Effects of pre-college variables and first-year engineering students' experiences on academic achievement and retention: a structural model.

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Abstract

Path analysis was used to evaluate a structural theoretical model of the relations among different pre-university variables, social and academic experiences during the first year of university, and academic success, evaluated through first-year university achievement and permanence in the sophomore year or student retention. The participants in the study were 243 first-year university students in the 2010–2011 academic year, enrolled in different engineering degrees at a public university in southeastern Europe. The estimated final model shows satisfactory fit levels, offering an adequate representation of the study variables and explaining 38% of the variance in Institutional Commitment, 35% of First-year academic achievement, and 16% of student retention. First year academic achievement and institutional commitment are the best predictors of student retention, showing quite similar effects. Pre-university preparation shows direct effects on academic results and indirect effects on permanence. Preference for studies, academic integration and academic conscientiousness show direct effects on first-year academic achievement. Academic and social integration, support services satisfaction, and degree commitment show effects on institutional commitment. The results are discussed taking into account the theoretical models and previous research, and implications are presented for designing actions and programs to help first-year students make a successful transition to university studies, fulfil their educational and personal goals, and improve their academic success.

Keywords: Engineering studies, Precollege variables, First-year students experience, Student retention, Academic achievement

Introduction

Academic success in the university has been a key topic in educational research in recent decades, due to the large number of students who do not graduate or who take much longer to graduate than predicted (Alarcon & Edwards, 2013; García-Ros, Cavas-Martínez, Pérez-González & Tomás, 2017; Mills, Heyworth, Rosenwas, Carr, Rossenberg, 2009; Richardson, Abraham & Bond, 2012). A significant part of the research has focused on the freshman year at university -because this is not only when the drop-out rate is highest, but also when most students transfer from one degree to another (Araque, Roldán & Salguero, 2009; Villar-Aguilés, García-Ros & Hernàndez-Dobon, 2017)- and on the degrees with the highest drop-out rates, commonly identified by the acronym STEM -Science, Technology, Engineering and Mathematics- (Araque, Roldán & Salguero, 2009; Litzer & Young, 2012).

Recent meta-analytic studies show the predictive capacity of different socio-demographic and pre-university educational variables (e.g., socioeconomic status, previous academic results), a broad set of student characteristics (e.g., learning skills, self-efficacy), and social and academic experiences at the university (interactions with faculty and peers), on academic achievement and permanence in the university (Harvey, Lotkowski, Robbins, & Noeth, 2004; Harvey, Drew and Smith, 2008; Robbins et al., 2004; Schneider & Preckel, 2017; Zanden, Danessen, Cillessen, & Meijer, 2018). Recent studies also emphasize the importance of non-institutional contextual dimensions –e.g., family responsibilities or economic problems- (Zepke, Leach & Butler, 2011) and many in-class and out-of-class university environmental variables (Tinto, 2012). Thus, because academic success is a complex and multidimensional phenomenon (Crissman & Upcraft, 2005), there is a need to determine the relationships and interactions among these sets of variables in order to better understand this phenomenon and ease the transition to university, increase students' academic engagement, and foster their academic success (Tinto, 2012). Furthermore, because more than half of the cases of attrition and many degree program migrations occur in the first year of university, it is especially important to analyze the determinants of the academic results in this key period, as well as permanence in the studies between the freshman and sophomore years, also called student retention (Kitsantas, Winsler & Huie, 2008; Nelson & Clark, 2014). This study adopts this perspective, making use of path analysis methodology to analyze the structural inter-relationships among different pre-university sociodemographic and educational variables –gender, age, preference for studies, first-generation students, and college entrance grade-, the students' experiential dimensions during their freshman year at university –academic and social integration, degree and institutional commitment, support service satisfaction and conscientiousness-, academic achievement in freshman university year (FY-GPA), and persistence (PER) in engineering studies between the freshman and sophomore years. The aim is to further our understanding of these constructs and design more efficient measures to foster permanence in the university (Ackerman, Kanfer & Beier, 2013; García-Ros & Pérez-González, 2011).

The situation of Engineering studies

The situation of engineering studies warrants special attention, given the high attrition levels compared to the other university degrees. In the North American context, almost half of the subjects who begin these studies do not reach graduation (Litzer & Young, 2012), and 23% of full-time students do not re-enroll in the second year. In addition, notable differences have been found in attrition rates across institutions, ranging from 30-60%. In the European context, the situation is similar, with attrition in engineering also higher than in other subject areas in Spain, as it is around 30-40% and concentrated in the first year (Araque et al., 2009; Hernández & Pérez, 2016; Villar-Aguilés et al., 2017). In a review study, Willis (2008) points out that these degrees present specific characteristics that provoke higher attrition rates than in other areas, highlighting their level of difficulty and the students' inappropriate academic expectations about their studies.

Coinciding with the general conclusions in the research, in engineering studies a relationship has also been observed between a wide range of students' pre-university and sociopersonal variables and their experiences in their first-year studies (Araque et al., 2009; Hall et al., 2015). More specifically, some predictors usually highlighted as the most relevant are: (a) pre-university preparation; (b) socialization experiences with engineering in earlier stages of the educational system; (c) interest in engineering and other scientific fields; (d) self-efficacy in mathematics, sciences and computer science; (e) learning and study strategies; (f) economic problems; (g) the level of family support; (h) interactions with classmates and professors; and (i) the initial level of institutional and degree commitment (French, Immekus & Oakes, 2005). Veenstra, Dey and Herrin (2009) also suggest considering the First-Year Grade Point Average –FY-GPA-, given its close relationship with students' retention.

In the same way, coinciding with research results for other degrees (Astin, 1993; Bean, 1985; Davidson, Beck & Grisaffe, 2015; Davidson, Beck & Milligan, 2009; Tinto, 1993, 2012), university students' experiences, perceptions and attitudes mediate the effects of personal and pre-university variables on academic success in the STEM degrees (Burtner, 2005; French et al., 2005). Some of the most important first-year engineering degree experiences –FYEE- showing a direct relationship with academic success are: the students' social and academic integration, their initial commitment to obtaining the degree, and, especially, their level of institutional commitment or identification, feeling of belonging, and satisfaction with the university and their studies (García-Ros, Cavas-Martínez & Pérez-González, 2015; García-Ros et al., 2017; Litzer & Young, 2012).

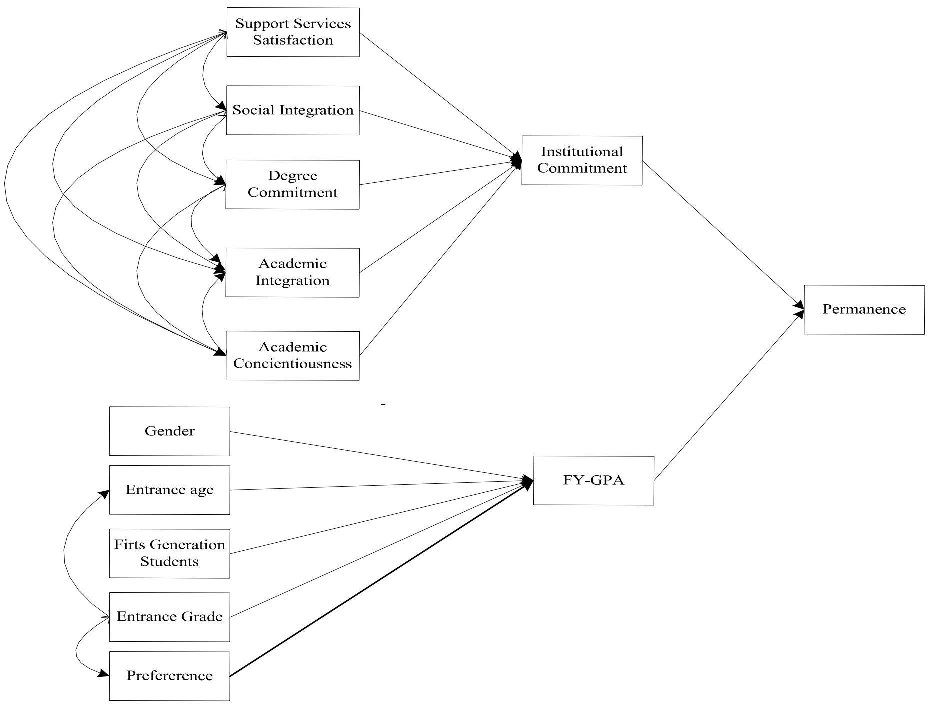
Considering the importance of combining/integrating different types of variables to predict academic success at the university (Robbins et al., 2004; Zanden et al, 2018), the few studies that analyze the complexity of these relationships through causal models while considering different indicators of academic success (FY-GPA and PER in the sophomore year) and the specific problems of engineering degrees (e.g., Litzer & Young, 2012), the present study uses a path analysis methodology to evaluate a structural theoretical causal model of academic success in engineering studies. This model integrates different pre-university variables whose relevance has been shown in previous research, the students' FYEE and FY-GPA, and PER in the sophomore year. The basic hypotheses of the initial model proposed (see Figure 1 for a graphical representation or the relationships modeled), considering the conclusions of the previous research, are the following:

(1) Pre-university variables considered (Gender, Entrance age, First-Generation students, Entrance grade, and Preference for studies) will show significant direct effects on the FY-GPA. The Entrance grade will show the greatest effects, as well as indirect effects on permanence through the FY-GPA.

(2) FYEE dimensions of Academic and Social integration, Academic conscientiousness, Satisfaction with support services, and Degree commitment will show direct effects on Institutional commitment (Beck & Milligan, 2014).

(3) Both Institutional commitment and FY-GPA will show direct effects on permanence in the sophomore year (Veenstra et al., 2009).

Figure 1. Initial hypothesized Model



Methods

Participants

The participants in the study were 243 first-year engineering students (52.8% of the first-year engineering student population) from the Superior Technical Engineering School at the School of Engineering of a public university in southeastern Spain in the 2010-2011 school year (Electrical Engineering, 11.2%; Industrial and Automated Electronic Engineering, 22.4%; Mechanical Engineering, 35.5%; Industrial Chemical Engineering, 6.6%; Industrial Technologies Engineering, 24.3%). The mean Entrance age is 18.53 years old (*SD* = 1.3, range 17-25 year), the mean Entrance grade is 6.94 (*SD* = 1.16; range 5.00-9.70), and engineering is their preferred choice (1st = 46.8%; 2nd = 21.3%; 3rd or later = 31.9%; range 1 - 5). In addition, 14.4% are women, 82.1% are full-time students, and 58.9% are first-generation students. The sample is representative of the referenced first-year-student population in terms of the following variables:

gender, preference for the degree, educational level of the family, and entry requirements. In carrying out the study, four participants were excluded because they had numerous missing data. Eventually, 84.5% of the students continued their studies in the same degree in their sophomore year (2011-2012 academic year), whereas the remaining 11.5% had dropped out.

The Spanish Higher Education system is basically public, attending to over 83% of university students (Hernández & Pérez, 2016, p.14). According to the European Higher Education Area, Spanish university studies in the area of Engineering have a three-level structure: Engineering degrees (equivalent to Bachelor's degrees), Masters, and Doctorates. Engineering degrees, with 240 ECTS (European Credits Transfer System), are structured over four academic years. Their study programs include general and specialized competences in each engineering field, combining practical training, external activities, and mobility (García-Ros et al., 2017). According to the Spanish regulations, the Engineering degrees grant direct access to the Master's degrees, the profession, and the Engineering Councils (Domínguez & Magdaleno, 2012).

Data published by the Spanish Ministry of Education show that the students' dropout rate from Engineering degrees (access cohort 2010-11) in Spanish public universities was 24.54% (Hernández & Pérez, 2016, p. 87), including both student dropout and migration between degrees. Data from the university participating in the study are quite similar to those reported at the national level.

Measures

The pre-university explanatory variables considered in the study are: *Gender* (0 = Man, 1 = Woman), *Entrance age* or age when beginning the studies, *First Generation students,* which indicates that neither parent has a university degree (0 = No; 1 = Yes), *Preference* or order of choice when enrolling in the major (0 = First choice; 1 = Second or more), and *Entrance grade* corresponding to the grade for accessing these studies.

FYEE were assessed by the Spanish language adaptation of the *College Persistence Questionnaire* –CPQ- (Davidson et al., 2009, 2015; García-Ros et al., 2015, 2016, 2017), developed by considering the most relevant theoretical models on permanence at university (e.g., Astin, 1993; Tinto, 1993). Studies analyzing their psychometric properties have found satisfactory reliability and structural validity, predictive validity of retention, and incremental validity, in terms of High School GPA and SAT-ACT scores, in the prediction of permanence (Davidson et al., 2009). The Spanish CPQ's adaptation and validation, which was developed using back-translation methods (Balluerka, Gorostiaga, Alonso-Arbiol, & Haranburu, 2007), also showed satisfactory structural and predictive validity of first-year students' retention (García-Ros et al., 2016, 2017). The CPQ evaluates six FYEE dimensions related to student retention:

Academic Integration. Degree of adjustment and satisfaction with the curriculum and with the instructional methodology. It consists of seven items (e.g., "I am satisfied with the quality of instruction in my major"), and its internal consistency is .79

Social Integration. Extent to which the students perceive similarities with their classmates and say they are satisfied with the relationships with their professors and peers. It consists of 7 items (e.g., "I have established important ties with my professors and classmates"). Its internal consistency is.86.

Supportive Services Satisfaction. Satisfaction with the amount and quality of the services designed to meet the students' academic and personal needs. It is composed of

6 items (e.g., “My school has adequate services for resolving problems and doubts related to my education”), and its internal consistency is .81

Institutional Commitment. Extent to which the student identifies with his/her school and university. It consists of 4 items (e.g., “I think this university is the right one for me”), and its internal consistency is .71

Degree Commitment. Value the student gives to obtaining the degree. It consists of 5 items (e.g., “I am sure that I will persist in the major until obtaining my degree, whether in this university or another one”). Its internal consistency is .76.

Academic Conscientiousness (lack of). Degree of fulfillment of and interest in the academic activities. It is composed of 3 items (e.g., “I am uninterested in academic work and do as little as possible”). Its internal consistency is .63.

The variables related to academic success are the *First-Year Grade Point Average (FY-GPA),* defined as the average of the grades in the first year at the university, and *Permanence (PER),* defined as student retention or re-enrollment in the same degree in the sophomore year (0 = No; 1 = Yes).

Procedure

The instruments were applied in the second semester of the 2010-11 academic year, during the school day and in the engineering classrooms. The students were informed of the study objectives, and their participation was voluntary. They filled out the CPQ and a questionnaire elaborated ad-hoc to obtain their sociodemographic characteristics. The data related to previous academic results, FY-GPA and Permanence in the sophomore year were provided by the administrative services of the university after the 2011-2012 academic year had begun.

Analysis

First, through the SPSS 23.0, a bivariate correlational analysis was performed to explore the relationships among the study variables, considering the relevant statistics depending on their nature. Next, to evaluate the hypothesized model, path analyses were conducted, with the Maximum Likelihood Robust estimation method via Mplus 8 (Muthén and Muthén, 1998-2014). Missing data were dealt with using Full Information Maximum Likelihood (FIML), adequate for both Missing Completely At Random (MCAR) and Missing At Random (MAR) data, and the most recommended method for structural models (Finney & DiStefano, 2013). Robust estimation was used due to the lack of normality in the quantitative indicators (see Table 1) and the binary nature of one of the outcome variables. The plausibility of the proposed model was assessed using several fit criteria: the corrected χ^2 statistic, the comparative fit index (CFI), the Square Root Mean Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA). Following Hu and Bentler's (1999) guidelines, a CFI equal to or above .95 along with SRMR below .08 and RMSEA below .05 are considered indicative of excellent fit to the data. It is considered an excellent fit when the CFI and TLI-NNFI values are above.95, and the RMSEA is below .05.

Results

Table 1 presents means, standard deviations, and the Shapiro-Wilk test for normality of the quantitative variables in the model, and percentages per category for the qualitative variables.

Table 1. Descriptive statistics and normality test for the variables in the model (Notes: SD= Standard Deviation; Min= Minimum; Max= Maximum; As= Assymetry; Ku= Kurtosis; SW-test= Shapiro and Wilks test).

Variable	Mean	SD	Min	Max	As	Ku	Missing	SW-test	p
Gender	1=85.5%	2=14.5%					0%		
Entrance age	18.53	1.29	17	45	3.4	11.9	1.48%	.540	<.01
First-generation student	0=41%	1=59%					0.4%		
Entrance grade	6.94	1.14	5	9.70	.35	-.57	0.4%	.976	<.01
Preference	1=41%	2=59%					0.4%		
Support services satisfaction	20.93	4.15	1.20	5	-.29	.10	0%	.986	<.05
Social integration	28.60	5.86	1.00	5	-.68	.53	0%	.970	<.01
Degree commitment	13.84	1.81	1	5	-.31	-.03	0%	.681	<.01
Academic integration	23.93	3.78	1.15	5	-.30	-.10	0%	.981	<.01
Academic conscientiousness	5.89	2.28	1	4.33	.71	.23	0%	.929	<.01
Institutional commitment	15.95	3.40	1	5	-.98	2.61	0%	.913	<.01
FY-GPA	3.97	2.39	0.50	9.45	.11	-1.01	0.4%	.965	<.01
Permanence	0=11.5%	1=88.5%					0%		

Table 2 presents the correlations among the study variables. The significant relationships among the pre-university variables are scarce and show low values. FYEE dimensions show significant relationships with each other in all cases and in the expected direction, with the range of values being between low and medium. The relationship between the pre-university variables and the experiential variables is significant for *Gender-Social Integration*. *FY-GPA* and *PER* show significant relationships with each other and with a large number of previous variables and FYEE in the expected direction: *FY-GPA* shows significant relationships with almost all of the previous variables and with four of the FYEE dimensions, although values were low for all of them (except the *Entrance grade*); *PER* is significantly related to previous variable *Preference,* and to five FYEE dimensions, also with low to medium-low values.

Table 2. Levels of association between the study variables (* $p < .05$, ** $p < .01$, *** $p < .001$).

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender	1.00												
2. Entrance Age	-.09	1.00											
3. Preference	.07	.05	1.00										
4. First Generation	-.05	.18**	-.07	1.00									
5. Entrance grade	.01	-.13*	-.15*	.24***	1.00								
6. Academic integration	.01	.04	-.05	.08	.10	1.00							
7. Social integration	.20**	-.02	-.06	.08	.10	.36***	1.00						
8. Satisfaction Services	.02	-.02	-.07	.06	.02	.52***	.45***	1.00					
9. Degree Commitment	.10	-.09	-.13	.08	.04	.37***	.28***	.32***	1.00				
10. Institutional Commitment	.07	-.03	-.10	.05	.09	.44***	.41***	.45***	.43***	1.00			
11. Academic Consc. (lack of)	-.06	-.01	.11	-.13	-.14*	-.31***	-.17**	-.28***	-.29***	-.30***	1.00		
12. FY-GPA	.01	-.13*	-.20**	.16*	.53***	.24***	.12	.13	.15*	.14*	-.26***	1.00	
13. Permanence	.01	-.04	-.16*	.12	.08	.18**	.18**	.11	.18**	.32***	-.14*	.33***	1.00

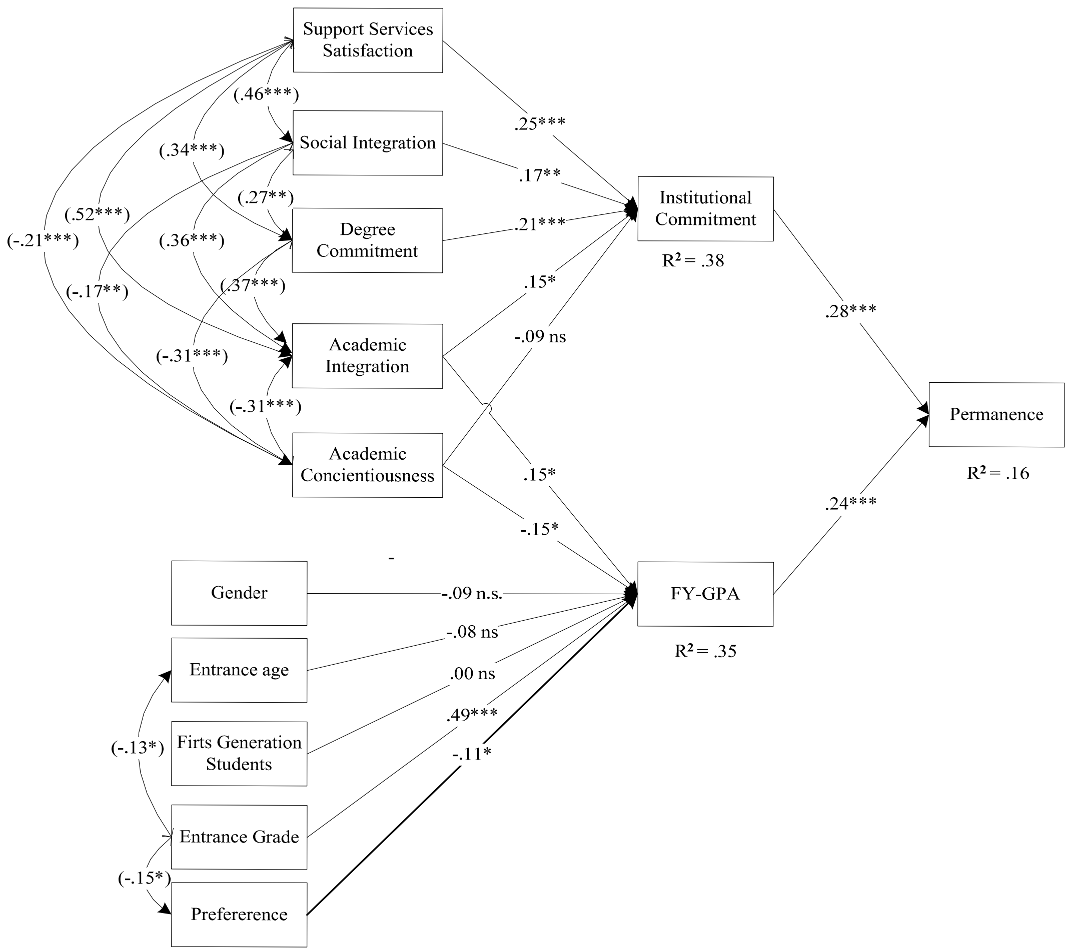
A first completely a priori path model (see Figure 1), or initial model, was estimated, and the model-data fit was adequate, but not excellent -χ^2 (46) = 67.39, p < .001, CFI = .901, RMSEA = .046, 90% CI (.018 - .068), SRMR= .068-. Modification indices showed that two of the dimensions in the CPQ, Academic Integration and Academic Conscientiousness, were strongly related to FY-GPA. This means that, apart from the previously considered predictors of FY-GPA, Academic Integration and Academic Conscientiousness were potential predictors of performance. No other modification indices were statistically relevant. Therefore, these two relations were added, and a second modified model was estimated. This model fitted the data extremely well: χ^2 (44) = 49.84, p < .001, CFI = .973, RMSEA = .024, 90% CI (.000 - .053), SRMR= .052.

Figure 2 shows the final standardized estimates in the evaluation of the model, as well as the R-squares for each outcome variable. The percentage of variance accounted for in Institutional Commitment was 38%. The R-square for FY-GPA was .35 (35%). Finally, the percentage of variance in Permanence accounted for by the predictors was 16%. These results show that most of the hypothesized effects are significant, with the exception of *Gender, Entrance Age, and First Generation* on *FY-GPA*, and *Academic Conscientiousness* on *Institutional Commitment*, as Figure 2 shows. Thus, even though the existence of a significant bivariate relationship between these variables has been shown in Table 2, the hypothesized effects do not reach statistical significance on the path, based on their relationship with other predictors considered in the model.

More specifically, the results show direct effects on *Institutional Commitment* of *Satisfaction with Services* (β = .25, p < .001), *Degree commitment* (β = .21, p < .001), *Social Integration* (β = .17, p < .01) and *Academic Integration* (β = .15, p < .05), but not

Academic Conscientiousness ($\beta = -.09$, p > .05). Direct effects are also found on *FY-GPA* of *Entrance grade* ($\beta = .49$, $p < .001$), *Academic Integration* ($\beta = .15$, $p < .01$) and lack of *Academic Conscientiousness* ($\beta = -.15$, $p < .01$). In addition, both *FY-GPA* ($\beta = .24$, $p < .001$) and *Institutional Commitment* ($\beta = .28$, $p < .001$) show similar direct effects on *PER*. Given that PER is a binary (0/1) variable, effects can also be given as odds ratios: the Odds-ratio for Institutional Commitment was 1.277, whereas the odds-ratio for FY-GPA was 1.736. Finally, *Entrance Grade* ($\beta = .13$, $p < .05$) shows significant indirect effects on *PER* through *FY-GPA* (*Entrance Grade* → *FY-GPA* → *PER*).

Figure 2. Estimated final model, standardized path coefficients and their level of significance (ns = non significant, * $p < .05$, ** $p < .01$, *** $p < .001$)



Conclusions

The results confirm the fit of the proposed model for predicting academic success in the first year of engineering studies, evaluated through the *FY-GPA* and *PER*, showing that Institutional Commitment and *FY-GPA* present quite similar direct effects on *PER*. Therefore, they show the suitability of the relationships and effects proposed for the hypothesized variables in the model, as well as the importance of both the pre-university variables and the FYEE (especially the Entrance Grade) in predicting academic success in engineering studies. From this perspective, the results confirm that academic success is a complex phenomenon that involves a large and diverse set of variables (Meyers, Silliman, Gedde & Ohland, 2010) related to students' characteristics, pre-university educational variables, and FYEE (Richardson, Abraham & Bond, 2012; Robbins et al., 2004).

Thus, the initial model proposed offered a plausible representation of the data, showing (a) the special relevance of both FY-GPA and Institutional commitment in predicting sophomore year performance, (b) the significant effects of the Entrance grade and the Preference for the degree on the FYGPA, (c) the effects of the FYEE on Institutional Commitment. Additionally, the analyses highlight two other significant effects not considered in the initial model -Academic Integration and Conscientiousness on FY-GPA- which increase the capacity to explain academic success in first-year engineering studies.

More specifically, the estimated final model explains 35% of the FY-GPA variance, showing that the most important effect on this variable corresponds to previous preparation (Lotkowski et al., 2004; Richardson et al., 2012), evaluated through the Entrance Grade. Additionally, the experiential dimensions of Academic Conscientiousness and Academic Integration also show direct effects on FY-GPA given their relationship with the cognitive and behavioral dimensions of academic learning. However, the hypothesized effects of the other variables on FY-GPA are not significant (Gender, Entrance Age, and First generation students). Regarding this issue, it should be pointed out that there are significant levels of association between most of these variables and FY-GPA, although significant effects are not seen when considering the model as a whole. Moreover, as predicted initially based on recent research, Gender does not present a significant relationship with FY-GPA or PER (Eris et al., 2010; Litzer & Young, 2012; Ohland et al., 2011). Finally, the pre-university variables do not show significant effects on the FYEE either, as shown in recent studies (Beck & Milligan, 2014).

The high magnitude of the effect size of prior knowledge, assessed by the University Entrance grade, on FY-GPA -and its indirect effect on PER- coincides with the conclusions of previous research (Harvey et al. 2004, 2008; Schneider & Preckel, 2017), and there are many explanations for these results: (a) Prior knowledge supports the acquisition of new knowledge; (b) prior achievement and knowledge result from prior effort and investment, which have some stability over time; (c) past academic success is a reward that reinforces further engagement in learning; and (d) prior achievement and subsequent achievement are also related because they are both affected by intelligence as a relatively stable personal characteristic (Zanden et al., 2018). This question has noteworthy implications in applied terms, at both institutional and instructional levels, prior to entering the university and once the students are already enrolled.

First, the study indicates that it is important for universities to strengthen the programs and actions they carry out in early stages of the educational system to attract students with a higher level of competence and interest in the engineering area. They should: (a) identify students with higher skills, performance and self-efficacy in mathematics and technology; (b) increase the relationship with the High School technology teaching staff and carry out educational experiences to socialize students in this stage in engineering; and, (c) if possible, link these actions to the students' motivations and interest in the topics of electronics, robotics and programming (Fantz, Siller & De Miranda, 2011). Second, once students have accessed the University, the study also highlights the importance of identifying, in the early stages of the first year of engineering, students who enter with a low level of competencies, in order to fill the knowledge gaps they may present. In addition, given their close relationship with the FY-GPA, the results of the study also suggest some potentially effective strategies, such as: (a) goal-setting interventions to encourage students to set proximal goals – including grade goals- in addition to their distal outcome goals; (b) interventions on setting goals related to FY-GPA, such as help seeking from teachers and peers, avoiding procrastination, reducing test-anxiety, increasing effort regulation in the form of plans to persist when task are difficult, improving students' learning and study strategies or establishing study routines; (c) self-efficacy engagement interventions, which may be especially important because self-efficacy beliefs are partially mediated by measures of grade goals, and they are considered modifiable (Richardson et al., 2012). Third, teachers' behaviors are especially important (Tinto, 2012; Zanden et al., 2018) because previous research reveals the importance of considering teaching methodologies and designing classroom environments that help students to develop effective learning and problem-solving strategies and support student engagement, including classroom goal structures (mastery-oriented classrooms), learning tasks (e.g., authentic, challenging, open tasks, meaningfulness and relevance of activities), teachers' instructional strategies and practices (e.g., using collaborative learning techniques, instructional and motivational scaffolding, effective feedback), and interpersonal relationships in the classroom (e.g., teacher and student/peer support, mutual respect, support for autonomy, competence, and collaboration) (García-Ros et al., 2017; Perry, Turner & Meyer, 2011). Finally, it is important to remember at this point that previous research showed that the institutions with the highest persistence rates focus their educational practices on encouraging the development of high-level cognitive skills (e.g., structuring the material on the basis of activities related to problem analysis), developing competences and practical skills (e.g., emphasizing solving complex real-life problems while working effectively with others), and encouraging the students' personal and social responsibility (Pascarella, Seifert & Whitt, 2008).

The results also highlight the relevance of FYEE in predicting both FY-GPA and PER (Robbins et al., 2004; Alarcon et al., 2013), showing that Institutional Commitment is an important determinant of permanence in engineering studies. Thus, these results emphasize that: (a) universities must foster students' sense of belonging and identification with their degree and university; (b) students' academic and social experiences at university have a much greater influence on institutional commitment than sociodemographic variables and pre-university education; (c) academic integration has positive effects on both FY-GPA and Institutional Commitment; and (d) there may be different student profiles that can explain the lack of institutional commitment, making it possible to adjust interventions to the students' specific needs (Beck & Milligan, 2014; Davidson et al., 2015). For example, students' lack of institutional commitment may be explained by their negative evaluation of the curriculum or teaching quality in their degree (Academic Integration), their perception of the limited reach or inappropriateness of the support services provided by the university (Satisfaction with support services), the low value they give to obtaining the degree

(Degree commitment), or any combination of these factors. This information can be especially useful for designing action proposals to meet different students' specific needs, while providing academic and institutional decision-makers with valuable information about the strengths and weaknesses of services and programs directed toward fostering students' academic involvement and success.

On this point, it should be highlighted that the FYEE dimensions Academic Integration and Student Conscientiousness showed significant direct effects on FY-GPA –although with a small effect size- that were not noted in the initial structural model and have been incorporated in the final model based on the results obtained. Along these lines, similar effects were found in recent meta-analytic studies (e.g., Scheneider & Preckel, 2017; Zanden et al., 2018), consistent with the definition of both constructs presented in the introduction of this study and with the indicators considered in their evaluation: Academic Integration (e.g., interest in class sessions, satisfaction with the relevance and quality of instruction, interest and usefulness of instructor feedback); and Academic conscientiousness: (e.g., interest in academic work, tardiness in submitting assignments, unexcused absences from classes, forgeting important academic responsibilities).

Moreover, the results reveal that 16% of the variance in PER is explained by FY-GPA and Institutional Commitment, both showing similar effects on PER. These results are congruent with previous studies that indicate the important effect of the FY-GPA (Veenstra et al., 2009) and Institutional Commitment (French et al., 2005) on students' retention in engineering studies. They also show that some engineering students may decide to abandon their studies due to insufficient academic performance, or because they perceive their first-year academic and social experiences to be inadequate, or due to a combination of the two. Overall, these results confirm the importance of university services and programs designed to promote and offer support when students demonstrate academic, personal and social difficulties –e.g., orientation programs, mentoring programs, supplementary instruction, first-year seminars, programs for minority groups with specific needs- (Meyers et al., 2010; Regehr, Glancy, & Pitts, 2013). As mentioned above, these results also emphasize the importance of teaching methodology in university studies, where previous research highlights that institutions with higher retention rates focus their educational practices on encouraging high-level cognitive skills, developing practical skills and abilities and fomenting students' personal and social responsibility (Laird, Cnebn & Khu, 2008). In sum, the results of the study show that it is important for university intervention programs and actions to focus on the variables with the greatest predictive power of academic success in engineering degrees, considering both the different student support services and the important role of the professors in improving academic involvement and success in their subjects, as well as the need to evaluate and monitor their effects in order to increase their efficacy (Pascarella, Seifert & Whitt, 2008).

Finally, these results should be generalized with caution, given that the explanatory variables of academic success can vary from one university to another (Tinto, 2012), and the sample comes from only one University. In addition, other personal or environmental variables must be considered that can also influence the structural relationships and effects found in this study -e.g., socioeconomic status, family support- (Cabrera, Nora & Castañeda, 1993) or significantly increase the explanatory capacity of the proposed model. It is also necessary to carry out longitudinal studies over longer periods of time and considering various institutions and university entrance cohorts. In any case, given the personal, educational, economic and social repercussions involved, these questions highlight the importance of continuing to focus research efforts on FYE in order to design more effective intervention strategies, actions and programs to promote students' academic involvement, respond to their broad range of needs, and improve their academic success.

References

Alarcon, G. M., & Edwards, J. M. (2013). Ability and motivation: Assessing individual factors that contribute to university retention. *Journal of Educational Psychology*, *105*, 129-137.

Araque, F., Roldán, C., & Salguero, A. (2009). Factors influencing university drop out rates. *Computers & Education*, *53*(3), 563-574.

Astin, A. W. (1993). *What matters in college? Four critical years revisited.* San Francisco: Jossey-Bass.

Balluerka, N., Gorostiaga, A., Alonso-Arbiol, I., & Haranburu, M. (2007). La adaptación de instrumentos de medida de unas culturas a otras: Una perspectiva práctica [Adaptation of measurement instruments from cultures to other cultures]. *Psicothema, 19*, 124-133.

Bean, J. P. (1985). Interactions effects based on class level in an explanatory model of college student dropout syndrome. *American Educational Research Journal, 22,* 35-64.

Beck, H.P., & Milligan, M. (2014). Factors influencing the institutional commitment of online students. *Internet & Higher Education,* 20, 51-56.

Burtner, J. (2005). The Use of Discriminant Analysis to Investigate the Influence of Non-Cognitive Factors on Engineering School Persistence. *Journal of Engineering Education*, *94*, 335-338.

Cabrera, A. F., Nora, A., & Castaneda, M. B. (1993). College persistence: Structural equations modeling test of an integrated model of student retention. *Journal of Higher Education*, 123-139.

Cabrera, L., Bethercourt, J. T., Álvarez, P., y González, M. (2006). El problema del abandono de los estudios universitarios. *Revista Electrónica de Investigación y Evaluación Educativa RELIEVE, 12* (2) http://www.uv.es/RELIEVE/v12n2/RELIEVEv12n2_1.htm.

Davidson, W.B., Beck, H.P., & Grisaffe, D.B. (2015). Increasing the institutional commitment of college students: enhanced measurement and test of a nomological model. *Journal of College Student Retention, 17,* 162-185

Domínguez, U., & Magdaleno, J. (2012, october). The European Higher Education Area. Spanish Engineering Education. Paper presented at the 40th SEFI annual conference hosted by the European Society for Engineering Education, Thessaloniki, Greece. On line, retrieved November 27, 2016, from http://www.sefi.be/conference-2012/Papers/Papers/121.pdf

Eris, O., Chachra, D., Chen, H. L., Sheppard, S., Ludlow, L., Rosca, C., ... & Toye, G. (2010). Outcomes of a longitudinal administration of the persistence in engineering survey. *Journal of Engineering Education*, *99*, 371-395.

Fantz, T. D., Siller, T. J., & DeMiranda, M. A. (2011). Pre-Collegiate Factors Influencing the Self-Efficacy of Engineering Students. *Journal of Engineering Education*, *100*(3), 604-623.

Finney, S. J., & DiStefano, C. (2013). Nonnormal and categorical data in structural equation modeling. In G.R. Hancock & R.O. Mueller (Eds.), *A second course in structural equation modeling* (2nd ed., pp. 439-492). Charlotte, NC: Information Age.

French, B. F., Immekus, J. C., & Oakes, W. C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education*, *94*, 419-425.

García-Ros, R., Cavas-Martínez, F., & Pérez-González, F. (2015). *Analizando las dimensiones psicosociales implicadas en el éxito académico en los grados de ingeniería.* International Conference on Innovation, Documentation and Teaching Technologies, Innodoct, Valencia (España).

García-Ros, R., Fuentes, M.C, y Pérez-González-F. (2016, june). *Spanish validation of the College Persistence Questionnaire.* Paper presented at the VIII International Congress of Psychology and Education, Alicante, Spain. Abstract retrieved from http://www.cipe2016.com/LibroResumenes_CIPE.pdf

García-Ros, R., Pérez-González, F., Cavas-Martínez, F., & Tomás, J. M. (2017). Social interaction learning strategies, motivation, first-year students' experiences and permanence in university studies. *Educational Psychology*, *38*(4), 451-469

Hall, C. W., Kauffmann, P. J., Wuensch, K. L., Swart, W. E., DeUrquidi, K. A., Griffin, O. H., & Duncan, C. S. (2015). Aptitude and Personality Traits in Retention of Engineering Students. *Journal of Engineering Education*, *104*(2), 167-188.

Harvey, L., Drew, S., & Smith, M. (2006). *The first-year experience: a review of literature for the Higher Education Academy.* York: The Higher Education Academy

Hernández, J., & Pérez, J. A. (2016). *La Universidad Española en cifras 2014-2015.* CRUE: Madrid. On line, retrieved June 11, 2018, from http://www.crue.org/Documentos%20compartidos/Publicaciones/Universidad%20Espa%C3%B1ola%20en%20cifras/UEC_14-15.pdf

Hu, L. T., & Bentler, P. M. (1999). *Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives.* Structural Equation Modeling, 6, 1–55.

Kitsantas, A., Winsler, A., & Huie, F. (2008). Self-regulation and ability predictors of academic success during college: A predictive validity study. *Journal of Advanced Academics, 20,* 42-68.

Laird, T. F. N., Chen, D., & Kuh, G. D. (2008). Classroom practices at institutions with higher-than-expected persistence rates: What student engagement data tell us. *New Directions for Teaching and Learning*, *2008*(115), 85-99.

Litzler, E., & Young, J. (2012). Understanding the risk of attrition in undergraduate engineering: Results from the project to assess climate in engineering. *Journal of Engineering Education*, *101*, 319-345.

Lotkowski, V. A., Robbins, S. B., & Noeth, R. J. (2004). The Role of Academic and Non-Academic Factors in Improving College Retention. ACT Policy Report. *American College Testing ACT Inc*.

Meyers, K. L., Silliman, S. E., Gedde, N. L., & Ohland, M. W. (2010). A Comparison of Engineering Students' Reflections on Their First-Year Experiences. *Journal of Engineering Education*, *99*, 169-178.

Mills, C., Heyworth, J., Rosenwax, L., Carr, S., & Rosenberg, M. (2009). Factors associated with the academic success of first year health science students. *Advances in Health Sciences Education*, *14*(2), 205-217.

Muthén, L. K.., & Muthén, B. O. (1998-2014). *Mplus user's guide.* Los Angeles, CA: Muthén & Muthén.

Nelson, K., & Clarke, J. (2014). The first year experience: Looking back to inform the future. *HERDSA Review of Higher Education*, *1*, 23-46.

Ohland, M.W., Brabner, C.E., Camacho, M.M., Layton, R.A., Long, R.A., Lord, S.M., & Wasburn, R.H. (2011). Race, gender, and measures of success in engineering education. *Journal of Engineering Education, 100,* 225-252.

Pascarella, E. T., Seifert, T. A., & Whitt, E. J. (2008). Effective instruction and college student persistence: Some new evidence. *New Directions for Teaching and Learning*, 115, 55-70.

Regehr, C., Glancy, D., & Pitts, A. (2013). Interventions to reduce stress in university students: A review and meta-analysis. *Journal of affective disorders*, *148*(1), 1-11.

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and meta-analysis. *Psychological bulletin*, *138*, 353.

Robbins, S., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004). Do psychological and study skills factors predict college outcomes? A meta-analysis. *Psychological Bulletin, 130,* 261-288.

Schneider, M., & Preckel, F. (2017, March 23). Variables Associated With Achievement in Higher Education: A Systematic Review of Meta-Analyses. *Psychological Bulletin, 143,* 565-600.

Tinto, V. (1993). *Leaving college: rethinking the cause and cures of student attrition* (2nd edition). Chicago: University of Chicago.

Tinto, V. (2012). *Completing college: Rethinking institutional action*. Chicago: University of Chicago Press.

van der Zanden, P. J., Denessen, E., Cillessen, A. H., & Meijer, P. C. (2018). Domains and predictors of first-year student success: A systematic literature review. *Educational Research Review*, *23,* 57-77.

Veenstra, C. P., Dey, E. L., & Herrin, G. D. (2009). A model for freshman engineering retention. *Advances in Engineering Education*, *1*, 1-31.

Villar-Aguilés, A., Hernàndez-Dobon, J.F., & García-Ros, R. (2017). Relocating within the university. Proposal of a relocation rate based on a study of educational trajectories. *Electronic Journal of Educational Research, Assessment and Evaluation*, *23*(1), art. 5.

Willis, L. (2008). *Enhancing the First Year Experience for Engineering Students.* Higher Educationa Academy Engineering Subject Center: United Kingdom.

Zepke, N., Leach, L., & Butler, P. (2011). Non-institutional influences and student perceptions of success. *Studies in Higher Education*, *36*(2), 227-242.