The Intellectual Sense of Belonging and Self-efficacy in the Introduction to Computer Science Courses at University of Brasilia in Brazil

1st Maristela Holanda
Depart. of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-0883-2579

2nd George von Borries
Depart. of Statistics
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-9072-2247

3rd Dilma da Silva
Depart. of Computer Science and Engineering
Texas A&M University
College Station, US
ORCID 0000-0001-6538-2888

4th Camilo Dorea
Depart. of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0003-2750-2425

5th Roberta B. Oliveira
Depart. of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-5373-9402

6th Edison Ishikawa
Depart. of Computer Science
University of Brasilia
Brasilia, Brazil
ORCID 0000-0002-0214-9234

Abstract—Research Full Paper Most top universities in Brazil are public government institutions and tuition free. However, until recently, access to these institutions has been limited by extremely difficult entrance exams. The high standards at public universities are in contrast to the k-12 educational system, where public schools fail to prepare students for the exams, with only some of the private schools offering adequate preparation. In 2012, the Higher Education System in Brazil changed: the *Quota Law* was implemented for all 59 federal public government universities. This law reserves 50% of the enrollments for the public high-school students with the best grades in the entrance exams. Also, from this 50% allocation of places for students from the public high-school system, half are allocated to students from low-income families (up to one and a half times the minimum monthly salary), black and indigenous students. In this context, this paper addresses the research question: "How does the intellectual sense of belonging and self-efficacy of the quota students compare to that the non-quota students' taking Introduction to Computer Science courses?" We devised a questionnaire for students enrolled in the first programming course of different majors at a top-10 Brazilian university. This paper presents an analysis of the responses that indicates some differences in self-efficacy perceptions between the students admitted through the quota system and the ones admitted exclusively by their placement in entrance exams.

Index Terms—Computer Science Education, Programming course, Sense of belonging, self-efficacy

I. INTRODUCTION

According to Stout and Blaney in [1] a sense of intellectual belonging is "the sense that one is believed to be a competent member of the community". The sense of belonging is also called ambient belonging [2], or feeling of belongingness [6]. This feeling is especially challenging for the underrepresented minority groups in Computer Science majors, as presented in [1] [2] [3] [4] [5] [6].

Most of the top 10 universities in Brazil are public government institutions and free (no tuition fees for the students). However, the entrance exams at those universities are extremely difficult. The high standards in public universities are in contrast to the k-12 educational system, where the highest standards are in private schools. Unlike many other countries, private schools in Brazil are not only for the wealthiest members of the population. Many families sacrifice other needs in order to pay for private schools as the only path to a quality education.

In 2012 the Higher Education System in Brazil changed, and the Quota Law [13] was implemented for all 59 federal public government universities. As a consequence, 50% of the enrollments are now reserved for public high school students with the best grades in the tests, and of these public high school quota places, 25% are allocated to students from low-income families (up to one and a half times the minimum salary per month), black and indigenous students. Before 2012, students from public high schools were in the minority in Computer Science majors in those top universities [22]. Nowadays they represent half of the students that enroll at the federal public universities.

In this context, this paper addresses the research question: "How does the intellectual sense of belonging and self-efficacy of the quota students compare to that of the non-quota students on the Introduction to Computer Science courses?". We devised a questionnaire in the second semester in 2019, with 20 questions for students on Introduction to Computer Science for different majors at one of the top 10 Brazilian universities. We chose the Introduction to Computer Science course because it is the first programming course and has been identified as a pivotal point in the retention of undergraduate students in Computer Science (CS) majors [7] [8] [9] [10] [11]

[12]. We analyzed the responses and have presented them in this paper.

Our paper is composed of the followed Sections: Section II presents a description of the Higher Educational System in Brazil; Section III describes the process applied in this paper; Section IV presents the demographic of the respondents; Section V presents the answers from the student survey; Section VI presents an analysis of the findings; Section VII discusses the study limitations; and Section VIII presents the conclusions and future work.

II. Brazilian Higher Education System

The Brazilian educational system is regulated in accordance with its Federal Government's guidelines. Within rights and responsibilities, federal law (*Lei* 9.394/1996) [14] establishes that basic education is free and mandatory. Basic education is structured around three stages: (i) early childhood (or pre-schools), (ii) elementary, which is mandatory from ages 6 through 14, and (iii) high school level, consisting of 3 more years of study. The latter is mandatory only for those wishing to enroll in higher education, such as that provided through the public government institutions (federal and state universities, among others). Publicly funded and free schools and universities are available for all educational levels as are privately financed, for-profit and non-profit institutions.

With a few exceptions, public education at the high school level in Brazil has provided a lower education standard than that of its private counterpart. According to a recent study [15] on PISA (Programme for International Student Assessment) 2018 results [16], when considering the performance of only private school students, Brazil ranks at position 11 among 79 countries in reading. When considering general performance among all privately and publicly schooled students, it drops to 65th position. These differences in quality are not, however, present at the higher education level. In fact, the opposite trend is observed. For example, 9 of the top 10 universities in Brazil, according to a recent survey [17], are public and tuition is free, with 7 of them belonging to the federal system.

Access to public higher education in Brazil is through entrance exams. These exams, widely adopted by universities and generally consisting of a competitive examination, aim to test knowledge from the elementary and high school curriculum. They are used to rank students who may then choose from a limited number of places offered for each major within a university. This system has been criticized for favoring candidates from wealthier backgrounds with access to basic education provided by higher-quality private schools.

In an effort to mitigate bias towards often better-funded private schools and to promote greater diversity on campuses, in 2012 the federal government implemented a new higher education law. The Quota Law 2.711/2012 reserves a 50% quota of the places offered by its tuition-free public universities to students originating from public high schools. The law [13] further requires that half of this quota be designated to students from families with per capita income below one and a half times the minimum wage. The law was gradually applied, 12.5% a year, until 2016 when it reached 50%. In particular, besides following federal guidelines, the University of (remove blind review) also reserves 5% of its admissions for black students. The student body at the university may thus be divided between quota students and non-quota students, the latter with admission access based on unrestricted competition.

III. Methodology

We devised a questionnaire for students in Introduction to Computer Science (the first programming course) taken by different majors at University of Brasilia, one of the top 10 Brazilian universities. The questionnaire is composed of 20 questions, divided into personal information, previous programming experience, self-efficacy and intellectual sense of belonging. In this context, this paper addresses the research question: "How does the intellectual sense of belonging and self-efficacy of the quota students compare to that of the non-quota students in the Introduction to Computer Science courses?".

The research questions analyzed in this paper are based on [1]:

- Do you think that your classmates think that you are not smart enough for your major?
- How many study hours have you spent on the course, outside the classroom, by week?
- Do you think that you need more hours of study than your friends?
- Do you think that your efforts were rewarded (study hours/grade)?
- How often have you felt that you had a great idea that was ignored by your friends?

We applied the questionnaire at the end of the second academic semester of 2019 for the undergraduate students enrolled in the first programming language courses. The University of Brasília offers two such courses: (1) the *Algorithm and Computer Programming* course (ACP) is based on the C language and targets undergraduate students in the Computer Science major, and (2) the *Introduction to Computer Science* (ICS) course, based on the Python programming language, offered for students who are not in the Computer Science major. We received 106 responses. Table I presents the number of responses by majors: Computer Science, Statistics, Mechanical Engineering, Maths, Building Engineering, Environment Engineering, Production Engineering and Others.

TABLE I
Number of Responses by Majors.

Major	No. Responses
Computer Science	22
Statistics	20
Mechanical Engineering	7
Maths	14
Building Engineering	10
Environment Engineering	17
Production Engineering	9
Others	7

We presented the results about undergraduate students' demographics, followed by the responses for the two groups: ACP course students and ICS course students. The results are analysed in the following sections.

IV. DEMOGRAPHIC OF THE STUDENTS

Table II presents the demographic of the 106 students who answered the questionnaire by gender, age, the first generation students to graduate at higher educational level (mother and father), quota students, and previous programming experience.

The distribution of the students by gender is: female students 38.7% (41), male students 59.4% (63), two students preferred not to declare, 1.9%. For the Computer Science undergraduates, female students make up 27.3% (6) and male students 72.2% (16). Two majors had more female than male respondents, the Environment Engineering major with 13 female students, and four male students; and the Industrial Engineering major with six female students and three male students. The other majors had more male than female respondents, which is expected in STEM majors.

ICS and ACP courses are taken at the beginning of the major, when the students enroll at the university, therefore the distribution of the students' ages was as expected. Only one student on the Computer Science major declared less than eighteen years old. Most of the students are 18-20 years old 64.2% (68), 24.5% (26) are between 20-23 years old, 10.4% (11) are more than 23 years old.

The distribution of the students which declared to be the first generation in their family, i.e., with parents who did not graduate from higher education: 19.8% (21) are first generation and 80.2% (85) are not. For the Computer Science undergraduate students, this rate is 13.9% (3), and 86.4% (19) not from the first generation.

Table II also presents the distribution of the quota and non-quota students. We have 55.7% (59) non-quota students, and 44.3% (47) quota students. At the university the quota students are 50% of the students that enroll in all majors, however our questionnaire was completed voluntarily, in December, the end of the academic semester in Brazil, and because of that the percentages are different in our research.

Finally, most students, 71.7% (76), did not have previous programming experience, and 28.3% (30) did. Specifically, for ACP (CS students) 59.1% of students had previous programming experience, in contrast to the ICS (non CS students) where only 20.1% had programming experience. The two groups declared that they had acquired these skills mainly through online courses, as the high schools in Brazil do not teaching programming lessons.

V. ANSWERING THE RESEARCH QUESTIONS

This section presents the answers to research questions defined in Section III for two groups, Computer Science students and non Computer Science undergraduate students.

TABLE II
DEMOGRAPHIC OF THE STUDENTS.

Gender		
Female	41	38.7%
Male	63	59.4%
Preferred not declare	2	1.9%
Age		
≤ 17 years	1	0.9%
18 - 20 years	68	64.2%
20 - 23 years	26	24.5%
>23 years	11	10.4%
First Generation		
Yes	21	19.8%
No	85	80.2%
Quota Students		
Yes	47	44.3%
No	59	55.7%
Previous Programming Experience		
Yes	30	28.3%
No	76	71.7%

A. Computer Science students

1) Do you think that your classmates think that you are not smart enough for your major?: Table III presents the results.

The data has 22 observations, with 16 quota students and only 6 non-quota students. Since the sample is small, we applied Fisher's Exact Test [18] for homogeneity, it shows no significant difference between the two groups of students related to the perception of class thinking about the capacity ("smart enough") of the students. Figure 1 shows that 100% of the non-quota students answered "no" for this question, for the quota students 62.5% answered "no", and 37.5% "yes".

TABLE III
QUOTA X SMART ENOUGH FREQUENCY TABLE - ACP.

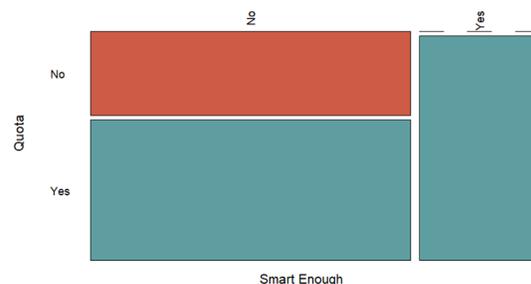| Row Total	Smart enough Perception		
Quota	No	Yes	Total
No	6	0	6
	1.000	0.000	0.273
Yes	10	6	16
	0.625	0.375	0.727

Fig. 1. Quota x Smart Enough - ACP.

Analyzing the question about the major in general, "Do you think that your classmates think that you are not smart enough for your major?", for the Algorithm and Computer Programming (CS undergraduate students), the quota students had 37.5% "yes" and the non-quota students had no "yes" responses (100% of the non-quota students answered "no" for this question). The quota students were more negative regarding this point. The quota students are not the minority group at our university, but they are from public schools and often from low-income families.

2) How many study hours have you spent on the course outside the classroom by week?: Figure 2 presents the result.

The data has 22 observations, 16 from quota students and only 6 from non-quota students. We can see an almost random distribution of responses from quota students with the smallest proportion studying 10 or more hours per week. For non-quota students, the largest group say that they study 10 or more hours but it is hard to say this reflects a tendency for the population (small sample).
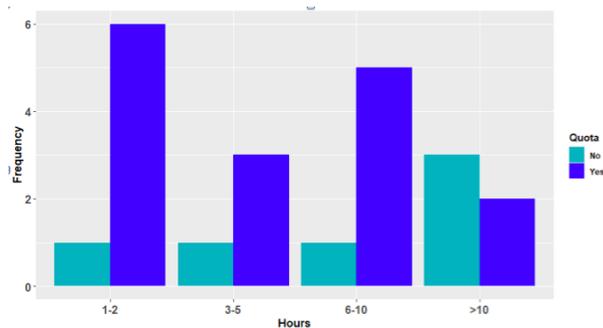
Fig. 2. Quota x Hour of Studies - ACP.

3) Do you think that you need more hours of study than your friends?: Table IV presents the results.

The two groups have a similar response to this question (see Figure 3). Since the sample is small and the contingency table has cells with 0 or less than 5 units, we again applied Fisher's Exact Test for homogeneity. The p-value for the bilateral test is 1, showing that both groups have a similar perception about the need for more hours of study than friends in this discipline.

TABLE IV
QUOTA X NEED MORE STUDY THAN FRIENDS - ACP.

Row Total	Need More Study Than Friends		
Quota	No	Yes	Total
No	2	4	6
	0.333	0.667	0.273
Yes	6	10	16
	0.375	0.625	0.727

4) Do you think that your efforts were rewarded (study hours/grade)?: The study of this question is similar to the previous one. The results are presented in Table V. The p-value for the Fisher Exact Test is p = 0.2919, indicating no significant difference in perception of Effort-Reward in the
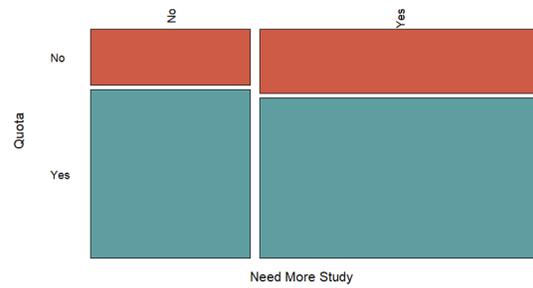
Fig. 3. Quota x Need more hours of Studies.

discipline for the two groups of students. Figure 4 presents the distribution.

TABLE V
QUOTA X YOUR EFFORT WAS REWARDED? - ACP.

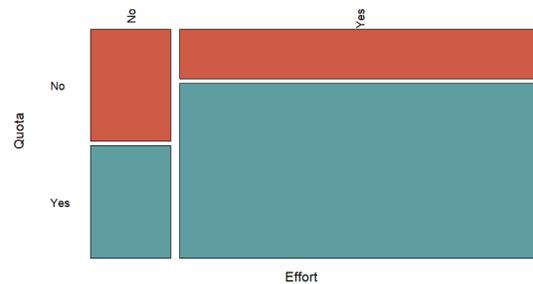| Row Total	Your Effort was Rewarded?		
Quota	No	Yes	Total
No	2	4	6
	0.333	0.667	0.273
Yes	2	14	16
	0.125	0.875	0.727

Fig. 4. Quota x Effort.

5) How many times have you felt that you had a great idea but your friends ignored it?: Here we restricted our analysis to a descriptive presentation, due to the large number of categories for response. However, we can not identify a similar pattern of decrease in how frequently students from both groups think they have good ideas not considered by their peers. Three quota students think they have these ideas sometimes or frequently. Table VI presents the distribution.

B. Non Computer Science students

1) Do you think that your classmates think that you are not smart enough for your major?: Table VII presents 83 students' responses to this question (1 student did not answer).

Applying the Chi-Square Test [19] to verify if there is a difference among these two groups, i.e., if cell counts are

TABLE VI
QUOTA X PERCEPTION - ACP.

Perception	Quota	
	No	Yes
Never	4	8
	0.333	0.667
Occasionally	2	4
	0.333	0.667
Sometimes	0	2
	0.0	1.0
Frequently	0	1
	0.0	1.0

homogeneous or not, we obtained $X_1^2 = 3.9289$ resulting in a p-value of 0.04746. Thus, we have an indication of non homogeneity among cell counts at 95% significance level. In other words, the proportion of students in the quota group that think negatively about their abilities is greater than in non-quota students. Figure 5 presents the distribution on quota and smart enough perception.

TABLE VII
QUOTA X SMART ENOUGH FREQUENCY TABLE - ICS.

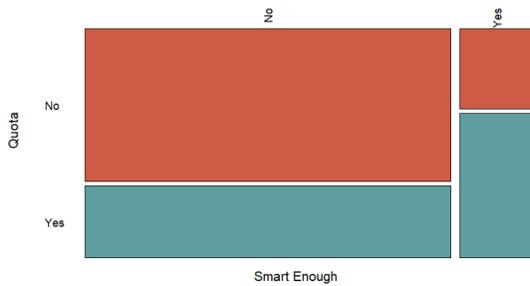| Row Total	Smart enough Perception		
Quota	No	Yes	Total
No	47	5	52
	0.904	0.096	0.627
Yes	22	9	31
	0.710	0.290	0.373

Fig. 5. Quota x Smart Enough - ICS.

Regarding this question, for the Introduction to Computer Science course (not CS undergraduate students), 29% of the quota students said "yes", and non-quota students only 9%. For non-CS undergraduate students, similarly to CS undergraduate students, the quota students were more negative regarding this point.

2) How many study hours have you spent on the course outside the classroom by week?: Kendall correlation [20] between quota and non-quota students for time spent studying is equal to $\tau = 0.69$, indicating a high correspondence between the ranking of categories in both groups. The rejection of the null hypothesis of no correlation (5% significance level)

means that there is an indication of a positive concordance in time spent studying. We can observe that in both groups most students spend 1 to 5 hours of study per week and few (or none) spend no time studying or more than 6 hours of study per week.
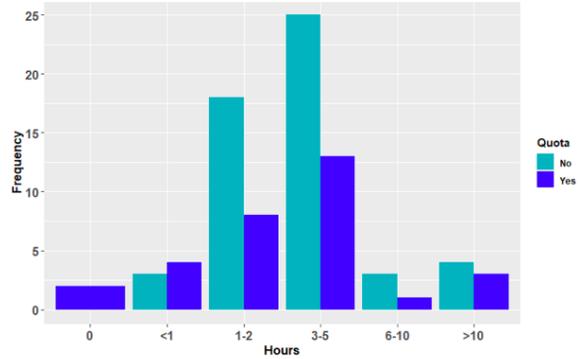

Fig. 6. Quota x Hour of Studies.

3) Do you think that you need more hours of study than your friends?: The frequency table with 84 students who answered this question is in Table VIII.

67.7% of quota students think they need more study than their friends in the discipline. This is not so different from the percentage of non-quota students that think they need more study, about 56.6%.

Applying the Chi-Square Test to verify if there is a difference between these two groups, i.e., since the sample size is not small here, we verify if there is a difference, if cell counts are not homogeneous. We obtained $X_1^2 = 0.6039$, resulting in a p-value of 0.4371. Thus, we have no evidence to reject the null hypothesis of homogeneity among cell counts. This indicates that both groups are not significantly different in relation to their perception of the need for more study time. Figure 7 presents the distribution of the hours of study.

TABLE VIII
QUOTA X NEED MORE STUDY THAN FRIENDS

Row Total	Need More Study Than Friends		
Quota	No	Yes	Total
No	23	30	53
	0.434	0.566	0.631
Yes	10	21	31
	0.323	0.677	0.369

4) Do you think that your efforts were rewarded (study hours/grade)?: The study of this question is similar to the previous one. The results are presented in Table IX.

Applying the Chi-Square Test to verify if there is a difference between these two groups, i.e., if cell counts are not homogeneous, we obtained $X_1^2 = 0.81802$, resulting in a p-value of 0.3658. Thus, we have no evidence to reject the null hypothesis of homogeneity among cell counts. This indicates
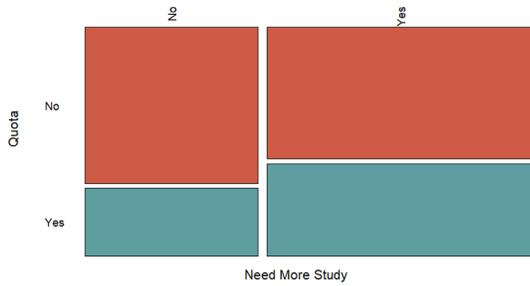
Fig. 7. Quota x Need more hours of Studies.

TABLE IX
QUOTA X YOUR EFFORT WAS REWARDED?

Row Total	Your Effort was Rewarded?		
Quota	No	Yes	Total
No	24	29	53
	0.453	0.547	0.631
Yes	18	13	31
	0.581	0.419	0.369

that both groups are not significantly different in relation to their perception of whether the effort in the discipline was rewarded or not in terms of grades. The distribution is presented in Figure 8.
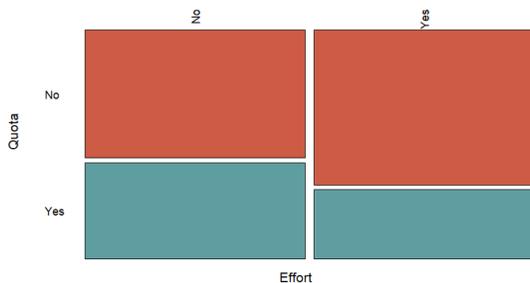

Fig. 8. Quota x Effort.

5) How many times have you felt that you had a great idea but your friends ignored it?: Here we used the Spearman correlation coefficient [21] to evaluate if there is a linear relation between quota and non-quota students in relation to how frequently they have good ideas that are ignored by their friends. The Spearman coefficient is 0.9486833 with p-value of 0.05132 for the test with null hypothesis of no significant correlation. Apparently, there is a relation in the perception of the two groups of students. But the proportion of quota students that thinks they have good ideas that are ignored occasionally or sometimes is equal, while this proportion decreases in the group of non-quota students. This is basically

the reason other linear trend tests did not detect a significant relationship between the perception of how frequently they have good ideas ignored. Table X presents the results.

TABLE X
QUOTA X PERCEPTION

	Quota	
Perception	No	Yes
Never	33	15
	0.623	0.484
Occasionally	10	8
	0.189	0.258
Sometimes	7	8
	0.132	0.258
Frequently	3	0
	0.057	0
Total	53	31
	0.631	0.369

VI. DISCUSSION

In our university the curriculum and teaching method for the first programming language courses are different for Computer Science students and the other majors. For example, in the Computer Science major, as already mentioned, the course is based on C language and for the other majors, this course is based on Python language. For this reason, we are going to analyze the other questions in different groups.

We could not identify a significant difference for the questions about the first programming course in our university for both group ICS (non CS majors) and ACP (CS major). However, there are some insights that we are going to present as follows.

When we analyze the question for the ICS course (for non CS students), we can see that the difference between the quota and non-quota students is not significative. It appears that ICS is demanding for all students. However, some insights are interesting:

- Although we didn't find significant differences in the hours of study declared by the students, for the question, "Do you think that you need more hours of study than your friends?", the quota students answered "yes" (67.7%), more than the non-quota students (56.6%).
- For the question, "Do you think that your efforts were rewarded (study hours/grade)? ", the quota students answered "no" (56.1%), more than the non-quota students (45.3%). The first programming classes are difficult for all students, however, the quota students feel worse compared to non-quota ones.
- For the question "How many times have you felt that you had a great idea but your friends ignored it? ", we didn't find a correlation with the quota and non-quota students. However, 62.3% of the non-quota students answered "Never", while only 48.4% of the quota students answered in this way. From this, it may be assumed that non-quota students are more confident.

Similarly, when we analyze the questions for the ACP course (for CS students), we can see the difference between the quota and non-quota students is not large. Some insights are:

- The non-quota students stated that they studied more hours than the quota students. The quota students have a relatively high percentage (37.5%) for only 1-2 hours, while the rate for many non-quota students was more than 10 hours (50%). However, for the question, "Do you think that you need more hours of study than your friends?", similar percentages of quota and non-quota students have "yes", 66.67% and 62.5%, respectively. The ACP course is demanding for both the quota and non-quota students.
- For the question, "Do you think that your efforts were rewarded (study hours/grade)? ", quota students answered "no" (12.5%), less than non-quota students (33.3%). Further investigation is required, but it is possible that this response relates more directly to hours of study than to whether or not the student is in the quota or non-quota group.
- For the question "How many times have you felt that you have had a great idea but your friends ignored it?", we didn't find a correlation with the quota and non-quota students. However, 50% of the non-quota students answered "Never" whereas 37.5% of the quota students responded in this way. The answer, "Frequently", was given by 0% of the non-quota students and 31.3% of the quota students. From this it may be supposed that non-quota students are more confident.

In general, the first programming course is challenging for a lot of the students, however, for students that are not doing Computer Science majors the results were worse.

VII. Limitation

The small number of students that answered the ACP questionnaire could limit the power of our test statistics, and even when present, we could not detect a significant difference between quota and non-quota students' perceptions of some questions. To confirm and expand the initial results in this paper, in future studies we intend to increase the sample size of our study through the creation of better mechanisms to incentivize instructors and students to answer the questionnaire.

VIII. Conclusion

The public higher educational system in Brazil changed in 2012, with 50% of the places reserved for public high school students. In Brazil, these students are mainly from low income families. This paper presents an analysis of the intellectual sense of belonging and self-efficacy of theses students, the quota students, compared to non-quota students. We devised a questionnaire and applied it in the first programming courses for Computer Science majors and other majors.

In regard to the general question "smart enough for the major", the quota students clearly felt worse the non-quota students. However, when analyzing the questions about the

courses, we didn't find significant difference between the quota and non-quota students groups in CS and non CS majors.

As future work, we intend to apply the questionnaire for advanced courses in the CS major curruiculum in order to identify other variables that could be influencing the intellectual sense of belonging. We are developing a tool to present to instructors the demographic of the students in the first week of the course, and we are going to explore ways to motivate the students to answer the questionnaire.

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