To this end, students need to acquire technical knowledge and transform their way of understanding the world. The latter

necessarily implies a transformation in their cognitive functions, perspectives, and emotions. Our enhancement cycle considers specifically two viewpoints aligned with the concept of quality as transformation: the theory Mediated Learning Experience (MLE) from Feuerstein [23][26] and Maturana's understanding of learning as a space of transformation for both the learner and the teacher [27] [28].

*Mediated Learning Experience.* Feuerstein defines the role of the mediator (or agent) as fundamental to promoting cognitive changes in a student. A teacher, a parent, or an advantaged peer can fulfill this role, depending on the objective of transformation. The mediator must have maturity, experience, and the ability to organize, reorder, group, and structure the stimuli or information the student receives based on a specific task or goal [26]. This means that the agent mediates between the world and the student (subject), transforming the stimuli the student needs to make cognitive changes. This transformation happens through a well-defined process with initial states, activities, and end-goals. [26].

*Learning as a space of transformation.* Maturana's conceptions about learning define the act of cognition and learning as a space of transformation in structural coupling [27-28]. As stated by Lyon [27, p.22] structural coupling is a "continual, mutual interaction and adaptation of the cognizing organism and the medium in which it lives". By cognizing organism Lyon means a human being. Furthermore, Maturana understands the educational space as a reciprocal transformative instance between teacher and student [28]. This educational space considers emotions and language from both participants as core elements for the transformation. [28]. For Maturana, the student and the teacher are at the center of the model as emotional beings that operate in structural coupling. In this process, they transform each other in congruence with their contextual circumstances. Furthermore, the transformation space is benefited or hindered according to the emotions from which it is generated [24] [28].

***Mechanisms for students learning outcomes evaluation.*** The literature on quality assurance in higher education emphasizes the importance of internal and external stakeholders' opinions for curricular evaluation and change [1] [21]. However, schools tend to use stakeholders' information to make changes only at the curricular level or at the course level. These changes impact students of later cohorts than those evaluated. The literature on engineering curricular innovations and change promotes the use of learning outcomes to design engineering curricula and describes different mechanisms to evaluate learning outcomes at the curricular level [10] [21]. The literature is scarce about reporting institutions that use stakeholders' information to promote changes at the student level.

Changes at the student level are relevant as they involve helping students achieve the desired engineering learning outcomes. Accreditation agencies mainly appraise the existence of mechanisms that evaluate the achievement of learning outcomes [11][14][15]. However, they rarely inquire for mechanisms to intervene in students' trajectories when they are not achieving learning outcomes. Furthermore, mechanisms to intervene at the student level require resources that not all engineering departments have. Thus, engineering departments generally use students' learning outcomes information to make changes at the course or curricular level only. This means that the students benefiting from curricular improvements belong to future cohorts. Hence, it is necessary to make longitudinal evaluations and interventions at the student level to improve current students' academic trajectories and help them achieve the desired engineering learning outcomes. Our learning outcomes enhancement cycle incorporates three mechanisms to evaluate students' academic trajectories and intervene when necessary: internships external evaluations, professors/lecturers'

evaluation, and individual academic performance indicators. These mechanisms incorporate quantitative and qualitative aspects of students learning trajectories in industrial engineering.

*Internships as external evaluations.* Our team believes that information from external stakeholders is necessary to understand whether graduates are developing engineering learning outcomes and meeting industry requirements. The literature on curricular assessment and evaluation reveals that the use external information typically happens at the curricular level [21][29]. Nonetheless, undergraduate engineering departments could obtain employers’ perspectives on students’ learning outcomes achievement from learning experiences that expose students to industry. Exposing students to industry in early stages of their academic trajectory allows them to apply theoretical knowledge to real engineering projects or problems [30].

Engineering students in our department must engage in three mandatory summer internships at three different employment levels. The first internship leads the student to understand how an enterprise works at the operations level. Interns at this level engage in physical work, such as working in a production line. The second internship allows the student to understand the enterprise from an intermediate job level. Students are assigned ‘desk jobs’ and work with essential data. The third internship is at the professional level and allows students to experience working and making decisions as industrial engineers.

We ask supervisors to complete a student evaluation at each internship through a questionnaire. We created the evaluation using our program’s learning outcomes and asked supervisors whether the student had developed a certain level at each engineering learning outcome. Supervisors use a scale from 1 to 4 for each learning outcome, where 4 is an outstanding achievement, and 1 is no achievement. Because each internship requires different abilities from students, not all questionnaires ask the supervisor’s opinion for the same learning outcomes. For example, in the first internship, students do not require specific engineering knowledge to perform their tasks, so we do not include that learning outcome in the questionnaire. However, as the third internship requires students to work as industrial engineers, we evaluate advanced learning outcomes such as design and management abilities. We also evaluate some learning outcomes in all three internships, such as professional ethics and communication. Table 1 presents some aspects of each internship’s evaluation.

**Table 1 - Internship evaluation**

General ability or skill	Learning Outcome	Internship 1	Internship 2	Internship 3
Teamwork	Ability to join work teams	X	X	X
	Ability to guide teams towards an organizational goal			X
Communication	Oral communication	X	X	X
	Formal and technical communication	X	X	X
	Teamwork communication	X	X	X
Professional ethics	Respectful attitude towards co-workers	X	X	X
	Honesty	X	X	X
	Commitment to accomplishing tasks	X	X	X
	Respect for the institutional rules	X	X	X
	Proactivity	X	X	X
Engineering knowledge	It refers to the disciplinary knowledge of the student. Their knowledge should allow them to perform the functions or tasks assigned to them, entrust, or acquire, during practice, new knowledge for performing their functions.		X	X

Production Systems Management	Quality of the work: It refers to the quality of the work done by the student from the technical-disciplinary perspective.	X	X	X
	Efficiency of the work: It refers to the time the student requires to achieve the tasks assigned by the supervisor		X	X
	Management abilities: It refers to the ability to carry out the operations and executive tasks of a position within the organization			X
	Design abilities: it refers to the ability to model and design solutions to organizational problems using industrial engineering tools. It also considers the proper treatment of requirements and context situations			X
Information Management	Ability to obtain and manage information from different sources		X	X
Innovation and creativity	Ability to contribute new ideas or tools to solve problems or improve activities within the organization.		X	X

When a supervisor evaluates a student with low performance in his/her internship, we invite the student to participate in the learning outcomes enhancement cycle. We first implemented this evaluation in 2018. Since then, we have collected data from more than 250 internship events.

*Professor/lecturer evaluations.* The school's Associate Head for Academic Affairs requests professors and lecturers of key courses to observe students' academic performance during regular coursework. These observations refer to a qualitative aspect of students' academic trajectories in industrial engineering. For example, if a student performs poorly in the course and reveals academic difficulties beyond performance, the lecturer informs the associate head of this situation.

What constitutes 'academic difficulties beyond performance' in our enhancement cycle is related to expected attitudes, values, and beliefs that help engineering students experience a significant developmental shift during their academic trajectories in industrial engineering. Attitudes, values, and beliefs in college students constitute important variables for students' academic achievement and development [31][32][33]. Some examples of expected attitudes and beliefs are openness to learning, responsibility, satisfaction, self-efficacy, motivation, and belongingness, among others. For example, suppose a student reveals that their low academic performance is because of difficulties with their sense of belonging or lack of motivation towards their academic trajectory. In that case, these attitudes and beliefs affect their academic performance; then, the lecturer informs this situation to the associate head. The student is invited to a session with the department's psychologist to understand where their lack of motivation comes from, and she assesses whether to invite the student to the learning outcomes enhancement cycle.

*Individual academic performance indicators.* The associate head oversees students' academic trajectories. At the beginning of each academic year, she revises different academic performance indicators for each student in our program. These indicators refer to the quantitative aspect of a student's academic trajectory. For example, some indicators are the number of failed subjects, rate of progress, and GPA, among others. If a student performs poorly in one of the indicators, he/she is invited to a meeting with the associate head. She then determines whether to invite the student to the learning outcomes enhancement cycle.

**Intervention.** As mentioned in previous sections, the learning outcomes enhancement cycle from our holistic quality assurance model aims to evaluate students' transformation during their academic trajectory and make changes to their trajectory through mediated experiences when students are not achieving the expected outcomes.

The cycle has the following design: once a year, students' trajectories are evaluated through the mechanisms presented in the previous section. If a student is facing difficulties in achieving the expected learning outcomes, the department invites them to participate in the enhancement cycle. This cycle includes several interventions, depending on what the student needs to improve. We created the interventions based on Feuerstein and Maturana's theories, as they are modulated learning spaces to promote cognitive and emotional transformation. Some activities include an interview with a psychologist, coaching workshops, and follow-up sessions with the psychologist. The following figure explains how the quality assurance model works.

The purpose of the interventions explained in the figure is two-folded. First, we aim to understand what is happening to the students that affects their academic trajectory. In the implementation of our model, we have observed that when a student decreases his/her academic achievements, it is usually because of the external conditions for cognitive change or emotional states for cognitive changes, and not necessarily because of a lack of academic abilities. The latter is consistent with Feuerstein's and Maturana's cognitive and emotional change perspectives. For

transformation to happen in a higher education setting, it is necessary to have certain conditions that allow cognitive and emotional transformation in students [26] [28].

The second purpose is to mediate transformation. Based on Feuerstein's Mediated Learning Experience theory and Maturana's learning perspective, all interventions designed by our team have a mediator. The role of the mediator depends on the activity, which in any case is to promote self-reflection and critical thinking about the student's behavior and his/her academic trajectory. The model's purpose is based on the belief that self-reflection and critical thinking on one's learning processes, mediated by a facilitator, are fundamental to promoting cognitive and emotional changes.

## Research methods

### Study Goals

The purpose of this study is to present the testimonies of engineering students that have undertaken the different steps of the continuous improvement model for our engineering curricular plan. As mentioned in the previous section, the model considers internship employers' evaluation of student outcomes, among other indicators. The work presented here aims to understand how students perceive their development of engineering learning outcomes throughout the continuous improvement plan.

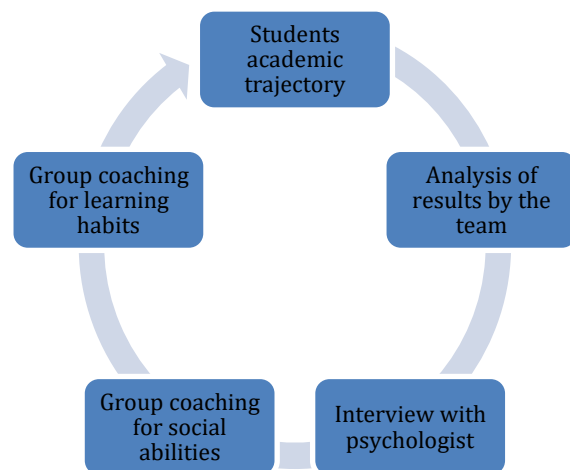


Figure 1 - Learning outcomes' enhancement cycle

## *Participants and Data Collection*

Data presented in the current paper are drawn from interviews with six undergraduate engineering students currently enrolled at a school of industrial engineering at a Chilean regional university. Participants for the interviews were recruited based on several selection criteria, including students' performance evaluation in at least one internship, overall academic performance, participation in the intervention designed in the continuous improvement model, and experts' criteria for students' development through the interventions. Although our sample is small, we tried to ensure diversity through personal background, academic performance, sociodemographic traits such as gender and type of high school, and type of industry where the students worked during their internships. The following table presents students' participating in this research.

**Table 2 - Participants' Characteristics**

	Student	Cohort (Incoming year)
Case 1	Santiago	2015
Case 2	Cassie	2016
Case 3	Deniss	2016
Case 4	Isaac	2017
Case 5	Daniel	2018
Case 6	Christian	2019

## *Interview Content*

One of our team members conducted the interviews using "trigger questions". The purpose of trigger questions was to promote reflection in the conversation and allow the student to speak freely about their academic experiences. We designed the questions with Feuerstein's theory and Maturana's theory as theoretical frameworks. The interviews were carried out in person and without a limited timeframe. The latter allowed the interviewer to only intervene when the student moved away from the central topic or to deepen into some aspect of interest for the investigation.

Our semi-structured interview protocol included questions about the student's personal and academic history, class experience, internships, and overall academic trajectory since they started college. Additionally, we asked about what students experienced while participating in the interventions provided by the school. Furthermore, we asked why they participated in the enhancement cycle and how the activities impacted and transformed their academic trajectory. Finally, our team wanted to understand from which emotions the students lived the academic experiences and what emotions appeared when talking about their past academic experiences. The latter also allowed us to verify whether students understood how their perception of what they have experienced has changed and why it has changed.

## *Data Analysis*

Two members of our team analyzed the interviews using the method of content analysis and the frameworks provided by Feuerstein's mediated learning experience theory and Maturana's approach to learning [23-24] [26-28]. The first analysis was mainly descriptive and included identifying different general themes related to students' academic trajectories. For the present paper, the same two team members partook in a second analysis, which only focused on questions relating to students' perceptions of their academic trajectories and learning experiences before, during, and after they participated in the activities from the



quality assurance model. Finally, one team member conducted a third review of students' responses to these questions with a holistic approach.

## **Findings**

This section presents how students in this study perceive their transformative academic trajectory, using Feuerstein's and Maturana's work as theoretical frameworks. We present results in three subsections: students' perceptions of their cognitive and emotional transformation before, during, and after participating in activities from the quality assurance model.

### ***Students coming to the intervention.***

We asked students why they participated in the learning outcomes enhancement cycle. Most students clarify that they were contacted by a professor or the associate head in response to problems in their academic performance and/or socio-emotional problems. These problems translate into poor grades, low performance in their internships, problems in course-related teamwork, relationships with their peers, and deficient oral presentations.

What is interesting in these results is that most students were struggling in more than one academic aspect of their trajectory. For example, Cassie had difficulties in a class and a low score in an internship evaluation.

Cassie: [There was a] a practical activity during the engineering ethics class ... I didn't participate... I felt that at any moment I would burst into tears... Later [the professor] called me, [inviting me] to a meeting. She called all the people that did not venture to participate in the [class] debate. Three or four female students came, and she started working with us. In addition to working with the professor, I went to the psychologist [internship evaluation]. I was reluctant to go to the psychologist, partly because my parents, [in] their culture, think that [therapy] is useless and that one must heal on one's own.

Only one student (Daniel) was self-motivated to ask for help because he felt overwhelmed. This is also interesting because seeking help on their own is rare in this context. Most students are invited to participate in the learning outcomes enhancement cycle by a professor or professional. Daniel expresses that few students know about the existence of this cycle, and that it is open to all students that may need it.

Daniel: I participated in a Focus Group ... we were around five students discussing the dynamics of [a particular] course: where could we have performed better, and how we could improve [in] it. I realized that there is an interest on the part of the University [for the students]. I emailed the psychologist to see if she could advise me or meet with her to discuss issues in my life, and she responded super quickly and satisfactorily... so we started holding meetings every other week

### ***Perceptions before the intervention.***

When we asked students how they were doing in their academic trajectory when the school invited them to participate in an interview with the psychologist, most of them acknowledged that they were academically failing at the time. When asked about what they thought of their academic trajectory, Deniss, Santiago, Isaac and Cassie answered:

Dennis: For me, the way to stand out or get approval was by getting results. And how was that? With good academic performance... In college, I was always there, like at the limit... There were times when I took two exams in one day, and the day before, I also took other exams. [...] If I failed a course, I took two [next semester] to catch up; when I fell behind, I took twice as much. I concentrated on the mandatory courses. Ultimately, I had to take about six electives at once.

Santiago: I did not turn in [a] homework because I am a perfectionist and writing assignments overwhelmed me so much... that semester my anxiety was high. Not only did I not turn in work in that class. I was being irresponsible; I was not going to class because I did not feel like it.

Isaac: In my evaluation of my first Internship, [marks in] almost all aspects were ok, but there was one item that was not well evaluated: proactivity. And I agree, I thought I only had to do what I was told (...) I thought I was only an operator and that I didn't have to worry about other things. I focused on the basics [minimum] of that I had to do.

Cassie: It was difficult for me to start college without being with her [twin sister]. I was very dependent on my twin sister, and it was hard for me to separate from her. Soon after I started my first year of college, I started dating a classmate, and he somewhat replaced the role my sister used to play in my life. He accompanied me and helped me enter the classrooms, and to expose myself to any type of social interaction (...) When we broke up, it became difficult for me to enter the classrooms, and I didn't talk to anyone. It was like a kind of snowball because since I did not come to class, I did not know what was happening in class, and I did not dare to ask questions. I would leave home to go to school and spend all day at the library.

Participating students considered themselves students with good academic achievements during high school, but that changed once they enrolled in college. As we can see in the students' answers, they felt frustrated and anxious about their academic trajectories for different reasons. Dennis indicates that he felt pressured to feel accepted, and the way to be accepted was to have exemplary academic records, which made him anxious. Santiago was feeling overwhelmed and expressed that schoolwork would make him anxious and depressed. Although Isaac had good study habits, he encountered new academic challenges, such as his first internship and a new class, which he found very difficult to deal with. Finally, Cassie shows low self-esteem and autonomy, as she depends on one of her family members to overcome academic and social challenges.

As Maturana states, emotions are bodily dispositions from which humans operate, reason, and, consequently, make cognitive changes (learn) [28]. When asked about their academic trajectories at the time they were invited to participate in the enhancement cycle, students state they were not in the best state to learn. The latter could be explained given the anxiety and other emotions generated by doing a task that required effort, the pressure to impress family members, or even encountering academic challenges they did not know how to overcome. These emotional conditions hindered their cognitive ability to operate adequately, and anxiety and demotivation interfered with their clear and organized exploratory and executive behavior, interfering with their cognitive strategies [23][26].

### ***Perceptions after the intervention***

When we asked students what happened to them during their participation in the learning outcomes enhancement cycle, we had different answers, however, there are two recurring elements: motivation/commitment and learning strategies.

***Motivation and commitment.*** All students in this study had at least one session with the department's psychologist. With help from the psychologist, students declare they became aware that motivation is necessary to achieve academic goals, but also, they need to be committed to their academic trajectories. In addition, they realized they were having difficulties in their academic trajectories because they lacked commitment to their professional transformation. Santiago, Daniel and Dennis stated:

Santiago: With the psychologist, I learned that apart from motivation, one has to be committed to the undergraduate program, which has also helped me motivate myself and be more committed to my studies.

Daniel: Before, I thought that the problem was my motivation or that I was not motivated by responsibility. However, with the psychologist, I learned that apart from motivation, one has to be committed to the program, which has helped me motivate myself and to be more committed to my studies.

Dennis: I learned that I could make a change from my position [as a student]. Now I try to take the initiative (...) Now I am proud of what I am doing (...) I don't need to rush my path (...) I now recognize [my] achievements, personally and academically

Both Santiago, Daniel, and Dennis experienced a change in their emotion toward their studies and academic responsibilities. This emotional change helped them improve their academic trajectories and achieve academic success after participating in the learning outcomes enhancement cycle. This change happened thanks to a mediator, the psychologist, who helped both students reflect on what was causing their academic difficulties. Aligned with Feuerstein's theory and Maturana's statements about emotions and learning [26] [28], the student's participation in sessions with the psychologist helped them reflect on their academic trajectories, exploring the leading causes of their difficulties and understanding that it was in their hands, with help from a mediator, to change their emotions to improve their academic achievements.

Another student, Isaac, participated in additional workshops because he had a low performance in one of his internships. He stated how the workshops helped him understand how he was operating in his academic trajectory, the causes of his difficulties and how to face future difficulties with his studies and internships.

Isaac: The workshop helped me understand that it could happen to all of us [having academic difficulties], how I could improve, and what I had to work on. She [the facilitator] made us work individually on some tasks. Then we had to explain [to all] how we understood the task and what we had put together. Later, [the facilitator] asked us to work in teams, and from there, we realized what we were missing... We gave each other feedback.

With the workshops I thought I may have to rethink things: how I work, what I must worry about, etc. I realized that I was expected to do what they had taught me to do and worry about doing it well. The workshop activities were helpful, and the explanations were consistent with what we needed for better academic results. As a

result, I understood that what I missed in my internship, which made me perform poorly in it, was not entirely necessary for the job, but it was something I needed to know as an industrial engineer.

I realized that all the interested parties have to participate in the process so that it can be better, both the companies that teach the engineers and the teachers and the students. Everyone must do their part for this to work out. The only feedback the students see is the course evaluations and nothing else. However, in this case (a session with the psychologist and workshops), it is helpful to know how a student is doing through his academic trajectory and what he experienced during the activities related to improvement processes.

Isaac declares the importance of the mediator several times in his statement. We observe in his statement that with the support received in the workshops from the learning outcomes enhancement cycle, Isaac clearly understood how he was operating and how many tools he had acquired in his studies. However, before the workshops, he was unaware of the practical and technical tools to carry out his work as an industrial engineer. As a result, he performed poorly in his internship because he needed to consider using those technical skills. On the other hand, Isaac recognizes the benefits of support activities and the value of teamwork. Additionally, he uses a systemic approach to understand the processes in which he was involved and may be participating.

Finally, Isaac makes an interesting reflection on how students need better feedback about their academic trajectories, as GPA is not the only way to see if a student is facing academic difficulties. This statement is consistent with quality enhancement in an undergraduate program at the student level and with what our team intends to do with our learning outcomes enhancement cycle.

***Learning strategies.*** The second element highlighted in the students' reflections after participating in the learning outcomes enhancement cycle was learning strategies. Most students realized they had difficulties with their learning habits before coming to the activities and interventions. Christian and Santiago stated:

Christian: Now, with what I have lived and the help of the psychologist, it is much easier to adequate myself to a study method (...) Things are more evident to me, and I feel I make more of my time (...) I'm very responsible with my learning strategies now. If something does not work for me, I look for other strategies to be more efficient in my classes.

Santiago: With the psychologist's support and with the help of the Students Affairs Office, I could understand which learning strategy was the best for me. I learned how to study and understood that studying in a team was much better for me.

The workshops in which they participated at the school and the conversations with the psychologist allowed them to discover new strategies for studying and working. We can see in Santiago's statement that the workshops in our school complement other offerings by the university (through the Office of Student Affairs). We can also evidence that with the help of these workshops, students become more aware of their own needs to succeed in their academic trajectories. Finally, we can evidence through both statements that they discover new ways of learning with the help of a mediator, which is aligned with Feuerstein's theory [26].

## Discussion and Next Steps

We understand the limitations of our study, as our sample is small (six students). Nonetheless, the participating students observed changes in their academic trajectories after participating in our learning outcomes enhancement cycle. Students recognized that they faced several academic difficulties when the industrial engineering department invited them to participate in the enhancement cycle. These difficulties were related to quantitative indicators, e.g., GPA, and qualitative elements of their academic trajectories, such as sense of belonging, motivation, and self-efficacy. Additionally, they manifest how the interventions (sessions with the psychologist and workshops) helped them understand why they were having academic difficulties and showed them techniques and mechanisms to improve. For example, some students did not feel motivated to become industrial engineers before participating in the intervention. They were questioning their sense belonging and doubting their self-efficacy. After participating in the intervention, they manifest an increase in their motivation and sense of belonging in the industrial engineering department. Students also manifest that the intervention helped them understand their lack of motivation and how they could grow their motivation to succeed in their academic trajectories towards becoming industrial engineers.

The results presented above are evident as all the designed activities are intended to improve students' academic trajectories. Nonetheless, what is most interesting about the interviews and students' statements, is that they evidence a change in their cognitive abilities, as all six students in this study reflect on their learning, leading to metacognition abilities. The latter is consistent with the literature on mediated learning experiences [23][26].

Students can develop the ability to reflect on their learning experiences and academic trajectories with the help of a mediator. However, quality enhancement at the student level requires more than following quantitative indicators such as students' GPAs. When students encounter academic difficulties in engineering, they need a more comprehensive assessment (qualitative) that will allow them to understand the reasons for the difficulties and how to overcome them to achieve the desired engineering learning outcomes. We understand that mechanisms for quality enhancement to evaluate students' academic trajectories and help them achieve the desired engineering learning outcomes require resources and time. Nonetheless, many of the difficulties students encounter during their undergraduate studies are not necessarily related to developing technical abilities, but much closer to personal traits or external circumstances that negatively affect their academic trajectories. Among personal traits we encounter different attitudes, values, beliefs that affect students' academic trajectories. Thus, schools could use university resources to help students with their learning outcomes achievement when necessary.

Further work is needed to evaluate our learning outcomes enhancement cycle at a larger scale. Additionally, with the results of this study, we considered the need to allow other students participate in the enhancement cycle, and not only those whose professors or internship supervisors evaluate poorly. Finally, we intend to expand the cycle by collaborating with other engineering departments or institutions. As mentioned by J. Bedensen et al. [19], collaboration might be essential to improve mechanisms for quality enhancement in engineering education programs.

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