

Protection factors self-efficacy and causal attributions related to academic performance, personal characteristics and life at university at engineering education

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Abstract— *This in-progress research paper is studying the relations between academic performance, protection factors, life at university, and personal characteristics, in order to identify protective factors for students' academic success. Engineering undergraduate courses in Brazil are known for their extensive theoretical curricula, overload in classes and content to study, constant failures, and high retention. On the other hand, several students can somehow overcome these difficulties, move on, and conclude studies. Current research studied the relations among academic performance, self-efficacy, causal attributions, personal characteristics, and life at university in a sample of 30 students from an electrical engineering public university in São Paulo state, Brazil, who voluntarily accepted to attend the survey. It was found a statistical relationship between academic performance and protection factors self-efficacy and causal attributions, specifically a positive one with dimensions initiation, persistence, and success, and a negative one with failure. Both positive and negative are due to internal causes. However, personal characteristics variables - such as color or race brown and having primary education in a public school associated with socioeconomic disadvantages in Brazil - showed a negative relationship with academic performance. Due to several sampling limitations, it is suggested further studies with larger samples to investigate the association of academic performance with some of the variables, especially the ones related to social minorities and how to balance them with other protective factors*

Keywords — *causal attribution, self-efficacy, engineering education, academic performance*

I. INTRODUCTION

Engineering undergraduate courses in Brazilian universities are usually known for their extensive theoretical curricula, high probability of failure, and evasion, even after succeeding in a very rigorous entry process. Several factors could lead a student to terminate, but several students can somehow overcome these difficulties, hold on, and conclude their studies.

A typical engineering undergraduate course structure in Brazil contains at least five years of disciplines, including a basic cycle of physics, math, sciences and programming (~26% of total classes), research introduction, optional courses and general sciences (~48%) and specific technical disciplines (~26%). There are several pre-requisites on each of these disciplines, especially the basic cycle, in which high percentages of failure can be found.

Assuming that a university is a place with several social interactions, interpersonal and academic skills are required, and such demands can worsen levels of mental health, while the previous experience, expectations, and changes in several areas of life take place [1].

Bandura [2] defines self-efficacy as the judgment one can make on how he/she can organize, execute, constitute cognitive skills, act social, and behaviorally on challenging situations. It does not refer to the skills one has, but the judgment this person makes while facing a challenging situation. Bandura [3] also states that people who stay firm on these challenges will have a corrective experience that improves the sense of self-efficacy, while those who prematurely withdraw will fear that same situation again in the future.

Efficacy expectations also determine how much effort one will invest in a given situation and how long will he/she endure, and no other belief is more reliable than the belief on their own skill to keep control on the event, especially if it can somehow influence their own life [4].

Consecutive successes increase the expectation for new positive experiences and reduce the impact of failures, while consecutive failures reduce the expectations for successful outcomes. Also, increasing the success expectations in different situations provides positive feedback for other experiences [3].

Bandura [11] propose that situational factors should also be considered in understanding the relationship between behavioral factors (student's academic performance) and cognitive factors (perception of self-efficacy and causal attributions). The dynamic interaction between this set of factors constitutes his theoretical concept of 'reciprocal determinism'. Socio-economic conditions, the presence of inspiring models of success, feedback from teachers are some examples of situational factors that interact with academic performance and students' self-perception.

The perception of efficacy on controlling stressful factors has a central role on anxiety, since people who believe that can control threats do not focus on negative thoughts, but those who believe not to have the required skills go through high anxiety situations [4].

Since always, human beings were engaged to attribute causality to the events: from warriors trying to understand why they won a battle to nowadays industries understanding the reason for low profit or losses [5]. The perceptions of success or failures share three main properties: locus (internal, like

skills or effort, and external, like luck or external aid), stability (like the probability of success or failure), controllability (whether a given factor is possible to be controlled or not) [5].

II. OBJECTIVES

The general objective of this research is to investigate protective factors - psychological, socioeconomic profile, and experiences - related to good academic performance in undergraduate engineering.

Precisely, the scope of research consists of studying jointly protection factors self-efficacy, causal attributions, and their influences and relationship with academic performance, personal characteristics, and life at university at a public engineering school located in São Paulo, Brazil.

It is also a scope of work to find an academic performance index that considers grade in class and evolution on curricula in a transversal study.

III. METHODOLOGY

The participants of the research are electrical engineering undergraduate students, a total of 30 from two moments of the engineering course (7th and 9th semester). Collecting data in two different stages is intended to avoid any disturbance on data and also to investigate the scope of research on students that are at an advanced stage.

The university where data was collected is known for being an elite one, with a high competitive admission process, that results in a high percentage of students with high income that studied in elite private high schools (in Brazil, public basic education is of lower quality compared to private one).

Psychological factors will be evaluated through the adapted Portuguese version of Sherer's self-efficacy scale (self-efficacy scale)[6] and Scale of causal attributions to academic success and failures in college students (causal attributions scale), developed by Boruchovitch and Santos [7].

A questionnaire developed for this research collected personal characteristics and life at university. Meanwhile, academic performance data were collected in the online system of the university by asking students to access the platform using their mobile phones during data collection.

Principal components factor analysis was used in order to find a synthetic index that can jointly explain the three main aspects of academic performance: (i) weighted average grade including reprobation, (ii) percentage of concluded disciplines compared to the course schedule, and (iii) amount of time at course in the number of semesters.

Jointly, these three variables can bring understanding on: (i) how was the performance of the student in the disciplines, including the ones he/she was not approved at; (ii) is this student on schedule compared to the program? (iii) how long is this student in the college? This index will show, in a quantitative way, how in phase with the critical path this student is and how likely it is for him to conclude the studies according to the proposed schedule, with good grades.

In order to generate a protection factor index that can explain part of self-efficacy and causal attribution through the scales used in the research, principal components factor analysis was also used.

With both indexes, all parameters can be added to the modeling. An OLS (ordinary least square) regression was

used to jointly study the indexes, personal characteristics, and life at university. Personal characteristics were added through *dummy* variables on possible answers to questions (e.g., gender male, gender female, color white, black, yellow)

$$academic\ performance = \alpha + \beta_1 psychological\ factors + \beta_2 life\ at\ university + \beta_3 personal\ characteristics + u_i \quad (1)$$

The academic performance index was the explained variable, while all others were explanatory variables.

IV. RESULT ANALYSIS

A. Factor analysis to find academic performance index

Bartlett's sphericity test showed, at a 5% significance level and 3 degrees of freedom, that factor analysis is appropriate, since Prob (p-value) < 0,05, e $\chi^2 = 38,547$.

Factor analysis showed that a single factor could explain 66,24% of total joint variation of the three variables (weighted average including reprobation, percentage of concluded disciplines compared to course schedule, amount of time at course in number of semesters). This new variable will be used in the upcoming model that also considers psychological protection factors (self-efficacy and causal attributions), personal characteristics, and life at university.

TABLE I. BARTLETT SPHERICITY TEST FOR THE PERFORMANCE INDEX

Bartlett's sphericity test	
χ^2	38.547
Degrees of freedom	3
p-value	0.000

B. Factor analysis to find protection psychological factor index

Bartlett sphericity test showed, at a 5% significance level and 21 degrees of freedom, that factor analysis is appropriate, since Prob (p-value) < 0,05, com $\chi^2 = 46,296$.

TABLE II. BARTLETT SPHERICITY TEST FOR PROTECTION FACTOR INDEX

Bartlett's sphericity test	
χ^2	46.926
Degrees of freedom	21
p-value	0.001

Two factors can explain 59,23% of total variance of the dimensions of Sherer's self-efficacy and causal attributions to academic success and failure of college students, and the variable was generated and included in the model, along with academic performance, personal characteristic, and life at university.

C. Relationship between academic performance index, psychological factor, personal characteristics, life at university

By analyzing the outcome of the OLS, variables that were statistically significant at 5% significance are: psychological factors, primary school at public schools, color brown, attend to university parties, living with parents, living with other

college students, high school at public school, has leisure activity.

It is possible to conclude that there is a positive relationship, at 5% significance, among the variables: academic performance and psychological factors, students who studied in a public middle school, who lives with parents or college accommodations and has leisure activities.

On the other hand, variables such as color or race brown, students who attend to university parties, and those who studied in public school showed, at a 5% significance level, had negative influence over academic performance.

TABLE III. OLS REGRESSION MODEL OUTPUTS FOR ALL STUDIED VARIABLES

R² = 0.8683		
<i>Variable</i>	<i>Coef.</i>	<i>p-value</i>
Psychological factor index	+0.4740	0.006
Studied middle school at public school	+0.6181	0.015
Color brown	-1.8532	0.000
Attend to university parties	-0.4373	0.003
Living with parents	+0.8741	0.003
Living in college accommodations	+1.1879	0.002
Studied high school at public school	-0.4250	0.028
Has leisure activity	+1.1903	0.000

Both living with parents or in college accommodations showed relevant at 5% significance, indicating that family and social support might also create a protection network that allows the student to move on the undergraduate course, by relieving stress along with leisure activities.

There are several highlights to be made in the result of the OLS. The sample is remarkably reduced when it is compared to the number of students of the engineering school, and also when it is compared to the total students of the specific program (electrical engineering). In general, the personal characteristics of the students made the sample homogenous (~80% of total) in terms of gender male, color or race white, age under 24 years-old, are living with parents, studied in private high schools (these are of higher quality compared to public ones) and focused on studies only (i.e., not currently working). This socioeconomic limitation of the sample might be related to the whole educational system that somehow draws people of the same socioeconomic reality to some careers instead of others, which perpetuates inequalities in public universities. A further and more in-depth investigation is required, especially regarding the relationship among the explained variable (academic performance), color or race and other social inequality factors. Since Brazil is one of the most unequal countries in the world, income is concentrated in the non-black population [8], and there might have influences in academic performance caused by this combination of long term social inequality. Besides, when compared to the private education system, public education is of higher excellence at the university level, but of lower quality in primary and secondary education in the country.

The studied sample brought strong influence from the social inequality in Brazil, as it turned to eliminate several intended studies and turned inconclusive the ones that were

possible despite the homogenous sample, especially the ones related to color or race and gender. Unfortunately, this sample is also a reflection of social privilege on the seek for a good education, which is easier to find on families that have better incomes.

Variables related to science initiation were surprisingly rejected in the modeling, such as attendance to research events and science projects. Assuming that participating in science initiation is a way to speed up development, creating awareness and maturity regarding the selected engineering specialty, the non-contribution of this variable in academic performance is surprising and requires further investigation with larger samples as well.

To understand what are the dimensions of self-efficacy and causal attributions that positively influence the academic performance, an OLS was also generated using the academic performance index and the several dimensions of the scales. From all the seven dimensions of the scales, three came from the Sherer's adapted to Portuguese self-efficacy scale (initiation and persistence, effectiveness in the face of adversity, social effectiveness), and four were from the Scale of causal attributions to academic success and failures in college students (success/internality, success/controllability, failure/internality, failure/controllability).

Initiation and persistence, success/internality, and failure/internality showed relevant at a 5% significance level. The first two dimensions showed a positive influence on academic performance, while the last one showed a negative influence.

$$academic\ performance = \alpha + \beta_1 initiation\ and\ persistence + \beta_2 social\ effectiveness + \beta_3 effectiveness\ in\ face\ of\ adversity + \beta_4 success/internality + \beta_5 success/controllability + \beta_6 failure/internality + \beta_7 failure/controllability + u_i \quad (2)$$

TABLE IV. OLS REGRESSION MODEL OUTPUTS FOR DIMENSIONS OF SCALES

R² = 0.4719		
<i>Variable</i>	<i>Coef.</i>	<i>p-value</i>
Initiation and persistence	+0.3368	0.023
Success/internality	+0.1082	0.014
Failure/internality	-0.0791	0.019

This outcome is in line with Bandura [3], which stated that people that persists in the face of challenging situations tend to strengthen its sense of self-efficacy, while those who withdraw prematurely tend to fear that same situation again and it also influences how much effort this person is willing to spend to overcome that challenge in future.

The positive feedback loop of consecutive successes in self-efficacy and reduction of the impact of failures discussed by Bandura [3] is shown in the findings of this model. Only five out of thirty participants are fully aligned to the course schedule, but even like this, the other twenty-five students are enduring and progressing on the course.

The positive influence of the dimension success/internality is in line with Weiner [5], who stated that students tend to associate good academic performance to effort, an internal factor. The negative influence of failures associated with internal factors might be interpreted as beliefs from the participants that they might not be good enough to attend a

high-quality university like this, and might fall into a negative feedback loop that can cause consecutive failures, retention and or evasion.

V. CONCLUSION

Current research studied the relationship between academic performance, self-efficacy, causal attributions, personal characteristics, and life at university. A total of 30 students from an electrical engineering public university in São Paulo, Brazil, attended to the research, and data was collected personally during the period of classes. It was found a statistical relationship between academic performance and psychological factors, specifically a positive one with dimensions initiation and persistence and success due to internal causes, and a negative one with failure due to internal causes. Results are in line with Bandura [3] where self-efficacy refers to the judgment one has regarding his/her skills to organize, structure, constitute cognitive skills, and deal with challenging situations. Following situations of success generate positive feedback loops that strengthen self-efficacy. Thus, these factors can act protectively to students in the face of their academic challenges.

When all variables were studied jointly (academic performance, psychological factors, personal characteristics, and life at university), it was found a positive relationship between academic performance and psychological factors, students that studied middle school in public school, are living with parents or in college accommodations, and has leisure activities. A negative relationship was found with variables color or race brown, students who attend university parties and students from high school at public school.

However, the generalization of these results finds some restrictions. It is essential to highlight that the studied sample had several standard variables between participants without considering its distribution in the sample universe of this research. These were the results found in this sample, and further investigation with an expanded sample, including a higher number of stages of the course, is needed to achieve conclusive results. Also, an investigation in individuals that are outliers compared to sample could lead to a deeper understanding in terms of mutual influence of these variables, and direct actions from the university could be taken in order to prevent students from falling in a negative loop caused by consecutive failures and evade.

Understanding how a failure in any critical discipline from the beginning of the course could lead to a snowball effect over the evolution of the student is also a relevant suggestion to be studied in future researches, especially by relating this with self-efficacy and causal attributions. Since all basic disciplines (like calculus, physics, and programming) are fundamental pre-requisite to several other disciplines of the curricula, so failures on one or more of these disciplines could cause a postponement of conclusion on the engineering course. Other aspects of psychology can be studied with similar methodologies, like motivation, coping strategies, self-damaging strategies, anxiety, depression, stress, and any other aspects that can be associated with academic performance and its evolution in course.

Participants shared similar characteristics, turning the sample a very homogeneous one (as discussed in section IV). These combined characteristics are a substantial evidence that this sample is a very privileged one in socio-economic and educational aspects, which would also influence the statistical

relationship of university academic performance, self-efficacy and causal attribution. These aspects made impossible to deepen the study on socio economic aspects while eliminating noise of other variables.

However, it is possible to discuss some ongoing initiatives of public universities in Brazil that might strengthen protection factors considering a socio-economic perspective: several ones (including the one were data was collected for this research) are reserving 50% of total available vacancies to students that came from public high schools, and that is an initiative that tends to turn the life at university more familiar since these students will live with other people that shares similar social/economic situation. The reservation of 50% of vacancies finds good support on teachers in general, and this is an influence that educators might have on strengthening self-efficacy and attribution of students. Unfortunately, this initiative started after the participants of this research started their studies (e.g. class was already formed), so sample reflects social/economic scenario from pre-vacancies reservation.

A great source of motivation is telling the students the valued outcome of tasks and problems, and *why* these skills are important, developing assessment methods and indicators that provides the students their level of proficiency [9]. Educators can also intervene in the cycle helping students to set clear, specific, challenging and proximal goals, providing honest and explicit feedback to students intended to increase the efficacy beliefs, facilitate the calibration of self-efficacy, and use peer modeling [10].

Teaming activities proposed by teachers provides students opportunities to improve self-efficacy by assessing their skills through comparisons between him/herself with other similar ones, by observing classmates and feel that “if he/she can do it, so can I”, especially if the teams are combined with high and low performer classmates [9].

Also, out from the seven dimensions of scales, only three showed statistical relationship with academic performance: initiation and persistence, success/internality, failure/internality. No external factor was statistically significant, which might indicate that students do not perceive educators as an important part of their support structure that allows them to endure in the face of adversity, and their success or failure are in their hands, and not in educators. This might indicate (for this sample) that educators have little influence on developing protection factors of students. A future research can be developed here.

As a final remark, the contribution of this study was to identify the relationship between certain aspects of students’ life and self-perception with their academic performance. It can guide new studies and support reflections on institutional and educational actions that strengthen the student in the face of the vulnerabilities inherent to his university education and avoid retention and evasion.

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