

Do students from underrepresented groups feel integrated into engineering degrees?

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Abstract—This Research Work in Progress paper examines the perception of discrimination that foreign-born students feel in engineering degrees. To this end, a survey was distributed to 928 engineering students, of which 298 responded. The first results suggest that foreign-born students feel more discriminated against than native-born students and that this perception of discrimination is correlated with satisfaction and dropout. The reasons, situations, and people that caused these discriminations were also studied, being academic activities, professors and peers the most relevant ones. In the following phases of the study, the survey will be extended to the rest of the university schools to compare the results and deepen the analysis.

Keywords—underrepresented minority, discrimination, diversity, inclusion, engineering degree

I. INTRODUCTION

Despite the efforts being made in the early stages of education to promote participation in engineering studies, there is still an insufficient representation of minority students [1-3]. This underrepresentation is an international concern and a fundamental element of equality policies. Reducing these inequalities is an objective of the sustainable development goals set by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the 2030 Agenda, specifically in quality education (goal 4) and reduced inequalities (goal 10) [4].

The latest data published by the National Science Foundation (NSF) [5] on higher education in the United States (US) indicates that although the gap in educational achievement has narrowed between native-born and foreign-born students, disparities still exist. In 2017, the percentage of people ages 25-29 with a bachelor's degree or higher differed between blacks (23%), Hispanics (19%), and whites (42%). These gaps reflect lower rates of university enrollment and lower rates of academic achievement for students from minority groups. These data are similar to those found in the European Union (EU) [6].

The need to ensure equitable access and increase the levels of minority participation in engineering degree studies has implications for individuals, organizations, and society. In the academic environment, many engineering schools struggle to attract and retain students that reflect the diversity of the general population. Different studies indicate that diversity among students is of vital importance for the academic development of both minority and majority students as it provides a diversity of opinions that are of great value when addressing critical questions of an increasingly diverse society [7, 8]. Also, a heterogeneous educational environment creates richer and more complex social and learning environments

and enhances critical, innovative, and divergent thinking, essential skills in engineering studies [9-11].

The lack of ethnically diverse students in engineering degrees is caused by multiple factors. One of the factors that have obtained frequent concern in the literature is the perception of ethnic discrimination. Different studies suggest that students who are part of minority groups feel discriminated against in academic environments [12-14]. The inability to create an inclusive environment for minority students also affects factors related to their satisfaction and persistence [15-18].

The National Center for Educational Statistics (NCES) found that approximately one-third of entering college students leave higher education without obtaining a degree, especially during their first year [19]. This rate is even higher amongst students of minority groups [20]. Some authors have made compelling discoveries regarding this issue. Smedley et al. [21] found a significant negative association between bad interracial relationships and experiences of racism on campus and the dropout rate of these students. A more recent investigation [16] reported similar findings, showing that students reporting more racial discrimination showed a lower school engagement.

Although some progress has been made in this field of study, it is necessary to obtain a better understanding of the factors that make minorities feel discriminated against in order to achieve a more inclusive university. Furthermore, most studies analyzing diverse ethnic populations in higher education have been carried out in the US, so it is necessary to carry out studies in other contexts where the sample has a different composition and variability to extend the knowledge in this field.

II. CURRENT STUDY

This work aims to address the multicultural imbalances within university engineering studies by analyzing the perception of discrimination of foreign-born students and its relationship with satisfaction and dropout.

In order to provide more in-depth knowledge, the study also seeks to identify which factors make students feel discriminated against in order to describe the contexts in which discrimination situations are experienced. If these causes can be identified precisely, it would be possible to design appropriate support systems that improve the inclusion of minority groups and promote a more inclusive environment.

With this purpose, the study focuses on answering the following research questions:

- Do students from minority groups feel integrated into the academic environment in engineering degrees? It is expected that foreign-born students show a higher perception of discrimination than native-born students.
- How does the perception of discrimination affect student satisfaction and dropout? It is expected to find a negative correlation between satisfaction and perception of discrimination and a positive correlation between dropout and perception of discrimination.
- What are the main factors that make these students feel discriminated against? Besides the above hypotheses, the factors that made the students feel discriminated are explored, including (1) the reason for discrimination, (2) the situation in which it occurred, and (3) the person(s) who caused it.

The present investigation is framed in Catalonia, a region from the EU, where the ethnic composition of the foreign-born students has a different variability from that studied so far. This will bring a new context and perspective to current research.

This article is a part of a larger study examining the perception of minority groups in engineering degree studies conducted at the Universitat Politècnica de Catalunya-Barcelona Tech (UPC), a public university of higher education in the fields of engineering, architecture, science, and technology. Enrollment data of this university shows the previously discussed disparities in engineering studies: during the 2019/2020 academic year, 20,177 undergraduate students were enrolled, of which 1,290 (6.39%) were of foreign nationality.

This work in progress article presents the results obtained in the Escola d'Enginyeria de Barcelona Est (EEBE), which offers seven bachelor degrees in engineering: electric, mechanics, chemistry, industrial electronics, biomedicine, energy, and materials. This school is the engineering school of the university with the highest percentage of foreign-born students (13.42%).

III. METHODOLOGY

A. Participants

The survey was sent to a total of 928 students, of whom 298 finally answered. 25.5% ($n = 76$) of the participants were women and 74.5% ($n = 222$) were men. In terms of nationality, 60% ($n = 179$) of the students were born in Spain and 40% ($n = 119$) were born outside Spain. Of the students born in Spain, 14% ($n = 25$) had at least one parent who was born outside Spain. The most common origin regions for students whose parents or themselves were born outside of Spain were: Latin American countries (38.9%), Morocco (11.8%), other countries of the EU (11.8%), China (9%), and Eastern European countries (6.9%).

For the analysis, those students born in Spain and whose parents were also born in Spain were categorized as native-born students. On the other hand, in order to include the second-generation immigrant students, those students born outside Spain or that at least one of their parents was born outside Spain were categorized as foreign-born students.

B. Procedure

The survey, which was anonymous and drawn up using Google® Forms, was sent by email together with a

motivational letter explaining its purpose. Students were recruited for participation via email messages sent by the authors of this research and faculty members. The protection of personal data was duly taken into account, ensuring that all recipients agreed to receive communications.

Participant recruitment and measure completion occurred during the second semester of this academic year so that first-year students had reasonable exposure to university engineering studies. The online survey presented demographic questions, along with measures of satisfaction, dropout, and perceived discrimination. It also contained additional measures and an open-ended question as a part of a larger study.

Although most of the measures have been used in prior research, faculty members were invited to review the survey, and it was tested with five students and three teachers before being sent. This allowed identifying if the survey omitted some question areas, and if the questions were clear and well formulated.

C. Measures

In addition to demographic questions about gender, nationality, nationality of their parents, name of their study program, and academic year, the survey also included the following measures:

- 1) Satisfaction was assessed with a measure based on the work of Ramsden [22]. Students were asked to indicate how satisfied they were with their studies on a 4-point scale (1 = Not satisfied, 4 = Very satisfied).
- 2) Dropout measure was based on the one used in the study of Bunker et al. [23]. Participants had to indicate if they had ever thought about changing or leaving their studies on a 4-point scale (1 = Never, 4 = Many times).
- 3) Perceived discrimination was assessed with a 5-item scale adapted from the work of Pachter et al. [24]. Participants were presented with six possible experiences of discrimination (e.g., "I haven't been treated with the respect I deserved."), and they had to indicate if any of the situations had happened to them on a 4-point scale (1=Never, 4=Many times). Cronbach alpha calculated for the scale showed an acceptable internal consistency ($\alpha = 0.72$). Students were also asked to indicate how often did they felt discriminated against on a 4-point scale (1=Never, 4=Many times) and why they think they were discriminated against (e.g., "My gender", "My sexual orientation", "My ethnicity or nationality"), questions inspired by the work of D'hondt et al. [14]. In addition, two more questions were added in relation to the situations (e.g., "In group work") and the people that made them feel discriminated against (e.g., "Peers").

IV. RESULTS

A. Descriptive Statistics

In line with what was hypothesized, a higher percentage of foreign-born students (24%) indicated that they had been discriminated against compared to native-born students (16%). Analyzing responses by gender, 33% of foreign-born female students indicated that they had suffered discrimination compared to 29% of native-born female students. As for men, 19% of foreign-born male students indicated having perceived discrimination compared to 13% in the case of native-born male students. Besides, native-born

men students were the ones who indicated to the greatest extent that they had never been discriminated against (87%) (see Fig. 1).

The mean for perceived discrimination was higher for foreign-born students ($M = 1.29$) than native-born students ($M = 1.21$). The mean of perceived discrimination by native-born students was below the average perceived discrimination of all students ($M = 1.25$), while that of foreign-born students mean was above. When analyzed by gender, foreign-born male students ($M = 1.22$) had a higher perception of discrimination than native-born male students ($M = 1.15$). In the case of women groups, the mean was almost the same between native-born female students ($M = 1.45$) and foreign-born female students ($M = 1.44$).

Satisfaction was higher for native-born students ($M = 2.79$) than for foreign-born students ($M = 2.73$). The satisfaction of native-born students was above the average satisfaction of all students ($M = 2.76$), while that of foreign-born students mean was below. These observations were consistent across all study groups, both in the aggregate of women and men and when separating them by gender.

Regarding the dropout, the means between native-born students ($M = 2.05$) and foreign-born students ($M = 2.03$) were quite similar. Nevertheless, the average was lower in all foreign-born groups compared to the same gender group of native-born students. As for women, there was a greater difference between native-born female students ($M = 2.26$) and foreign-born female students ($M = 2.16$).

B. Correlations

Correlations between satisfaction and dropout with perceived discrimination were found for foreign-born students but not for native-born students. As illustrated in Table 1, perception of discrimination and satisfaction showed a significant and negative correlation ($r = -0.25$, $n = 144$, $p < 0.001$), which means that the more perceived discrimination, the less satisfied are foreign-born students with the studies. Correlations between the perception of discrimination and the dropout were positive and significant ($r = 0.24$, $n = 144$, $p < 0.001$), which means that the more perceived discrimination, the more foreign-born students think about leaving or changing their studies.

Satisfaction and dropout showed a significant and negative correlation, both for native-born students ($r = -0.34$, $n = 154$,

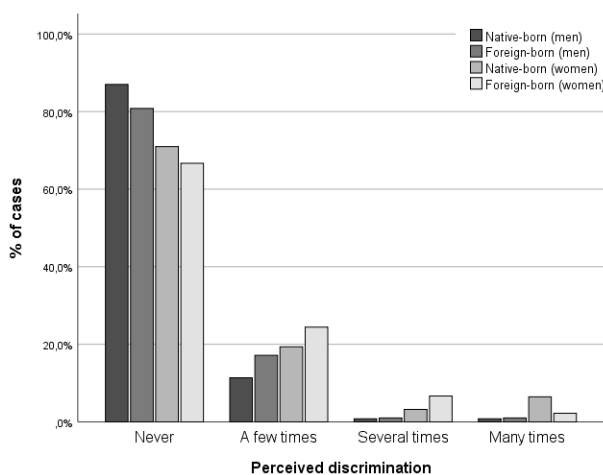


Fig. 1. Perceived discrimination by origin and gender

TABLE I: CORRELATIONS

	1	2	3
1 Discrimination		-0.25**	0.24**
2 Satisfaction	-0.10		-0.37**
3 Dropout	0.14	-0.34**	

^a. The lower left side of the first section of the table refers to native-born students, and the upper right side of the second section of the table refers to foreign-born students.

^b. ** Correlation is significant at the 0.01 level (2-tailed)

$p < 0.001$), and for foreign-born students ($r = -0.37$, $n = 144$, $p < 0.001$). This means that the more satisfied students are, the less they think about leaving their studies.

C. Discrimination causes

The main reasons why the students think they were discriminated against were nationality/ethnicity (31%), physical appearance (23%), gender (13%), and way of dressing (11%). In the open question "other" the main reasons stated were: not knowing the rest of the students previously, being shy, having a lower academic level, their way of thinking, politics, and religion.

The situations where these discriminations occurred the most were the academic activities (64%) divided into classes (32%), group work (21%), and evaluations (11%), followed by leisure and extracurricular activities (28%) and administrative procedures (8%). According to students' origin, for native-born students, academic activities represented 58%, while for foreign-born students represented 67%. Leisure and extracurricular activities represented 21% for foreign-born students and 37% for native-born students. Finally, administrative procedures represented 12% for foreign-born students and just 5% for native-born students.

Concerning the people who made them feel discriminated against, in 57% of the cases it was pointed out to peers, 32% to teachers, and 11% to administrative staff. Considering students' origin, for native-born students, peers represented 73%, while for foreign-born students, it represented 45%. Finally, for foreign-born students, teachers and administrative staff represented 41% and 14% respectively, while for native-born students, they represented 20% and 7%.

V. DISCUSSION

The results obtained identify some differences between native-born and foreign-born, which may provide insights of value to provoke further thought and open doors to new lines of research.

The findings show that foreign-born students feel more discriminated than native-born students in engineering studies. More specifically, there is a considerable difference between the discrimination perceived by native-born male students, who feel less discriminated, compared to all other groups. These findings are consistent with prior research [12, 14] and suggest that academic institutions must take action to reduce discrimination among their students. Some of the initiatives that could be carried out are: conduct periodic and regular measurements of racial harassment, empower students to report these situations, increase awareness of these situations of discrimination among academic staff and create support networks for students such as tutoring or mentoring. These actions should take place in a coordinated way in order

to demonstrate the commitment of the university to challenge all forms of racism and discrimination.

In alignment with previous research [25], there is a correlation between the perception of discrimination and the satisfaction of foreign-born students. These students show a higher perception of discrimination and less satisfaction with their studies in comparison with native-born students. Besides, a correlation has also been found between satisfaction and dropout, as in other studies [16-18]. This leads to thinking that if actions are carried out to reduce the perception of discrimination suffered by foreign-born students, the dropout rate in engineering studies would also be reduced.

Contrary to what was expected, when comparing foreign-born students with the same gender native-born students, it can be observed that foreign-born students think less often about changing or dropping their studies than native-born students. Perhaps, the fact of suffering a stereotype threat makes foreign-born students who come to study engineering do so by their own decision and not by social conviction, as can happen in the case of native-born male students. Also, these minorities may have to make a greater effort to reach these studies so, only the most confident and able end up in engineering studies [26].

Concerning foreign-born women students, the results show that the perception of discrimination they feel compared to native-born women students is practically the same. Contrary to what some studies point out [27], the results seem to indicate that in the case of suffering a double stereotype threat like gender and nationality, it does not have an additive effect.

Regarding the reason why students felt discriminated against, the most often pointed option was the ethnicity or nationality. However, it is necessary to highlight the other reasons why students, both native-born and foreign-born, felt discriminated against as gender, physical appearance, way of dressing, and sexual orientation. This suggests that further research should also take into consideration these other groups in order to have a complete view of the discrimination that occurs in engineering studies.

The most outstanding contexts where discriminations took place were academic activities such as classes, group work, and assessment activities. About the person causing discrimination, there were differences between native-born and foreign-born students. For native-born students, peers were the most frequently chosen option, while foreign-born students indicated in the same proportion peers and teachers as people causing discrimination. In alignment with other studies [14, 28], this shows that there is a difference in the perception of how teachers treat students according to their origin and highlight the need for academic institutions to achieve greater inclusion in the classroom. With this aim, it is necessary to ensure that teachers are trained to deal with issues related to diversity and culture, facilitate greater interaction inside the classroom, and establish adequate channels of communication between them and students. It is also essential to embrace an inclusive language, use examples and materials that incorporate diversity, and review the curriculum to provide more ethical knowledge instead of focusing mainly on technical aspects in order to make students become socially responsible engineers.

In the case of leisure time and extracurricular activities, foreign-born students point them out to a lesser extent than native-born students as environments in which they suffer discrimination. Perhaps, this happens because, in these environments, foreign-born students can choose whom they interact with, making these contexts safer for them. On the contrary, in academic activities where students usually cannot choose their peers, foreign-born students feel more threatened. This reinforces the theory that it is necessary to work on the inclusion policies in the classroom and also opens the door to think that in nonacademic environments, students may be segregated by origin, which means that there is a lack of inclusion in these situations as well. Many studies discuss the importance of having a diverse group of friends to counter discrimination not only for students from minority groups but to increase the awareness and tolerance of the majority [13, 29].

Finally, foreign-born students point-out more frequently administrative procedures as situations in which they feel discriminated against than native-born students. Besides, foreign-born students indicate with a higher proportion the administrative staff as people who discriminate against them than native-born students. Other studies make similar findings for women [30] and point out that it may be especially harmful as these experiences could lead to feelings of institutional betrayal. Therefore, it is necessary to include administrative procedures in the inclusion plans of universities.

VI. LIMITATIONS AND FUTURE WORK

Though this article provides relevant insights into the study of perceived discrimination against minorities in engineering studies, several limitations should be addressed in future research.

First, participants were recruited from the engineering school of the UPC with the highest number of foreign-born students. This proportion may have an impact on the perception of discrimination of those students compared to schools with a different proportion of foreign-born students. Moreover, the fact of including second-generation immigrants in the sample of foreign-born students may have affected the results obtained. Finally, in addition to the own limitations when using a questionnaire as a data collection method, it is important to note that many measurements were based on the perception of the students, so there may be differences between this perception and reality.

The next step of the project will be to distribute the survey to the rest of the schools of the UPC to analyze and compare whether the findings hold or there are differences depending on the schools' characteristics. Those hypotheses whose results are statistically more significant will be identified so that a detailed study of the validity of each hypothesis may be conducted.

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