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A descriptive analysis of the higher education courses for major in Mathematics in Brazil

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ABSTRACT

Introduction: The study of the evolution of indicators related to higher education courses is fundamental for monitoring the quality of education, demand for courses and detecting trends in different areas. **Objective:** The present work aims to describe quantitatively the higher education courses for Mathematics teachers in Brazil through indicators such as the number of courses, enrollments, graduates, admissions, and positions offered in the period from 2009 to 2021 by teaching modality (in person and distance) and by administrative category (public and private). **Methodology:** Based on a descriptive and quantitative methodology, INEP Higher Education Census were used in the period considered for extracting the analyzed data set and descriptive statistical techniques such as graphs and tables are applied, in addition to simple linear regression fits to estimate the average annual growth (decrease) of indicators. **Results:** It was found in the analyzes that in person courses at public institutions dominate the area in terms of number of courses and enrollments. In addition, the private sector has evolved in opposite directions regarding the type of education. In this category, in person courses are in sharp decline in the indicators considered, while distance learning courses are increasing considerably, even surpassing in person courses in public institutions in terms of the number of graduates. **Conclusion:** Despite the dominance of in person courses at public institutions, distance learning courses at private institutions have shown considerable increases in terms of numbers of enrollments and graduates.

KEYWORDS

Mathematics. Higher education. Teacher graduation. Higher Education Census.

Uma análise descritiva sobre os cursos superiores de formação de professores de Matemática no Brasil

RESUMO

Introdução: O estudo da evolução de indicadores acerca de cursos superiores é fundamental para o monitoramento da qualidade de ensino, demanda por cursos e detecção de tendências nas diversas áreas.

Objetivo: O presente trabalho tem como objetivo descrever quantitativamente os cursos superiores de formação de professores de Matemática no Brasil por meio de indicadores como os números de cursos, matrículas, concluintes, ingressos e vagas ofertadas no período de 2009 a 2021 por modalidade de ensino (presencial e a distância) e por categoria administrativa (pública e privada). **Metodologia:** Com base em uma metodologia descritiva e quantitativa, foram utilizados os Censos da Educação Superior do INEP no período considerado para extração do conjunto de dados analisados e técnicas estatísticas descritivas como gráficos e tabelas são aplicadas, além de ajustes por regressão linear simples para estimar o crescimento (decréscimo) médio anual dos indicadores. **Resultados:** Constatou-se nas análises que os cursos presenciais das instituições públicas dominam a área em termos de números de cursos e matrículas. Além disso, o setor privado tem apresentado evolução em sentidos opostos quanto a modalidade de ensino. Nesta categoria, os cursos presenciais de formação de professores em Matemática estão em abrupta queda nos indicadores considerados ao passo que os cursos a distância estão aumentando consideravelmente, superando inclusive os cursos presenciais de instituições públicas em número de concluintes. **Conclusão:** Apesar da dominância dos cursos presenciais de instituições públicas, os cursos na modalidade a distância de instituições particulares têm apresentado consideráveis aumentos em termos dos números de matrículas e concluintes.

PALAVRAS-CHAVE

Matemática. Ensino superior. Formação de professores. Censo da Educação Superior.

Un análisis descriptivo de los cursos de educación superior para profesores de Matemáticas en Brasil

RESUMEN

Introducción: Estudiar la evolución de los indicadores relacionados con los cursos de educación superior es fundamental para monitorear la calidad de la educación, la demanda de cursos y detectar tendencias en diferentes áreas. **Objetivo:** El presente trabajo tiene como objetivo describir cuantitativamente los cursos de educación superior para profesores de Matemática en Brasil a través de indicadores tales como el número de cursos, matrículas, graduados, admisiones y vacantes ofrecidos en el período de 2009 a 2021 por modalidad de enseñanza (presencial) y distancia) y por categoría administrativa (pública y privada). **Metodología:** Basado en una metodología descriptiva y cuantitativa, se utilizaron los Censos de Educación Superior del INEP en el período considerado para la extracción del conjunto de datos analizados y se aplican técnicas de estadística descriptiva como gráficos y tablas, además de ajustes de regresión lineal simple para estimar el crecimiento (decremento) promedio anual de los indicadores. **Resultados:** En los análisis se constató que los cursos presenciales en instituciones públicas dominan el área en cuanto a número de cursos y matrículas. Además, el sector privado ha evolucionado en direcciones opuestas en cuanto al tipo de educación. Los cursos presenciales de formación de profesores de Matemática presentan un fuerte descenso en los indicadores considerados, mientras que los cursos a distancia aumentan considerablemente en las instituciones privadas, superando incluso a los cursos presenciales en las instituciones públicas en cuanto a número de egresados. **Conclusión:** A pesar del predominio de los cursos presenciales en las instituciones públicas, los cursos a distancia en las instituciones privadas han mostrado incrementos considerables en términos de matrículas y egresados.

PALABRAS CLAVE

Matemáticas. Enseñanza superior. Formación de profesores. Censo de Educación Superior.

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Introduction

The offer of undergraduate courses in Brazil has been changed over the last few years. By the development of the distance learning (DL) modality in higher education in the country since the beginning of the 21st century, several courses that were offered exclusively in the in-person modality are now also offered in Distance Learning both in public higher education institutions (HEI) and private ones. In this sense, monitoring the evolution of undergraduate course under in-person and DL modalities becomes fundamental for analyzing the demands of the population for such courses and modalities, demands that can be explained by economic, logistical, market demands work, quality of teaching and learning, among other factors. In addition, monitoring such evolution allows the identification of courses or specific areas of knowledge that are susceptible to big changes in terms of their offerings.

Several comparative studies between in-person and distance learning modalities in Brazilian higher education have been conducted in recent years. Costa and Cochia (2013) discuss how public and private institutions have incorporated DL as a way of promoting access to higher education in the country. They also compare the number of in-person and distance learning courses in public and private institutions according to data from the Higher Education Census of the National Institute of Educational Studies and Research Anísio Teixeira (INEP) in 2011. Giolo (2018) also uses data from the Census of Higher Education from 2000 to 2015 to analyze the great expansion of DL in undergraduate courses in Brazil in the period. Cruz and Lima (2019) describe the trajectory of the DL modality in the country since 1978, with its strengthening due the use of television as a way of disseminating and offering courses at a fundamental level, such as the Telecurso of the Roberto Marinho Foundation in partnership with the Padre Anchieta Foundation for example. The study also draws up a chronological line with the main legal frameworks for distance learning in Brazil and compares the number of courses and the number of enrollments in undergraduate distance education courses between public institutions and private between 2003 and 2017 from the Higher Education Census datasets.

The three cited studies present comparisons between in-person and distance learning modalities in higher education in general terms. Specifically in the pedagogical area, Sardelich (2014) relates the expansion of distance learning in Brazil under government policies for pedagogical area based on the Law of Guidelines and Basis of Education (LDB), Law 9.394/1996. It also compares the number of enrollments in courses between in-person and DL modalities by administrative category in the period from 2001 to 2012 based on the Higher Education Census, Figueiredo (2018) presents the historical process of DL in Brazilian courses in pedagogical area, through the discussion of projects that contributed to the expansion of this teaching modality in the country and, in particular, in pedagogical area and Vizzotto (2021) describes the scenario of the degree in Physics using Census microdata by geographic region of the country.

Despite the availability of comparative studies based on data about the evolution of higher education courses in in-person and distance learning modalities by administrative

category (public and private), in general, little attention is given to the trajectory of the offer of courses in such modalities in the formation of Mathematics teachers specifically. In this sense, the present work aims to describe statistically the evolution of higher education courses for major in Mathematics in Brazil in in-person and distance learning modalities and by administrative category. This description considers the number of courses, enrollments, graduates, admissions and offered positions in each category. For this purpose, data extracted from the INEP Higher Education Census from 2009 to 2021 were used.

This article is organized as follows: Section 2 presents the dataset used for the analyzes as well as the statistical methodology. The results of the analyses, subdivided by indicators (number of courses – Subsection 3.1, number of enrollments – Subsection 3.2, number of graduates – Subsection 3.3 and ratio admissions and positions – Subsection 3.4) are presented and discussed in Section 3. The final considerations are placed in Section 4.

2 Materials and Methods

Subsections 2.1 and 2.2 describe the dataset used in the analyzes and the statistical techniques applied in the study respectively.

2.1 Description of the dataset of study

The dataset was extracted from the Statistical Synopses of Higher Education Census of INEP from 2009 to 2021 and available in Brasil (2009-2021).

The Statistical Synopses of the Higher Education Census are composed by spreadsheets in xls and pdf format with several information about higher education at the levels of national geographic disaggregation, by geographic regions, by federative units and by administrative category and are published annually since 1995. Data about the distribution of higher education institutions, teachers, technical-administrative staff, enrollments, graduates, offered positions, enrolled candidates and admissions disaggregated by socioeconomic and demographic information such as sex, color/race, age group and location, as well as the distribution of courses and academic organizations are made available by the synopses. The last synopsis, published in 2022 and related to 2021, for example, is made up of 65 tables, one of which is institutions, 9 are professors, 3 are courses, 17 are selection processes, 16 are enrollments, 16 are from graduates and 3 are from general data. In this way, the Statistical Synopses of the Higher Education Census provide several relevant information for the construction of an overview of higher education in Brazil at different levels.

Although synopses have been published since 1995, data related to the distance learning modality have been provided since 2000, initially from public institutions. Data on this modality in private institutions appear only in 2002. In addition, information on the number of distance learning courses, as well as enrollments and graduates disaggregated by course appear for the first time in the synopses only in 2009. For this reason, we consider the year 2009 as the beginning of the period considered in the study.

In the statistical synopses from 2009 to 2021 selected for the study, the following data related to the specific course of major in Mathematics and at the national geographic level were extracted: number of courses, number of enrollments, number of graduates, number of admitted candidates and number of offered positions, disaggregated by teaching modality and by classification of the HEI in public and private. Once the dataset of interest extracted, statistical analyzes can then be performed.

2.2 Statistical Methodologies

Data extracted from the Statistical Synopses of the Higher Education Census from 2009 to 2021 related to the course of major in Mathematics with information about the number of courses, enrollments, graduates, admissions and offered positions in Brazil will be statistically analyzed using descriptive techniques, essentially trend and pie charts and comparative tables with percentage change calculations. Thus, it is planned to describe quantitatively the evolution of such indicators in the considered period by modality of teaching (in-person and distance learning) and by administrative category of the institution (public and private). Further, comparisons between these levels will be made.

For the numbers of courses, enrollments and graduates, after the descriptive analysis, a simple linear regression model will be adjusted for each indicator, with the aim of estimating its average annual growth (or decrease). In general, linear regression is a statistical technique widely used to study relationships and make inferences between a response variable (quantitative) and a set of explanatory variables. When there is only one explanatory variable, there is simple linear regression, and when there are two or more explanatory variables, there is multiple linear regression.

In fact, a simple linear regression model involving two variables x (explanatory) and y (response) assumes a linear relationship between them, of the form

$$y = \alpha + \beta \cdot x + \varepsilon,$$

where α is the intercept (linear coefficient), β is the slope (angular coefficient) and ε is a random error with normal distribution of mean equal to zero and unknown variance equal to σ^2 , $\sigma > 0$. In geometric terms, the simple linear regression model assumes that the relationship between x and y can be approximately described by a straight line with linear and angular coefficients equal to α and β respectively, which are initially unknown, but estimated based on the data, usually by the Ordinary Least Squares Method (Bussab and Morettin, 2017). In our study, the variable x will represent the year and y will represent the indicator in question (number of courses, enrollments or graduates). In addition, in the analysis to be carried out, the main interest in the regression line will be in the estimate of β , since this coefficient measures the average variation of the indicator y associated with the variation of one unit of the variable x . Thus, in our study, β measures the average variation (increase or decrease) of indicator y per year.

Fitting a simple linear regression model may or may not be plausible for relating two variables. For that, there are several statistical techniques to analyze the quality (goodness) of the adjustment made. Furthermore, for each estimated coefficient, its statistical significance is verified by calculating the p-value. In this study, a significance level of 5% is adopted, so that the coefficient will be statistically significant if its p-value is less than 5%. If it is greater than or equal to 5%, the hypothesis that it is null is not rejected. For more details on descriptive statistical techniques, statistical inference, and simple linear regression models, see Bussab and Morettin (2017). For further study on linear regression techniques, see Montgomery et al. (2021).

3 Results and Discussion

The following subsections present and discuss the results on the number of courses for major in Mathematics in in-person and distance learning modalities, as well as the number of enrollments and numbers of graduates in these courses at public and private HEIs. In addition, the relationships between the number of new entrants and the number of offered positions in in-person and distance learning courses without considering the type of HEI are also discussed.

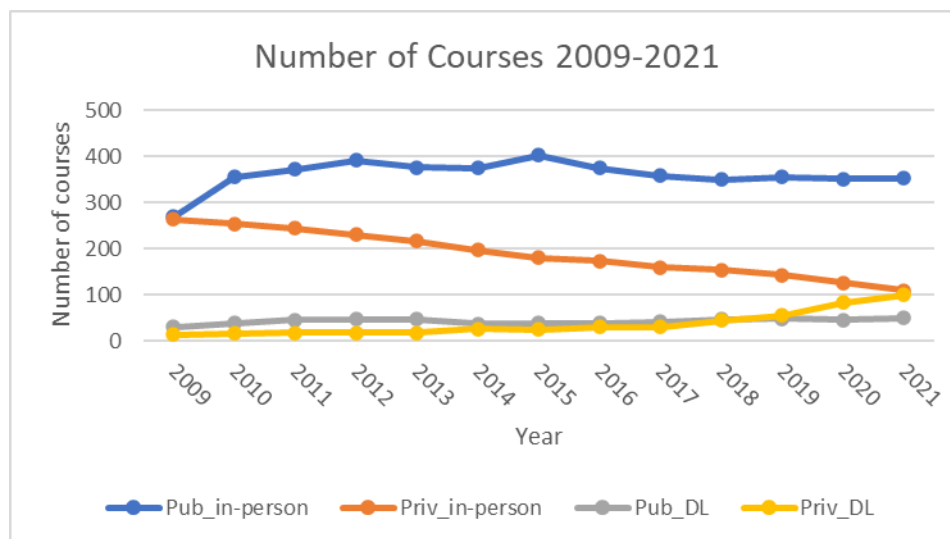
3.1 Number of courses for major in Mathematics in Brazil between 2009 and 2021

The number of courses for major in Mathematics is essential to analyze the evolution of such area in Brazil, since it indicates the demand on the part of students for courses and the attention of HEIs regarding their offers. Graph 1 presents the trajectories of the numbers of courses for major in Mathematics between 2009 and 2021 for public and private institutions and in-person and distance learning modalities. It can be seen in the graph that in-person courses at public institutions are predominant in the country over the period considered. There was even an increase in the number of courses in this category from 269 to 403 between 2009 and 2015 and, as of 2016, the number remained stable, with little variation, reaching 353 courses in 2021. In the same graph it is possible to detect a drop of the number of in-person courses at private institutions during the period. This drop increased the distance between the numbers of in-person courses at public and private institutions between 2009 and 2021. In 2009, there were 264 in-person courses at private HEIs, that is, only 5 courses less than at public HEIs. In 2015, the number of in-person courses at private HEIs reduced to 181 courses and in 2021 reached 110 courses, that is, in this last year, there were 243 more in-person courses in public institutions compared to private ones.

In relation to courses in the distance learning modality, Graph 1 also shows the evolution of such courses in private institutions. In fact, at the beginning of the period considered, in 2009, the number of distance learning courses in private institutions (13) was even lower than that of public institutions (31). As of 2019, the order was reversed, that is, the number of distance learning courses in private institutions exceeds that of public institutions, reaching twice the number (100) in public institutions (50) in 2021. Although the numbers of

courses in the distance learning modality are lower than the in-person courses in general (in 2021, there were 463 in-person courses against 150 in DL) it is possible to see the approximation of the number of distance learning courses in relation to the in-person courses in private institutions. In 2021, there were 110 private in-person courses against 100 distance learning courses in this administrative category.

Graph 1: Number of courses for major in Mathematics in Brazil between 2009 and 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

Table 1 compares the numbers of courses for major in Mathematics in 2009 and in 2021, with their percentage changes in the period. The numbers in the private institutions stand out. In these institutions, between 2009 and 2021, there was a 58% reduction in the number of in-person courses, falling from 264 courses in 2009 to 110 in 2021, and a 669% increase in distance learning courses, from just 13 courses in 2009 to 100 in 2021. In this way, the number of private DL courses for training Mathematics teachers grew approximately 7 times between 2009 and 2021. DL courses in public institutions.

Table 1: Number of courses for major in Mathematics in Brazil between 2009 and 2021 and its percentual variation.

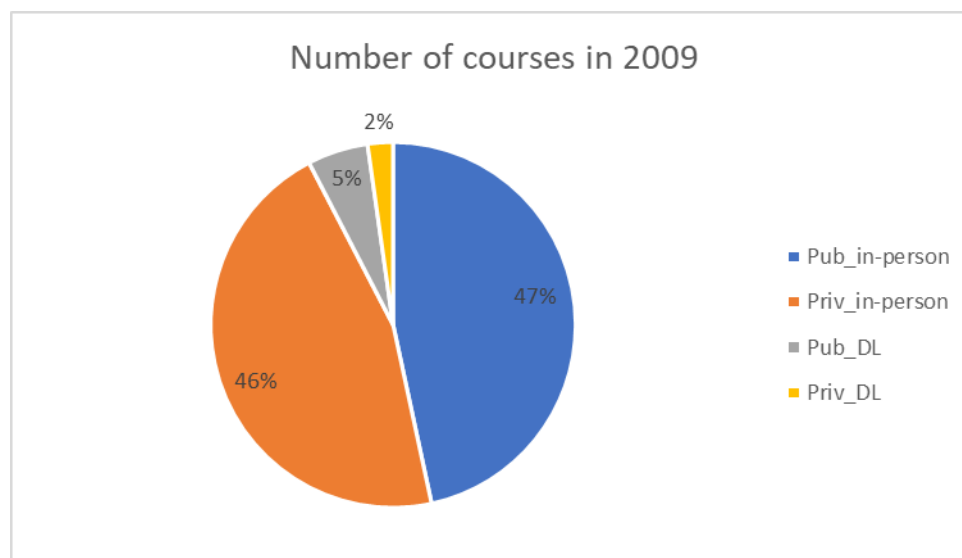
Year	Public in-person	Private in-person	Public DL	Private DL
2009	269	264	31	13
2021	353	110	50	100
Variation	31%	-58%	61%	669%

Source: The author and Higher Education Census of INEP between 2009-2021.

Graphs 2 and 3 show the proportions of the number of courses in each category in 2009 and 2021 respectively. Such graphs confirm the dominance of in-person courses in public institutions, while they show the evolution of courses in the distance learning modality in private institutions. In 2009, 47% of Courses for major in Mathematics were in-person at public institutions, 46% were in-person at private HEIs and only 2% were at a distance at

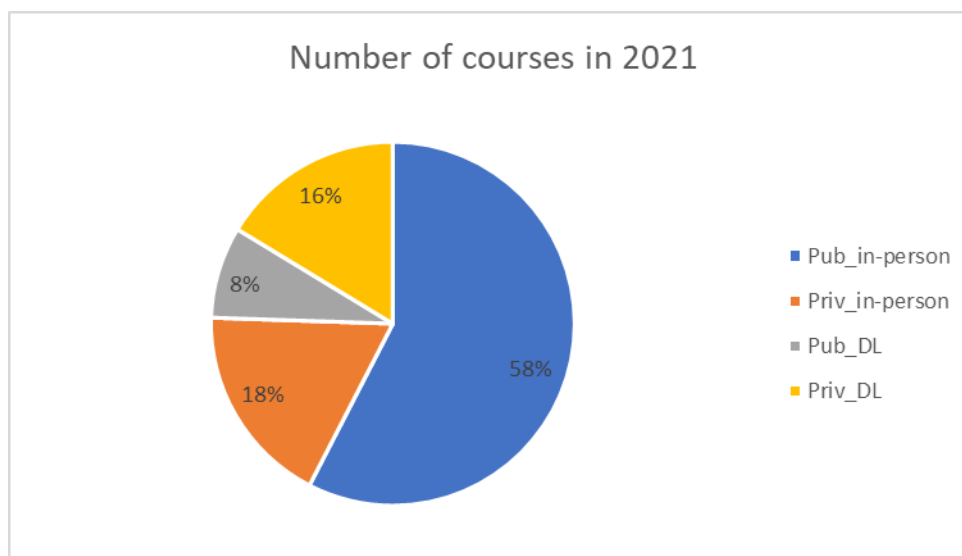
private institutions. In 2021, 58% of courses are in-person at public institutions, only 18% are in-person at private institutions and 16% are distance learning at private HEIs. It is also noted that the proportion of distance learning courses in public institutions did not have significant variation, going from 5% in 2009 to 8% in 2021.

Graph 2: Proportion of courses for major in Mathematics in Brazil in 2009.



Source: The author and Higher Education Census of INEP between 2009-2021.

Graph 3: Proportion of courses for major in Mathematics in Brazil in 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

Finally, Table 2 shows the estimates of the coefficients of the simple linear regression model adjusted to data on the number of courses in the period, in addition to standard errors, t statistics and p-values to assess the significance of the coefficients. We emphasize that the main interest in the adjustments made is in the coefficient β (angular coefficient), which represents the speed of growth or decrease of the variable. Thus, we can observe in the table

that the adjustments related to in-person and distance learning courses from public institutions and distance learning courses from private institutions show positive estimates of angular coefficients, indicating average growth in the considered period. In fact, the results obtained for private institutions are statistically significant at a significance level of 5%, where the estimated growth rate is 6.08 distance learning courses per year while in-person courses decrease at an estimated rate of 12.83 courses per year.

In relation to public institutions, in-person courses grow at an estimated rate of 1.41 courses per year and distance learning courses grow modestly, at an estimated rate of 0.84 courses per year. However, we must emphasize in the adjustments of public institutions that, under a significance level of 5%, the coefficient β of the adjustment of in-person courses is not statistically significant, with a p-value of 0.57 and the same coefficient in the adjustment of distance learning courses is significant, but with a p-value (0.04) close to the significance level adopted.

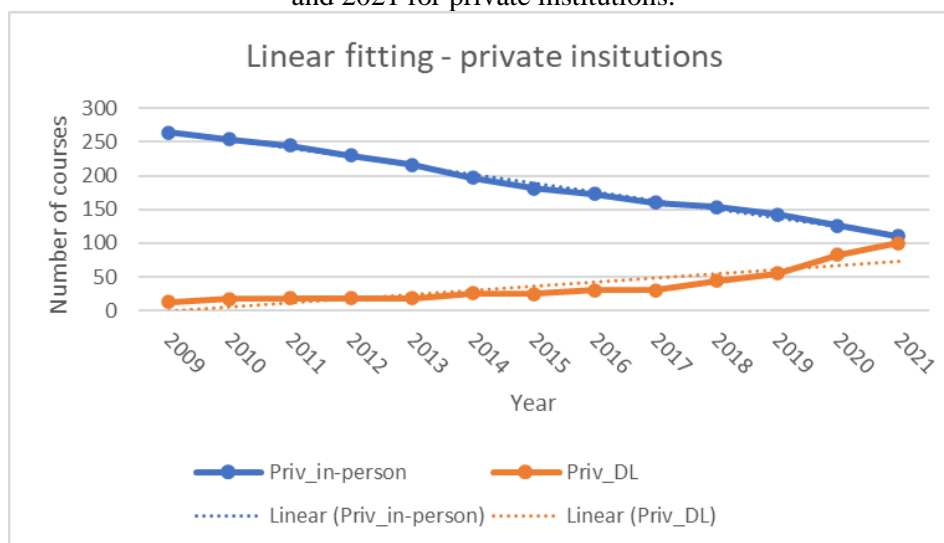
In fact, the simple linear regression model did not prove to be suitable for adjusting data on the number of courses in public institutions, however, it proved to be interesting for adjusting such data for private institutions. This is due to the growth behavior of distance learning courses and the decrease of in person courses at private institutions throughout practically the entire period considered, which favors the linear adjustment, as can be seen in Graph 4.

Table 2: Estimates, standard errors, t statistics and p-values of the linear regression coefficients for the number of courses for major in Mathematics in Brazil between 2009 and 2021.

	Estimate	Standard error	T statistic	p-value
Public in-person				
α	351,75	17,21	20,44	<0,001
β	1,41	2,43	0,58	0,57
Private in-person				
α	265,70	2,17	122,68	<0,001
β	-12,83	0,31	-41,90	<0,001
Public DL				
α	37,76	2,52	15,01	<0,001
β	0,84	0,36	2,35	0,04
Private DL				
α	0,23	7,34	0,03	0,98
β	6,08	1,04	5,85	<0,001

Source: The author.

Graph 4: Linear fittings for the number of courses for major in Mathematics in Brazil between 2009 and 2021 for private institutions.



Source: The author and Higher Education Census of INEP between 2009-2021.

In general, we found that private institutions stand out in relation to the provision of courses in the opposite directions in which the teaching modalities walk. While the supply of in-person courses drops year after year in the period considered, distance learning courses have shown substantial growth in this administrative category. We emphasize, however, that the number of training courses for Mathematics teachers in Brazil is dominated by public institutions, and in the in-person modality. The share destined for public DL courses is a minority, although it grew timidly between 2009 and 2021.

The two subsections below analyze whether enrollments and graduates follow the trajectories observed in the number of courses in the considered categories.

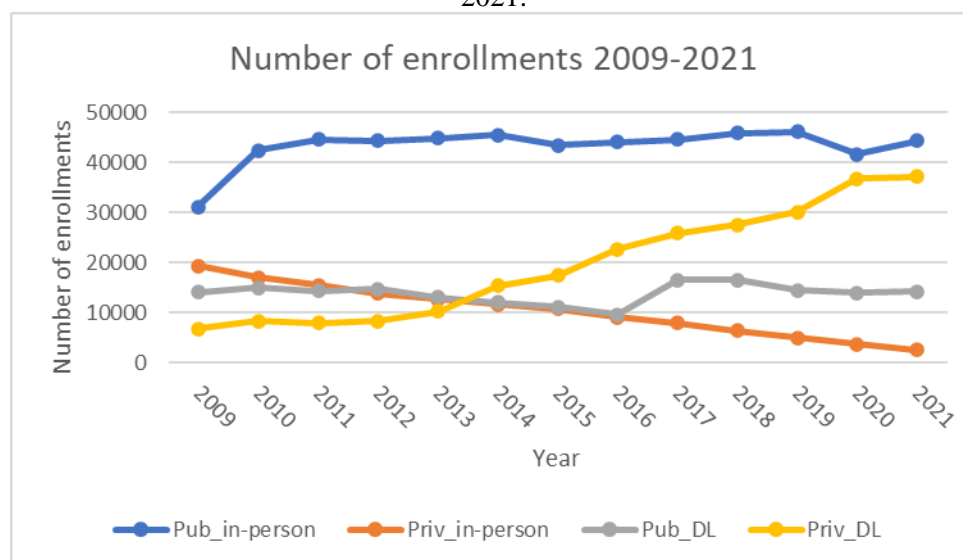
3.2 Number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021

As well as the number of courses, the number of enrollments in courses for major in Mathematics is important for us to understand the demand for courses by the population and the trajectory of each modality in public and private institutions.

Graph 5 shows the number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021. We can observe, as well as the number of courses in the previous subsection, the predominance of enrollments in in-person courses at public institutions across the country. considered period. In this category, there was a large increase at the beginning of the series, from 31,186 enrollments in 2009 to 42,442 enrollments in 2010 and, since then, the number of enrollments has been stable, between 44,000 and 46,000 in the rest of the series. Little variation is also observed in the number of enrollments in distance learning courses at public institutions. Despite a drop between 2013 and 2016, this category remained in third place in the number of enrollments throughout the period, with 14,039 enrollments in 2009 and 14,224 enrollments in 2021.

Courses at private institutions, on the other hand, evolved radically in opposite directions. The number of enrollments in in person courses at private HEIs, which was the second highest in 2009 with 19,367 enrollments, decreases throughout the period, reaching 2,606 enrollments in 2021. In 2012, the number of enrollments in in person courses at private institutions is surpassed by the number in distance learning courses from public institutions and in 2014 also by the number of distance learning courses from private institutions, becoming the smallest among the categories considered since then. On the other hand, enrollments in distance education courses at private institutions, which in 2009 were the lowest, with 6,781 enrollments, have grown throughout the period, and aggressively since 2014, reaching 37,122 enrollments in 2021. In fact, since 2014 the distance learning courses from private institutions have the second highest number of enrollments among the categories considered in Brazil, second only to in-person courses from public HEIs.

Graph 5: Number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

Table 3 shows the enrollments in 2009 and 2021 and percentage variations, which emphasizes the situation of courses for major in Mathematics in private HEIs. In this class, while in-person courses had an 87% drop in the number of enrollments in the period, distance learning courses showed an increase of 447% in the same period. It is also noteworthy that public institutions showed an increase in the period, with 42% in in person courses and only 1% in distance learning courses.

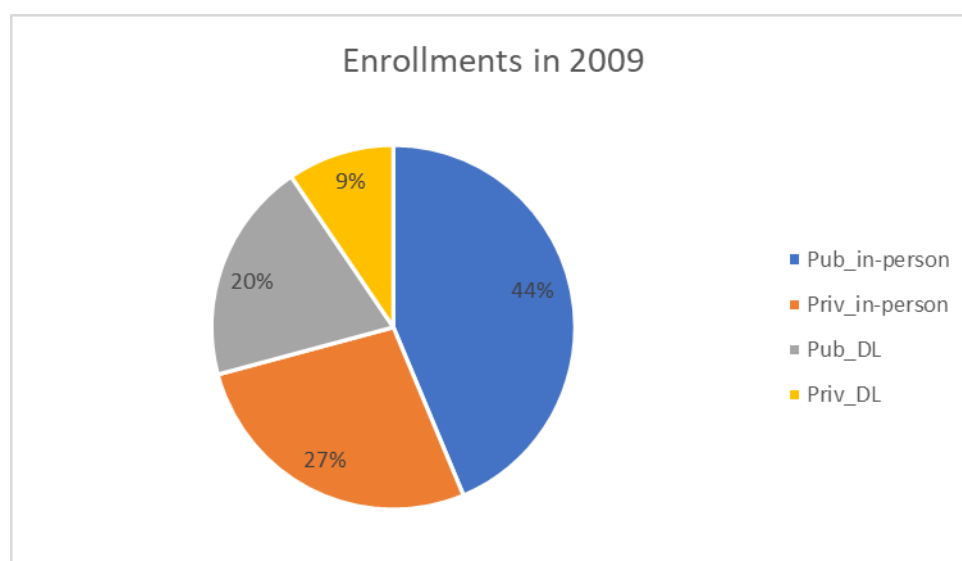
Table 3: Number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021 and its percentual variation.

Year	Public in-person	Private in-person	Public DL	Private DL
2009	31.186	19.367	14.039	6.781
2021	44.298	2.606	14.224	37.122
Variation	42%	-87%	1%	447%

Source: The author and Higher Education Census of INEP between 2009-2021.

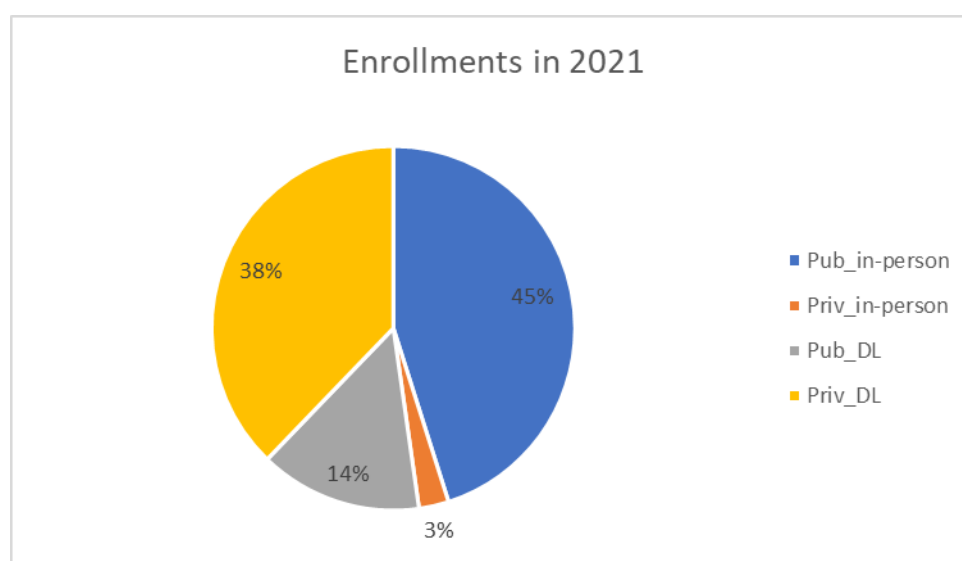
Graphs 6 and 7 show the proportions of enrollments in each category in 2009 and 2021 respectively. In person courses at public institutions increased from 44% of enrollments in Courses for major in Mathematics in 2009 to 45% in 2021. Despite the 1% increase in the number of enrollments in distance learning courses at public institutions, as shown in Table 2, the category drops from 20% of enrollments in 2009 to 14% in 2021. In the private sector, in person courses accounted for 27% of enrollments in 2009, the second highest proportion among categories, falling to a surprising 3% of enrollments in 2021, making it the smallest share of enrollments among the categories. In the opposite direction, private DL courses had 9% of enrollments in 2009 and evolved to 38% in 2021, the second largest share this year.

Graph 6: Proportion of enrollments in courses for major in Mathematics in Brazil in 2009.



Source: The author and Higher Education Census of INEP between 2009-2021.

Graph 7: Proportion of enrollments in courses for major in Mathematics in Brazil in 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

The adjustments of the data on the number of enrollments by the simple linear regression model show, as in the case of the number of courses, statistically significant values for private institutions. According to Table 4, for this category, an average increase of 2,801.22 enrollments per year in distance learning courses and an average reduction of 1,340.24 enrollments per year in in person courses is estimated. Both values were significant under the 5% significance level, according to their p-values. By the way, the intercepts of both adjustments, represented by the coefficient α , are also statistically significant. In this way, the simple linear regression model adjusted well to the data from private institutions, as can also be seen in Graph 8 and justified by the increasing behavior of the number of enrollments in DL courses and decreasing in in person courses in this category of institutions in practically the entire period considered.

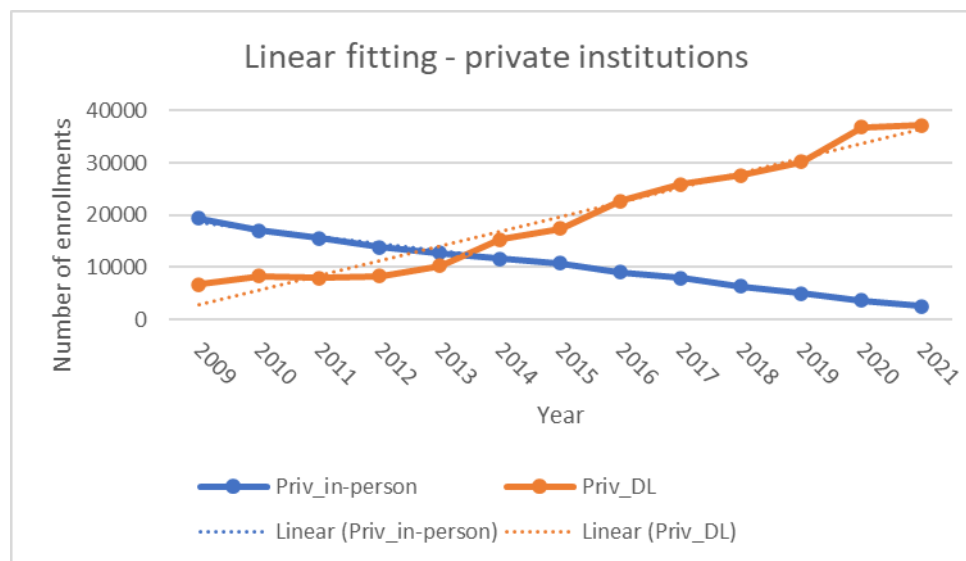
On the other hand, the linear regression model did not prove to be suitable for adjusting enrollment numbers in public institutions. The punctual estimates of the angular coefficient β are positive both in in-person and distance learning courses, according to Table 4, which indicates growth in both courses. In person courses have an estimated average growth of 464.11 enrollments per year and distance learning courses show a more modest growth, of 29.17 enrollments per year according to linear adjustments. However, such values are not statistically significant, with p-values of 0.11 and 0.85 for in-person and distance learning courses, respectively, above the 5% significance level. Therefore, other statistical models would be necessary to analyze the speed of enrollment growth in public institutions.

Table 4: Estimates, standard errors, t statistics and p-values of the linear regression coefficients for the number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021.

	Estimate	Standard error	t statistic	p-value
Public in-person				
α	40.534,19	1.863,75	21,75	<0,001
β	464,11	263,57	1,76	0,11
Private in-person				
α	18.466,86	198,51	93,03	<0,001
β	-1.340,24	28,07	-47,74	<0,001
Public DL				
α	13.653,59	1.071,96	12,74	<0,001
β	29,17	151,60	0,19	0,85
Private DL				
α	2.775,99	1.271,89	2,18	0,05
β	2.801,22	179,87	15,57	<0,001

Source: The author.

Graph 8: Linear fittings for de number of enrollments in courses for major in Mathematics in Brazil between 2009 and 2021 for private institutions.



Source: The author and Higher Education Census of INEP between 2009-2021.

Therefore, enrollments have evolved in opposite directions in the private sector, as has occurred in the offer of courses in the period. While the distance learning modality leaves the last place in 2009 among the considered categories and becomes the second with the highest number of enrollments since 2014, the private classroom courses had an abrupt drop in enrollments and represented in 2021 the smallest slice of this indicator among the categories. Enrollments were higher in in-person courses at public HEIs in the country throughout the entire period, although the difference with private distance learning courses has decreased in recent years.

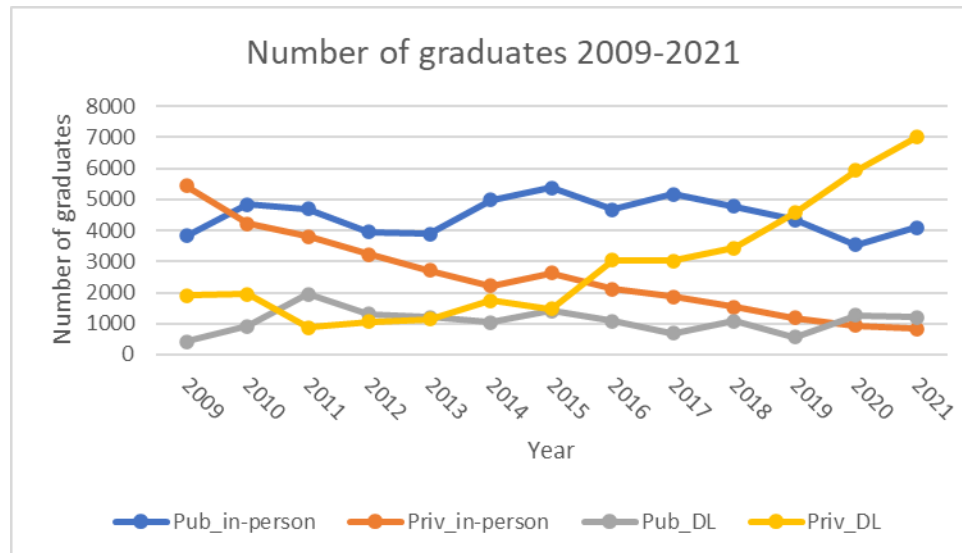
3.3 Number of graduates in courses for major in Mathematics in Brazil between 2009 and 2021

The number of graduates allows us to analyze the evolution of the number of new Mathematics teachers in the market over the years. Graph 9 presents the number of graduates in Courses for major in Mathematics in Brazil between 2009 and 2021. A change observed in relation to the previous variables is that, although in-person courses at public institutions present the highest number of graduates in a significant part of the period considered in the study, namely, between 2010 and 2018, this number was lower than that of in person courses at private institutions in 2009 and, as of 2019, it was surpassed by distance learning courses at private institutions. It is important to emphasize that such behavior does not refer to any significant variation in the number of graduates in in person courses at public HEIs, but refer to the phenomenon of private institutions, which showed a large increase in the number of graduates in distance learning courses and a large drop in in person courses in the period.

Regarding private institutions, in-person courses had 5,446 graduates in 2009, the highest number in that year among the categories considered. In that same year, distance learning courses had 1,900 graduates, above only distance learning courses in public institutions, which had only 428 graduates. In 2016, distance learning courses surpassed in-person courses in the private sector for the first time, with 3,046 completing the former versus 2,113 completing the latter. As already mentioned, in 2019, DL courses at private HEIs surpassed (4,565 graduates) in-person courses at public HEIs (4,348 graduates) and became the category with the highest number of graduates since then. In 2020, the number of graduates of in person courses at private HEIs (942) was surpassed by the number of DL courses at public HEIs (1,270) and became the category with the lowest number of graduates among the categories since then.

In 2021, distance learning courses at private HEIs reached the mark of 7,004 graduates, followed by in-person courses at public HEIs, with 4,095 graduates, while distance learning courses at public HEIs had 1,207 graduates and finally, in-person courses at private HEIs ended with just 834 graduates. Thus, in relation to the private sector, the number of graduates of DL courses is approximately 8.4 times greater than in in-person courses. In the public sector, in-person courses had a number of graduates approximately 3.4 times higher than distance learning courses in 2021.

Graph 9: Number of graduates in courses for major in Mathematics in Brazil between 2009 and 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

Table 5 compares the number of graduates in 2009 and 2021 and their percentage changes between the two years. In terms of variations, distance learning courses stood out, with an increase of 269% in private institutions and 182% in public ones. In person courses at public institutions showed an increase of 7% in the number of graduates, while at private institutions there was a reduction of 85% in the number of graduates.

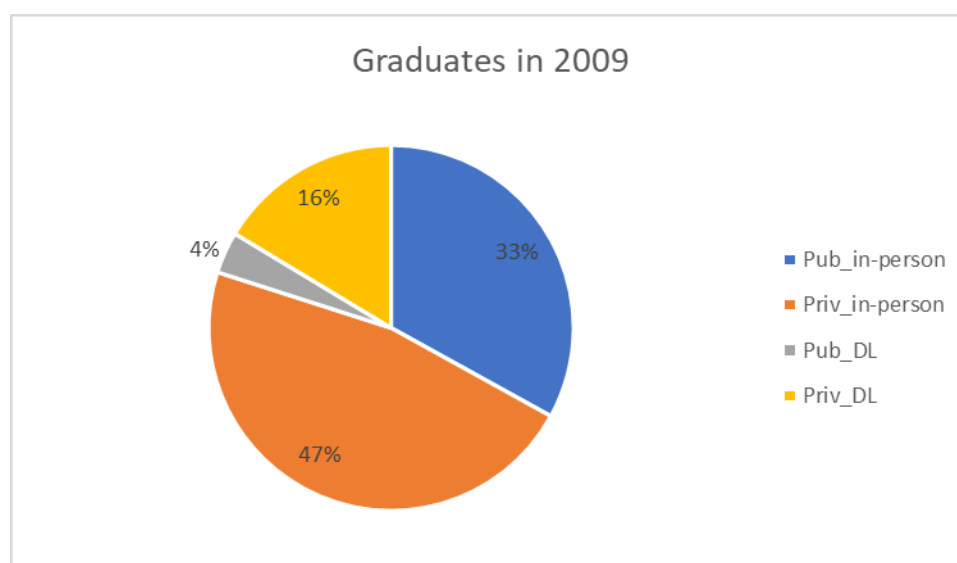
Table 5: Number of graduates in courses for major in Mathematics in Brazil between 2009 and 2021 and its percentual variation.

Year	Public in-person	Private in-person	Public DL	Private DL
2009	3.832	5.446	428	1.900
2021	4.095	834	1.207	7.004
Variation	7%	-85%	182%	269%

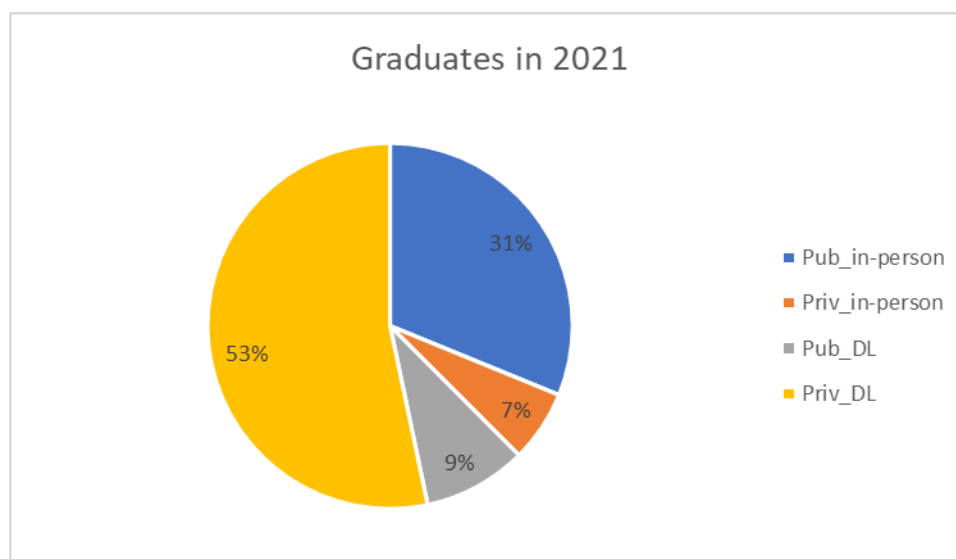
Source: The author and Higher Education Census of INEP between 2009-2021.

Graphs 10 and 11 show the proportions of graduates in the categories considered in 2009 and 2021 respectively. Such graphs emphasize the growth of the share of graduates in distance learning courses. In 2009, distance learning courses jointly accounted for 20% of graduates, 16% in private HEIs and 4% in public ones. Thus, in-person courses accounted for 80% of graduates, comprising 47% of private HEIs and 33% of public ones. In 2021, DL courses accounted for 62% of graduates, comprising 53% of private HEIs and 9% of public ones. In person courses formed 38% of the graduates together, 31% from public institutions and only 7% from private HEIs.

Graph 10: Proportion of graduates in courses for major in Mathematics in Brazil in 2009.



Source: The author and Higher Education Census of INEP between 2009-2021.

Graph 11: Proportion of graduates in courses for major in Mathematics in Brazil in 2009.

Source: The author and Higher Education Census of INEP between 2009-2021.

As occurred in the analysis of the number of courses and enrollments, the adjustments of the number of graduates using the simple linear regression model provided statistically significant results for private institutions. Table 6 presents the estimates, standard errors, t-statistics and the p-values of the adjustments made. Regarding private institutions, we can see in the table that distance learning courses have an estimated average growth of 425.80 graduates per year, while in-person courses show an estimated average reduction of 337.49 graduates per year. These estimates reflect the evolution, in terms of number of graduates, of the distance learning modality in the private segment, with a significant increase mainly since 2016 and the retraction of the same variable in the in-person modality in practically the entire period considered in the study.

Still in the private sector, we can associate the average growth in the number of graduates in distance learning courses with the average growth in the number of enrollments (2,801.22 per year), although this number is approximately 6.58 times the first, that is, the growth estimated average number of enrollments in distance learning courses is 6.58 times the estimated average growth in the number of graduates in the same modality. The same reasoning can be used in relation to in-person courses, which have a decrease in the number of enrollments (-1,340.24 per year), which impacts on the decrease in the number of graduates, although at different speeds. In fact, the estimated average decrease in the number of enrollments in in-person courses is approximately 3.97 times the estimated decrease in the number of graduates in the modality.

In relation to public institutions, the adjustments of the number of graduates by the linear regression model were not adequate, that is, the average evolution of this variable is not well modeled by a regression line. Note also that, according to Table 6, the estimated values for β are not significant, with p-values of 0.85 for in-person courses and 0.89 for distance learning courses. Thus, although the punctual estimates obtained by the adjustments are

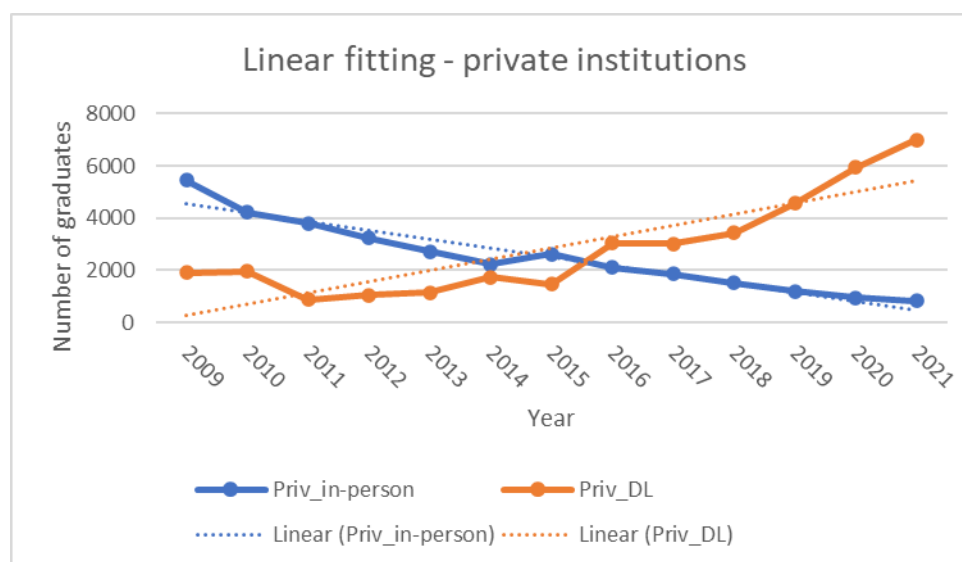
negative (-8.52 and -4.25 for in person and distance learning courses, respectively), we do not reject the hypothesis that such coefficients are null. In this way, linear adjustments are useful for data from private institutions and can be seen in Graph 12.

Table 6: Estimates, standard errors, t statistics and p-values of the linear regression coefficients for the number of graduates in courses for major in Mathematics in Brazil between 2009 and 2021.

	Estimate	Standard error	t statistic	p-value
Public in-person				
α	4.528,56	312,59	14,49	<0,001
β	-8,52	44,21	-0,19	0,85
Private in-person				
α	4.543,81	205,32	22,13	<0,001
β	-337,49	29,04	-11,62	<0,001
Public DL				
α	1.112,29	215,92	5,15	<0,001
β	-4,25	30,54	-0,14	0,89
Private DL				
α	301,11	547,53	0,55	0,59
β	425,80	77,43	5,50	<0,001

Source: The author.

Graph 12: Linear fittings for de number of graduates in courses for major in Mathematics in Brazil between 2009 and 2021 for private institutions.



Source: The author and Higher Education Census of INEP between 2009-2021.

Therefore, the number of graduates followed the trend observed in enrollments and number of courses analyzed in the previous subsections. The highlight, however, occurs in the superiority of private DL courses in this indicator from 2019, that is, since this year the largest share of graduates in Mathematics teacher training come from distance learning

courses from private institutions in Brazil. Private in person courses formed the smallest share since 2020 among the categories considered and showed a reduction in this indicator year after year over practically the entire period.

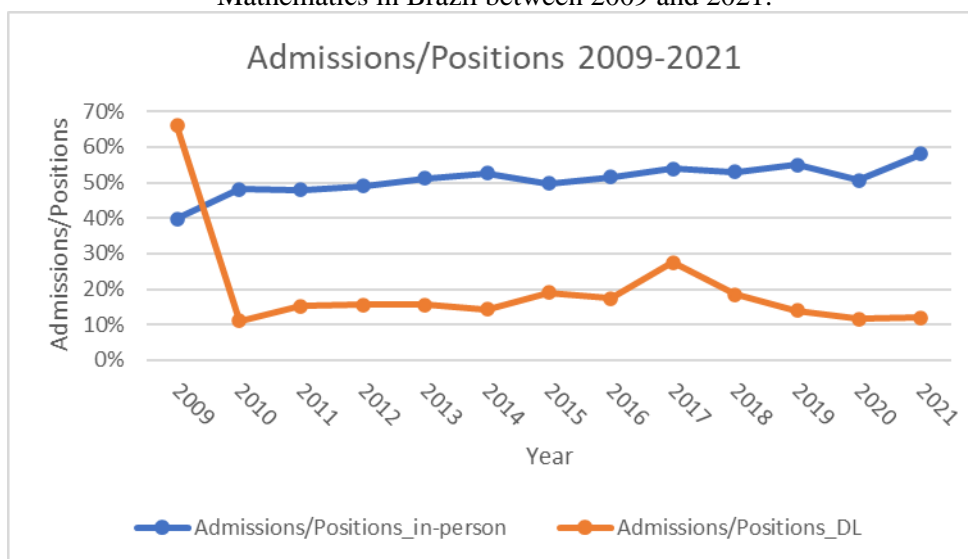
3.4 Ratio between the numbers of admissions and available positions in courses for major in Mathematics in Brazil between 2009 and 2021

For the analysis of the degree of occupancy of Mathematics teacher training courses, the ratio between the number of admissions and the number of positions offered in the courses is a measure that allows us to carry out such an analysis. This relationship can be obtained in percentage terms by dividing the number of admissions by the number of positions offered and, later, multiplying by 100, without distinguishing between public and private institutions. Thus, the analysis here is concentrated on the comparison between in-person and distance learning courses.

Graph 13 shows the ratio between the numbers of admissions and positions offered (in percentage) in Courses for major in Mathematics in Brazil between 2009 and 2021 by teaching modality. In fact, as expected, the ratio was higher in in-person courses in practically the entire period considered. Only in 2009, at the beginning of the series, did distance learning courses present a higher ratio (66%) than in-person courses (40%), probably due to the small number of DL courses in that year. In 2010, the ratio for distance learning courses dropped sharply to 11%, being surpassed by the ratio for in person courses, which had a slight increase to 48% and, since then, the ratio has been higher for in person courses. We can also observe that the ratios of both modalities were stable from 2010 onwards, that is, they suffered little variation over the years. Only between 2016 and 2017 can we observe a jump in the distance mode curve, from 17% to 28%, returning to the usual values in 2019.

The differences in behavior between the modalities can be explained mainly by the number of positions offered in each modality. For example, in 2021, in-person courses offered 21,228 places, while distance learning courses offered 216,329 places, that is, the offer in distance learning courses was approximately 10.2 times greater than in in-person courses in 2021. it should be noted that such a difference can be justified by the physical limitation regarding the offer of positions existing in in-person courses, which does not occur in distance learning courses, since these are conducted virtually and, if there are in-person activities, these are usually carried out in poles of distance education of HEIs, in a decentralized way.

Graph 13: Ratio between the numbers of admissions and available positions in courses for major in Mathematics in Brazil between 2009 and 2021.



Source: The author and Higher Education Census of INEP between 2009-2021.

Table 7 presents the comparison between the ratios of new entrants and positions between the teaching modalities in 2009 and in 2021, with their percentage variations between these years.

It is observed that, while the ratio increased by 45% between 2009 and 2021 for in-person courses, this measure decreased by 82% for distance learning courses, which can be explained by the increase in the number of courses and, consequently, positions offered in this modality.

Table 7: Ratio between the numbers of admissions and available positions in courses for major in Mathematics in Brazil between 2009 and 2021 and its variation.

Year	In-person	DL
2009	40%	66%
2021	58%	12%
Variation	45%	-82%

Source: The author and Higher Education Census of INEP between 2009-2021.

In general, the ratios between admissions and positions did not change significantly over the period considered, except from 2009 to 2010 in distance learning courses. In-person courses, as expected, had higher ratios than distance learning courses, with considerable distances between the modalities. The private sector has great influence on the calculated ratios, due to the sharp increase in positions in DL courses and the reduction in them in in-person courses between 2009 and 2021.

4 Conclusions

The present study was carried out with the objective of statistically describing the scenario of training courses for Mathematics teachers in Brazil in the period from 2009 to 2021 in relation to the number of courses, enrollments, graduates, admissions and positions offered by teaching modality (in-person and DL) and administrative category (public and private). For that, we used data extracted from the Census of Higher Education of INEP in the period considered and through graphs and descriptive tables, the analyzes were conducted. In addition, still with a descriptive focus, simple linear regression models were adjusted to estimate the average growth (decrease) of each indicator in the classes formed by teaching modality and administrative category.

In general terms, the analyzes showed stability regarding the indicators considered in public institutions in the considered period. In fact, public in-person courses are dominant in the country in terms of quantity and enrollment, while public distance learning courses grow in terms of indicators, albeit timidly.

The major highlights of the analyses, however, are found in the behavior of the private sector. In this administrative category, teaching modalities evolved in opposite directions between 2009 and 2021. In person courses showed a practically linear decline in all indicators, while distance learning courses grew linearly in them. In 2021, in-person courses at private institutions represent the smallest share of enrollments and graduates among the four classes of teaching modalities and administrative categories, even surpassed by DL courses at public institutions. Private distance learning courses are responsible for the largest number of graduates in Mathematics in the country since 2019, surpassing in-person courses at public HEIs, in addition to having the second largest number of enrollments in the area since 2014.

The trajectories of the modalities in the private sector had an impact on the ratios between admissions and positions by modality. The growth in the offer of distance learning courses in this sector caused a drop in the ratio of admissions and positions in the distance mode, while the reduction in the offer of in person courses had an impact on the increase of this ratio in the in-person modality.

The analysis of the scenario of courses for major in Mathematics by region or even by Brazilian state, as well as comparisons with other undergraduate courses, as well as possible impacts of the scenario described at the national level on the quality of teacher training are suggestions for further studies. futures.

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