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Analysis of factors that influence the academic performance of first-year Chilean engineering students

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Analysis of factors that influence the academic performance of first-year Chilean engineering students

Abstract

This complete research paper identifies and analyzes the factors that influence academic performance and, consequently, the retention rate of first-year students in the school of engineering at a private Chilean university. Chile's retention rate has slightly increased in recent years, from 72.2% in 2016 to 75.9% in 2020. Comparisons by area of study show that the lowest rates are found in degree programs associated with Technology and Basic Sciences, with 70.7% and 76.5%, respectively. Prior research on this subject has evaluated the importance of the academic success of first-year engineering students as one of the key factors that promote student retention in this and related fields. On the other hand, factors associated with these results in the first year of engineering include socio-demographic variables, pre-university and university educational experiences, socio-cognitive characteristics of students, and family background. This research aims to analyze the factors related to students' academic performance according to the association between the independent variables of socio-demographic, family, social and economic backgrounds, and the dependent variable of academic performance in the first semester of their first year of studies. Through a quantitative non-experimental methodology, a descriptive and correlational analysis was conducted to explore the variables. This was achieved via an institutional survey undertaken by n=1,273 first-year students from 11 different degree programs who answered before starting their classes in 2022. Results highlight certain factors that affect student academic performance. The present research has improved our understanding of the new generation of young people entering the engineering field through several different variables. Therefore, higher education institutions must analyze and implement appropriate actions to enhance first-year students' academic performance and improve retention rates.

Introduction

The retention of students who decide to pursue a degree in the science, technology, engineering, and mathematics (STEM) fields is of crucial importance to universities around the world. It is broadly recognized that the development of nations is directly associated with the education of their populations in these specific academic areas since this promotes their scientific and technological advancement. It is well established that several factors are associated with attracting and retaining students in the STEM fields, including an affinity with the discipline, a sense of belonging, interest in the field, self-efficacy, and prior educational experiences, among others [1, 2]. One indicator of academic progression commonly used in educational management is the student retention rate. Academic progression reflects the ability of the educational institution to achieve the retention of its students. High retention rates imply good institutional management, low dropout rates, and, consequently, positive economic benefits for the families of students and the State itself [3, 4].

Beyond the quality of institutional management, additional factors have been found that influence students' academic performance in STEM degree programs. For example, Russell & Zafonte [5] report that first-year students have valuable skills that enable them to succeed in their careers, such as critical thinking. Nevertheless, this study argues that students consider writing skills and collaborative work less important for their career development. Regarding those mentioned above, it has been widely documented that university students require a broad set of skills to be successful in their careers. For example, it has been shown that collaborative work helps students to promote conceptual learning, develop

communication skills, foster interdependence among peers, and generate a positive classroom environment [6-8].

Demographic indicators such as socio-economic status, family realities, and living conditions are also essential for understanding student backgrounds in the context of higher education. Jarvie-Eggart, Singer, & Mathews [9] contend that parents and friends, i.e., their immediate circle, significantly influence the career choice of students and, thus, whether they persist with their degrees. Students who are the first generation in their families to study at university generally receive less support from their parents since they are largely unfamiliar with university processes and have fewer financial resources to support a university degree [10]. In this regard, the factors associated with student finances also enable researchers to analyze their degree of commitment and predisposition to continue with their studies [11]. It should be noted that, as reported in related literature, students sometimes drop out of university because of financial difficulties [12]. In the Chilean context, in which the present study was carried out, researchers found that the main factors that cause engineering students to drop out include a lack of self-confidence, excessive academic workload, and financial situation [13].

In order to increase the academic performance of first-year students, it is necessary to ensure a thorough understanding of the different associated factors. A satisfactory academic performance in the first year of study favors the continuity of students in their careers, positively associating the retention rate, which in the first year of study since it represents a significant proportion of dropouts [14]. In Chile, this indicator averaged 75.9% in the 2020 cohort and identified differences based on factors such as the institution type or the study area. Concerning the type of educational institution, the lowest retention rate of first-year students was identified among technical training centers, with 66.2%, while the highest percentage was found in universities, with 85.0%. When compared by area of study, the lowest values are found in degree programs associated with Technology and Basic Sciences, with 70.7% and 76.5%, respectively. On the other hand, the areas with the highest retention rates are Health and Law, with 81.7% and 82.3%, respectively [15]. Accordingly, the present study aims to identify and analyze the factors primarily associated with the academic performance of first-year students in the school of engineering of a private Chilean university.

Methodology
In this study, an institutional survey before starting classes was distributed to and completed by all first-time students (2022) from 11 different engineering degree programs (n=1,273). Through a quantitative non-experimental methodology, a descriptive and correlational analysis was conducted to explore the variables. The survey was a characterization survey with four dimensions: i) family and social factors; ii) economic factors; iii) prior study experience; iv) personal skills and study habits. Considering the weighted grade point average (GPA) of the first semester of studies, which can vary between 1.0 and 7.0.

Results
The results are presented in the following manner: A. Descriptive analysis conducted via Microsoft Power BI software about i) family and social factors; ii) economic factors; iii) prior study experience; iv) personal skills and study habits, and B. Correlation analysis was undertaken using the IBM SPSS Statistics software.

Descriptive analysis

Family and social factors. The following variables were analyzed for this factor (Fig. 1): the level of education of parents; the perceived importance of the level of contact with the family and close-knit groups; whether the students have children; and who is the head of the household. Concerning parents' education level, it was observed that students with the highest weighted grade point average (GPA) were those whose parents both had a university education (5.1). In contrast, the students with the lowest GPAs were those whose parents had incomplete schooling. However, when analyzing the association of the father or mother's education level, a standard deviation of 0.18 was observed with respect to the level of education attained by the father, and a higher standard deviation in the case of the mother (std. dev. = 0.39). Finally, a gap of 7.1% was observed concerning parents with postgraduate studies, while the gap for parents with no studies reached 18.6%.
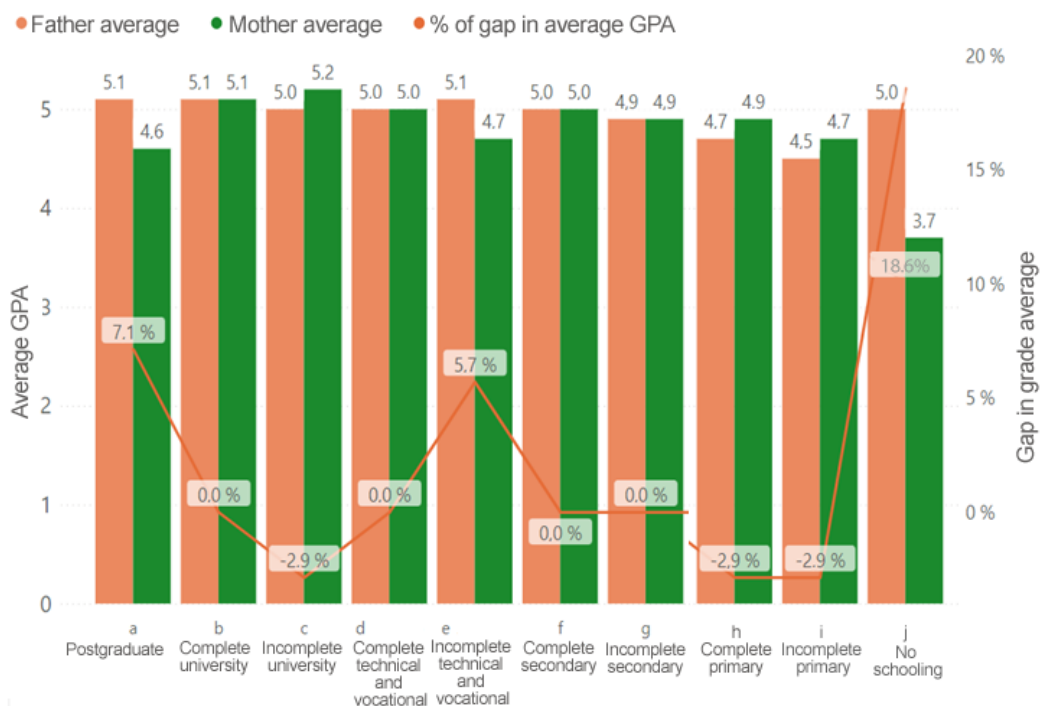

Figure 1. Analysis by parental education level.

Concerning the level of contact with the family and close-knit groups (Table 1) and how this is associated with academic performance, 75.5% of respondents noted the importance of maintaining communication with family members and 52.3% with friends. On the other hand, there was a low or almost no level of importance given to maintaining contact with spouse/partner groups (49.6%) and teacher groups (45.9%).

Table 1. Level of contact with family or close-knit groups.

Level of contact with family or close-knit groups	GPA	Numbers of students	Students (%)
Members of nuclear family			
Very important	5.0	956	75.5
Moderately important	4.9	256	20.2
Of little or no importance	4.9	55	4.3
Spouse/partner			
Very important	5.0	511	40.3
Moderately important	4.7	128	10.1
Of litle or no importance	5.0	628	49.6

Grandparents, uncles, aunts, cousins			
Very important	5.0	494	39.0
Moderately important	4.9	586	46.3
Of litle or no importance	5.1	187	14.8
Friends			
Very important	5.1	663	52.3
Moderately important	4.8	491	38.8
Of litle or no importance	5.0	113	8.9
Teachers			
Very important	4.7	127	10.0
Moderately important	5.0	558	44.1
Of litle or no importance	5.0	582	45.9

Although students reported distinct priorities regarding the importance of the level of contact with family and close-knit groups, it can be confirmed that the association of this level of contact on their academic performance is not significant since the standard deviation of the GPAs does not exceed 0.17 in this regard.

About students who are parents, 3.4% reported having one or more children. However, having children does not affect academic performance since the average GPA of this group of students was 5.0, with 84.8% scoring a GPA higher than 4.0. This compares to students without children, who were found to have an average GPA of 5.1, with 86.0% scoring a GPA higher than 4.0.

Figure 2 shows a correlation between the individual who assumes the role of head of the household and academic performance. Students with immediate family members (such as parents or siblings) who assume the role of head of the household have a higher average GPA. In this case, the "sibling as head of the household" is noteworthy since students in this group obtained an average GPA of 5.4, and 91.7% obtained a GPA of over 4.0.
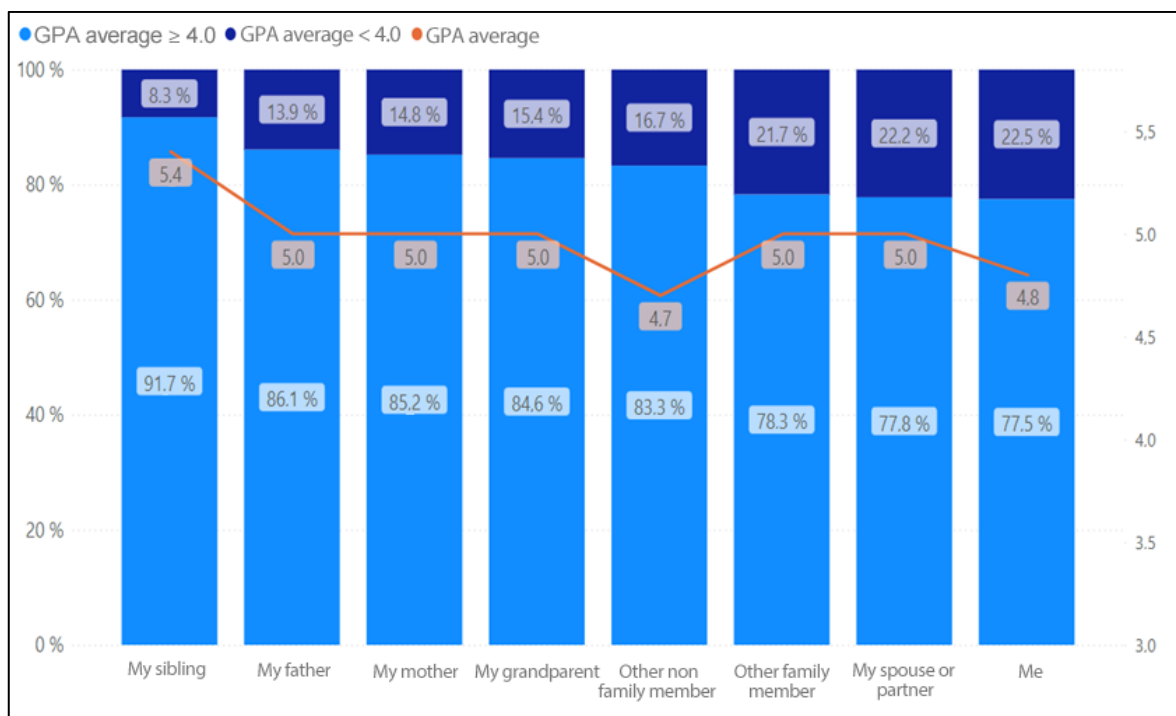

Figure 2. Average GPA results breakdown < 4.0 and ≥ 4.0 based on head of household figure.

Economic factors. In the second stage of the analysis of factors associated with the academic performance of students, the economic aspect was considered concerning their respective employment situations, who finance their studies, and general financial support (whether state-sponsored credit/scholarships/other) (see Fig. 3). In terms of the employment situation of students, it was found that working short hours favors academic performance. Students who worked fewer than 8 hours per week had the highest average GPA (5.1), and the same group represented the highest percentage of students with an average GPA of over 4.0 (89.2%). Conversely, working more than 8 hours per week was shown to be negatively associated with academic performance. The average GPA of this group of students decreased to 4.8, and the percentage of students with a GPA of over 4.0 was 78.6%.
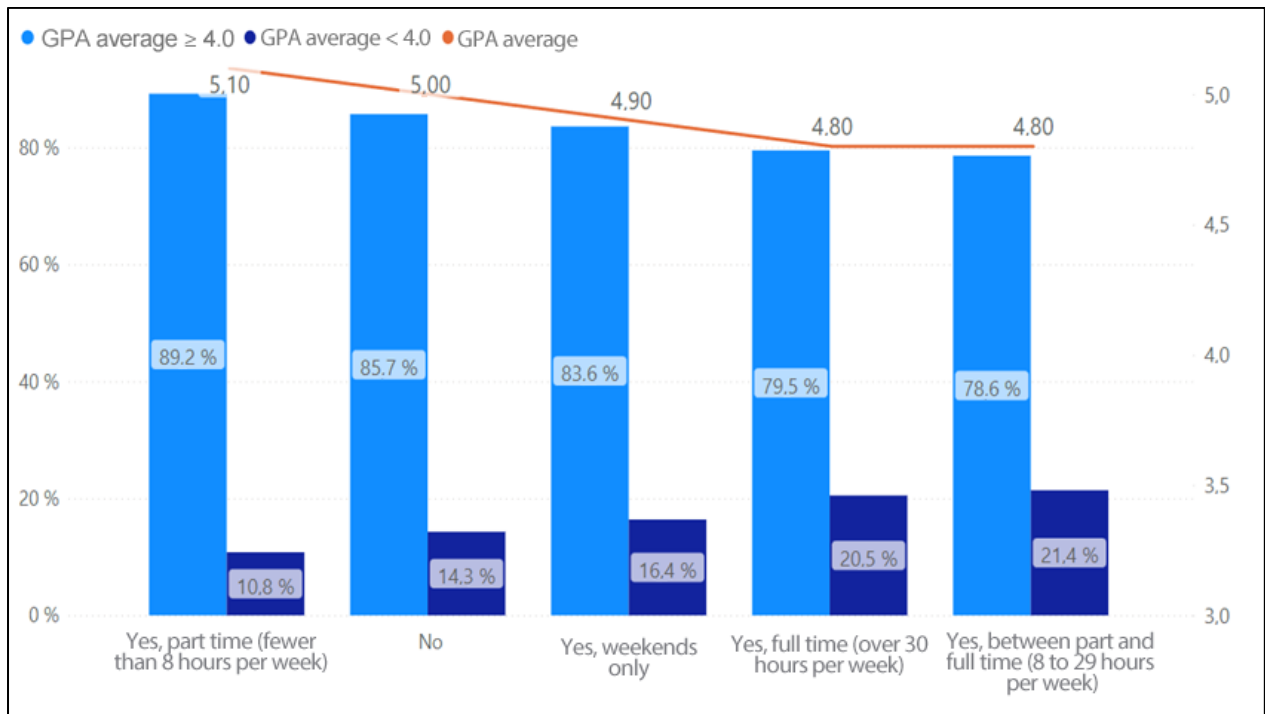

Figure 3. Average GPA of students based on intent to work.

A second factor in this analysis relates to who finances the student's studies and how this influences their GPA. In the daytime student group, 81.78% of parents/guardians finance their studies. As a result, these students achieve improved academic performance with an average GPA of 5.0 and 86.5%, scoring a GPA of over 4.0.

In contrast, 73.24% of evening students self-finance their studies. This group achieved an average GPA of 4.8, with 78.9% scoring a GPA of over 4.0 (as shown in Table 2). Concerning sources of financing, it was found that students who self-finance their studies with diverse sources perform better academically, with an average GPA of 5.1 and 86.3% scoring a GPA of over 4.0.

Prior study experience. About the relationship between the prior study experience of students and how this influences their academic performance, Fig. 4 shows that students who had already completed a previous degree achieved high performance. Those who had completed a previous degree in the same institution as their current studies achieved an average GPA of 5.8. In contrast, those who had done so at another institution scored an average GPA of 5.4. On the other hand, the group with the lowest academic performance corresponds to students

who have dropped out of more than one-degree program, with an average GPA of 4.9 and 21.4% scoring less than 4.0.
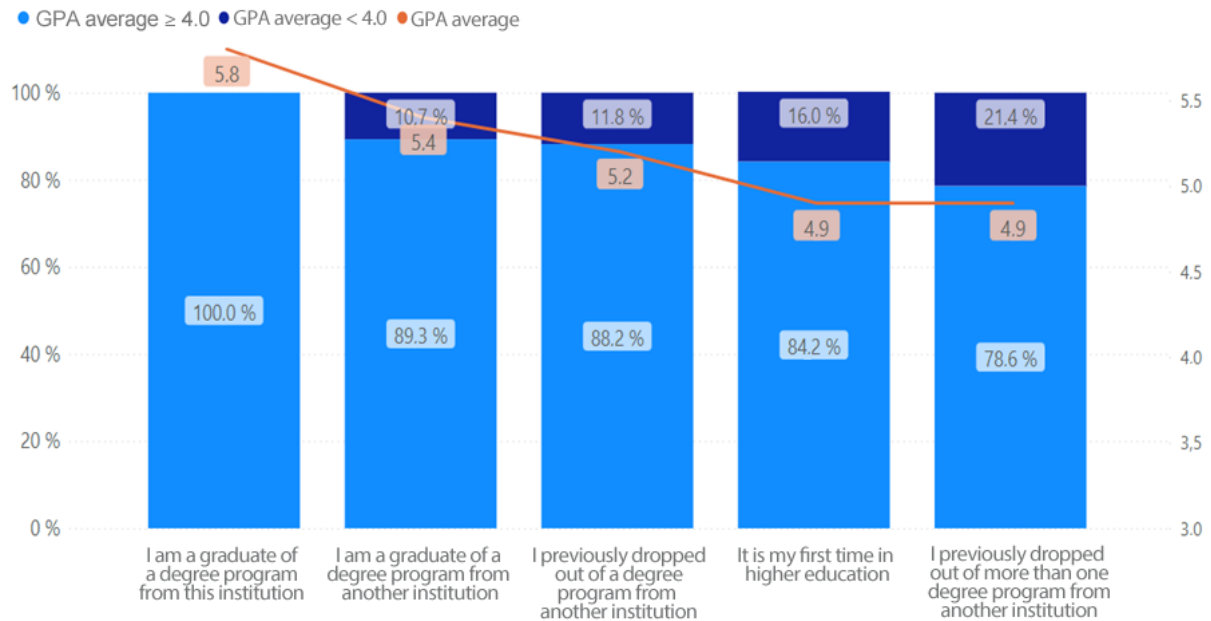

Figure 4. Average GPA results breakdown < 4.0 and ≥ 4.0 based on prior study experience.

Personal skills and study habits. Fig. 5 shows student responses to their perceived importance of specific key skills. For example, according to the students surveyed, 86.9% stated it is important to have effective communication skills, and 84.1% noted the importance of collaborative work. On the other hand, the skills that received a ranking of low or moderate importance include negotiation and civic education, with 40.6% and 34.7%, respectively.
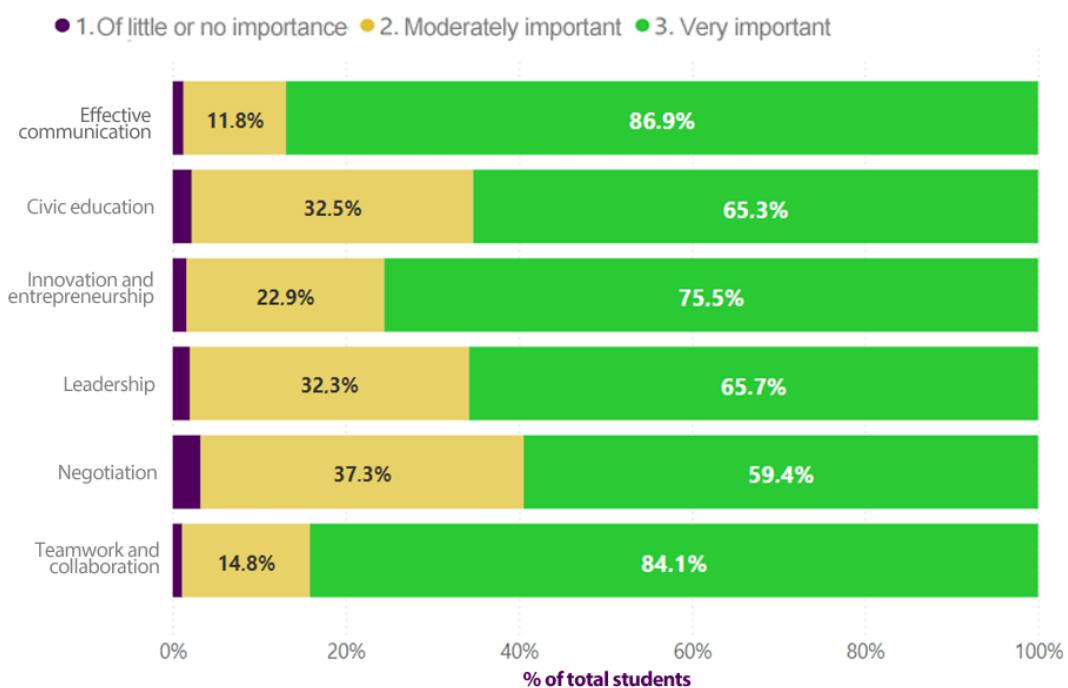

Figure 5. Categorization of importance of skills.

Analyzing performance results (GPA) and the results in Fig. 5, an inverse relationship was identified between the GPA value and the level of importance assigned (see Table 2). For example, the average GPA was high (5.2) regarding leadership, teamwork, and collaboration, whereas students declared the lowest importance to these two skills.

Table 2. GPA averages based on the importance of skills.

Skill relevant to academic/professional development	Of little or no importance	Moderately important	Very important
Effective communication	4.9	4.8	5.0
Civic education	5.0	5.0	5.0
Innovation and entrepreneurship	4.8	5.1	4.9
Leadership	5.2	5.0	4.9
Negotiation	5.1	5.0	4.9
Teamwork and collaboration	5.2	4.7	5.0
Average	**5.0**	**4.9**	**5.0**

Table 3 shows the data for the students who obtained an average GPA of less than 4.0 and greater than or equal to 4.0. Again, the group that reported that Leadership, Teamwork, and collaboration skills were "of little or no importance" had the highest percentage of students with average GPAs greater than or equal to 4.0.

Table 3. Results breakdown < 4.0 and ≥ 4.0 based on the importance of skills.

Skill relevant to academic/professional development	GPA average	Of little or no importance	Moderately important	Very important
Effective communication	GPA < 4.0	18.8%	19.3%	14.5%
Civic education	GPA ≥ 4.0	81.3%	80.7%	85.5%
Innovation and entrepreneurship Leadership	GPA < 4.0	21.4%	14.6%	15.3%
	GPA ≥ 4.0	78.6%	85.4%	84.7%
Negotiation	GPA < 4.0	20%	14.5%	15.3%
	GPA ≥ 4.0	80%	85.5%	84.7%
Effective communication	GPA < 4.0	8%	16.4%	14.8%
Civic education	GPA ≥ 4.0	92%	83.6%	85.2%
Innovation and entrepreneurship Leadership	GPA < 4.0	12.2%	14.8%	15.5%
	GPA ≥ 4.0	87.8%	85.2%	84.5%
Negotiation	GPA < 4.0	7.1%	19.8%	14.4%
	GPA ≥ 4.0	92.9%	80.2%	85.6%

A minor positive association with academic performance was found concerning study techniques. As such, students who used techniques including summarizing or concept mapping scored an average GPA of 5.0, while those who reported not using these techniques scored an average GPA of 4.9.

Inferential analysis
After analyzing the survey results descriptively, tests of association of variables were carried out using the Chi-squared test. The categorical variables revealed a significant association between the cumulative weighted GPA and the person who pays for university studies (p=0.027, with a significance level of 0.05).

In addition, non-parametric tests were utilized because the data has a non-normal distribution. The Mann-Whitney U test was used to identify differences between groups according to the variables described below. The groups were separated according to student GPA and the

educational level of the father and mother, and it was found that in both cases, the null hypothesis was rejected, and the medians were assumed to differ. Students whose fathers (p=.004) and mothers (p=.030) had a university education were found to have improved academic performance. Tests were repeated for the remainder of the variables; however, no statistically significant differences were found.

Discussion
The main objective of this research was to identify and analyze the factors primarily associated with the academic performance of first-year students in the school of engineering at a private Chilean university. According to the literature review presented in the introduction, the importance of students' academic success has motivated several authors to analyze the elements that favor academic performance and, consequently, student retention. Sure of these elements include the use of open educational resources [16], block scheduling [17], interventions in first-year subjects [18], or the self-confidence of students and economic factors [13]. Therefore, the present study analyzed factors associated with characterizing first-year students that could influence academic performance and their retention at the university.

Family history
Similar results to those of Martin et al. [10] were identified. The parental level of education was associated with student academic performance, whereby the higher the parental level of education, the better the student's academic performance. The group of students with the highest academic performance, with an average GPA of 5.1, related to individuals from families from which both parents had previously completed university studies. Soria and Stebleton [19] document similar results, stating that parents' level of education directly influences student performance.

Similarly, it was observed that there is an association between the person who assumes the head of the household role and the student's academic results. Students whose sibling assumes the role of head of the household achieve improved academic performance (average GPA = 5.4) compared to students who assume the role of head of the household (average GPA = 4.8). Additional factors related to the family context, such as the level of contact with relatives and close-knit groups or whether students have children, were not significantly associated with academic performance.

Economic factors
The financial support that a student may or may not receive determines whether he or she persists in his or her degree [11]. With that in mind, results were also obtained concerning the economics of the students surveyed. Regarding additional economic factors, engaging in part-time work that does not exceed eight hours per week is positively associated with academic performance. This particular group of students obtained an average GPA of 5.1. Conversely, working long hours was associated with a decrease in the average student GPA to 4.8 among this group. Parental financial support also positively associates with academic performance, reflected in a 0.2-point increase in average GPA compared to students who self-fund their studies. Indeed, in this regard, Johnson et al. [12] mention that poor academic performance and financial hardship drive students to drop out of university. In light of the results of the present study, it is essential to promote scholarships for students and to generate opportunities that allow them to maintain a good GPA for their career advancement.

Educational background and study habits

The successful experience of prior university studies favors academic performance, as reflected in the average GPA obtained by students from this particular group: 5.8. This contrasts with students who entered university for the first time or who had previously dropped out of more than one degree program, who scored an average GPA of 4.8. Concerning the importance of skill development in academic training, students reported the following priorities: effective communication, teamwork, innovation, and entrepreneurship. Studying among first-year students is predominantly undertaken on an individual basis, in contrast to students in subsequent years, who report a preference for collaborative work. The use of study techniques favors academic results. Indeed, among the sample studied, a minor difference was identified between students who use techniques such as summarizing or concept mapping, who scored an average GPA of 5.0, compared to those who reported not using such techniques, with an average GPA of 4.9.

Conclusions

The main objective of this research was to identify and analyze the factors primarily associated with the academic performance of first-year students in the school of engineering at a private Chilean university. Using an entrance survey to characterize 1,273 students from 11 distinct engineering degree programs, statistical tests were subsequently conducted to determine how the following variables of interest behaved: GPA, academic background, family background, economic and financial background of the student, and study habits. Concerning conclusions, the following reflections can be drawn:

- Specific factors related to academic performance were identified, of which those with a positive association with student GPA results include: some level of university education of the parents, families in which the role of head of the household is assumed, and siblings or parents cover the financing of the degree; working on a part-time basis that does not exceed eight hours per week; the experience of prior university studies; and, to a lesser extent, study habits.
- The group of students with the lowest GPA scores relates to people in which the family nucleus is composed of parents with incomplete schooling, and the head-of-the-family role is assumed by the student themselves or by a person who forms part of the immediate circle, all of which makes them more susceptible to drop out of university at some point.
- Skills important in professional development, such as teamwork and collaboration or innovation and entrepreneurship, had no association with the present study sample. In contrast, the students with the best academic performance reported these skills as having little or no importance. Nevertheless, it is critical to promote the development of these skills among students since to reiterate what was stated in the introduction; these skills help to enhance student performance and, consequently, their retention in the degree program. We hypothesize that the students completed a large part of their high school studies in virtual mode due to the Covid-19 pandemic, so they became more individualized and independent.

Based on a correlational exploration of the study variables, an association was identified between cumulative weighted GPA and the person who pays for the university studies, in

addition to significant differences between the academic performance of students and the level of education of the parents.

Limitations and future work

This study has certain contextual limitations since results are confined to a private university in Chile, thus limiting the possibility of generalizing the results obtained. In addition, future work must follow up on the sample of students who responded to this survey to monitor their academic performance progress. Finally, it is crucial to incorporate a qualitative approach to identify students who consider individual work better than collaborative work to know why they perceive this factor.

Acknowledgements

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