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STUDENTS WITH DISABILITIES AND HIGHER EDUCATION ATTAINMENT: PREDICTORS AND ARTIFICIAL INTELLIGENCE

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ABSTRACT

Support actions appropriate to the needs of students with disabilities in Higher Education to complete the course are fundamental. Prediction studies, through artificial intelligence, in the educational context for this audience can contribute to improving inclusion policies and minimize academic, social, economic, and political damage caused to all involved. It sought to identify the predictive factors for the completion of Higher Education of students with disabilities through artificial intelligence. This is an exploratory, retrospective study, with a database composed of 563 students with disabilities enrolled in undergraduate courses from 2001 to 2020. Input variables: sociodemographic and academic variables indicated at the time of enrollment. The accuracy of five algorithm models was tested to identify the one with the best performance. XGBoost was the model with the best performance in identifying the predictor variables for higher education completion (ACC=76.38%). The SHAP method of post hoc interpretation was used to identify the degree of importance, the characteristics of each of them, and their relationship with the outcome variable. The predictor factors for completing the course for this audience were high school modality, form of admission, grade in the selection process, age, and gender. The prior identification of predictors for non-completion of the course by students with disabilities can be an important tool that helps the institution to direct actions and resources

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to meet the needs of these students early and contribute to their permanence, completion of the course, and future occupational perspective.

Keywords: Undergraduate. People with Disabilities. Machine Learning. Predictors.

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INTRODUCTION

The inclusion of people with disabilities in education has been defined as a State policy (Teixeira et al., 2022). To expand and favor the possibility of training people with disabilities in Higher Education, in 2016 Law No. 13,409 was published, which instituted the reservation of vacancies for this public in higher education courses. Since then, there has been a growing number of enrollments of students with disabilities in universities (Silva; Pimentel, 2022).

According to data from the Higher Education Census, in 2022 the total enrollment in undergraduate courses was 9,444,116, with a growth of 5.1% compared to 2021. Of this total, 79,262 undergraduate enrollments are declared with a record of disability, global developmental disorder, or high abilities/giftedness, which corresponds to 0.83% of the total enrollments at this level of education. Comparing the number of enrollments of students with disabilities in 2022 with the previous year, there is a growth of 25% (National Institute of Educational Studies and Research Anísio Teixeira [INEP], 2023, 2024).

Entering university demystifies the idea that people with disabilities are incapable or inferior (Rossetto, 2009) and has a meaning that goes beyond professional qualification. It represents overcoming barriers and prejudices, in addition to occupying social places that were previously unthinkable and intended only for normal people (Borges et al., 2017). However, despite being a constitutional right, access to university does not imply permanence and completion of the course; and inclusion in Higher Education is still short, unequal, and far from adequate (Brum; Barbato; Oliveira, 2020; Gomes et al., 2021; Teixeira et al., 2022).

If entering the university brings with it the search for training, professional identity, and the future perspective of insertion in the labor market (Menezes, 2018; Silva et al., 2022), in addition to being the realization of a dream often considered impossible for this public, the diploma is of paramount importance. It is therefore necessary to monitor students with disabilities in Higher Education from the moment of access, through their permanence and participation, until the conclusion of the undergraduate course (Menezes, 2018).

Cabral, Orlando, and Meletti (2020) report a discrepancy between the number of students who finish high school and those who enter higher education, which signals the need to discuss the number of students who manage, in addition to access, to complete their studies at the higher level. Research reports that, regardless of the modality of Higher

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Education, it is essential to identify, for example, which students have the prospect of higher or lower academic performance with the possibility of approval or not at the end of the semester, as these data can contribute significantly to the anticipation and implementation of the necessary and individualized support, aiming to meet the specific demands of each student (Candido; Birth; Martins, 2016; Filatro, 2020; Silva; Pimentel, 2022). The performance of students during their academic trajectory may depend on factors such as family history, economic situation, performance in mid-semester exams, and previous academic record, among others. Thus, the identification of what these factors are, how they impact the trajectory of these students, and when this happens is fundamental. It is also essential to apply and use intervention resources as early as possible to obtain graduation completion.

For Abed, Ajoodha, and Jadhav (2020), the offer of good academic guidance for all students, especially those with disabilities, is the key to the success and completion of the course and is directly linked to the search for new paths, and it is necessary to face barriers – and fight against them – and attend to the plurality of students. Understanding the decisions that led them to choose and enroll in their courses, with consequent implications for their future, is considered vital for academic development and the core of each student's trajectory.

In this sense, Goodman et al. (2011) and Martinho (2014) highlight the need for prediction studies in the educational context aimed at this public to minimize social, economic, political, academic, and financial losses caused to all those involved in the educational process. They also consider that not all students develop at the same pace, as each one has their qualities and abilities, and, therefore, it is necessary to verify characteristics and barriers that can interfere with their permanence in the university.

The timing of admission to the university becomes crucial. The identification of predictive factors for the completion of graduation of students with disabilities should be done as early as possible, because, in this way, institutional actions and learning support for students with disabilities can be implemented in a timely and satisfactory manner. From this perspective, the present study aimed to identify, through artificial intelligence (AI) analysis, the possible predictive factors for the completion of Higher Education by students with disabilities.

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METHODOLOGY

This study is part of a larger study entitled "Profile of Students with disabilities entering undergraduate and Graduate Courses at a Higher Education Institution and their academic trajectory: An Analysis of Secondary Data", approved by the Ethics Committee of the Federal University of Minas Gerais (UFMG), CAAE No. 35465120.8.0000.5149. This is an exploratory, quantitative, and retrospective study, whose data were made available by a public institution of Higher Education in Minas Gerais.

The database was composed of information from 563 students who entered a higher education course at UFMG, from 2001 to 2020, and who indicated that they had a disability, regardless of gender and the type of admission vacancy.

The database was composed of information: i) socioeconomic and demographic; ii) related to the academic trajectory before entering the university; and iii) related to the moment of entry into the university. This information was coded as input variables – age, gender, disability, grade in the selection process, high school modality, area of knowledge of the chosen course, among others – and outcome. The outcome variable was classified as (1) when the student with disabilities completed the course; and (2) when the student was dismissed from the institution without completing the higher education course.

The following models were used: Logistic Regression (LR), K-Nearest Neighbours (KNN), Light Gradient Boosting Machine (LGBM), Randon Forest (RF), and Extreme Gradient Boosting – XGBoost – (Silva, 2021). In all analyses, the Python programming language was used. The Stratified K-fold method was used to divide the database into training and testing subsets. According to Silva (2021), Bayesian optimization was applied with 15-fold cross-validation (K=15).

The models were evaluated for their performance based on accuracy; the confusion matrix; the F1 Score; and the area under the curve (ROC AUC). Accuracy of 71% to 80% is considered moderate and above 81%, is good (Cooper, 2021; Lima, 2022; Silva, 2021). The F1 Score with higher values was considered indicative of high precision. Models with a ROC curve of 0.7 to 0.8 are considered acceptable; from 0.8 to 0.9, excellent; and from 0.9 to 1.0, exceptional (Chung; Lee, 2019).

To quantify the importance of each input variable for the outcome studied, the Shapley Additive explanations (SHAP) (Molnar, 2020) were used. The mean absolute SHAP values are displayed as bar graphs that classify the variables by their importance, and the bee swarm graph (Beeswarm) presents the actual relationships between the input

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variables and the target variable (Lundberg; Lee, 2017). For the bee swarm graph analysis, the input variables encoded with the highest value are represented in red; and those with lower values, are in blue (Y axis of the graph). For each variable, each individual in the database appears as its point, distributed horizontally along the X-axis according to its SHAP values. In locations where there is a high density of SHAP values, the points are stacked vertically. The distribution of colors horizontally along the X-axis for each variable provides insight into how the underlying values of each feature relate to the model's predictions (Lundberg; Lee, 2017). That is, if the input variable with the greatest predictive value is the student's age, this graph will indicate which of them (older or younger) has a greater relationship with the outcome variable analyzed (completion of Higher Education).

RESULTS

Initially, the characterization of the input and output variables was performed, as well as the characterization of the analyzed sample, as shown in Table 1 and Table 2, below.

Table 1 - Characterization of numerical input variables

Variable (n=563)	Kind	Average (±SD)
Age of entry (years)	Entry	26.8 (±10.7)
End time High School/university entry (years)	Entry	6.16 (±8.43)
Grade obtained in the selection process	Entry	603.61 (±97.24)
Total course load	Entry	3235.4 (±913.45)

Source: prepared by the authors, 2024

Table 2 - Characterization of categorical input and output variables

Variable	Kind	Classification	n (%)
Sex	Entry	Female	285 (50,6)
		Male	278 (49,4)
Type of disability	Entry	Hearing	103 (18,3)
		Physics	117 (20,8)
		Intellectual	119 (21,1)
		Multiple	26 (4,6)
		Visual	184 (32,7)
		TEA	14 (2,5)
Color/race	Entry	Yellow	5 (0,9)
		White	188 (33,4)
		Indigenous	4 (0,7)
		Brown	215 (38,2)
		Black	70 (12,4)
		Not informed	81 (14,4)
Marital status	Entry	Married	68 (12,1)
		Divorced/Separated	26 (4,6)

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		Single	458 (81,3)
		Widower	5 (0,9)
		Not informed	6 (1,1)
Modality Previous education	Entry	Bachelor's Degree/Bachelor's Degree	7 (1,2)
		Middle school	485 (86,1)
		Youth and Adult Education (EJA)	4 (0,7)
		Technical/Vocational	29 (5,1)
		Not informed	15 (2,7)
Type Institution High School	Entry	State	282 (50,1)
		Exterior	6 (1,1)
		Federal	49 (8,7)
		Municipal	29 (5,2)
		Particular	181 (32,1)
		Not Informed	16 (2,8)
Shift	Entry	Distance	18 (3,2)
		Diurnal	305 (54,2)
		Integral	13 (2,3)
		Nocturne	227 (40,3)
Admission modality	Entry	Wide competition	424 (75,3)
		EP, RF ≤ 1.5 SM, APP	27 (4,8)
		EP, RF≤ 1.5 SM, APPI, PCD	17 (3)
		EP, RF ≤ 1.5 SM	16 (2,8)
		EP, RF ≤ 1.5 SM, PCD	16 (2,8)
		EP, RF ≥ 1.5 SM, APP	17 (3)
		EP, RF ≥ 1.5 minimum wage, APPI, PCD	8 (1,4)
		EP, RF ≥ 1.5 SM	15 (2,7)
		EP, RF ≥ 1.5 SM, PCD	23 (4,1)
Course situation	Output	Disconnection	284 (50,4)
		Conclusion	279 (49,6)

Legend: EP=Public School, RF= Family Income, SM= Minimum Wage, APPI= Self-declared Black, Brown, Indigenous; PCD=Person with Disabilities.
Source: Authors' data, 2024

Among the models tested, the one that showed the best performance for identifying the predictive factors for the completion of the undergraduate course of students with

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disabilities was the XGBoost, with an accuracy of 76.38%, considering the analysis parameters as shown in Table 3.

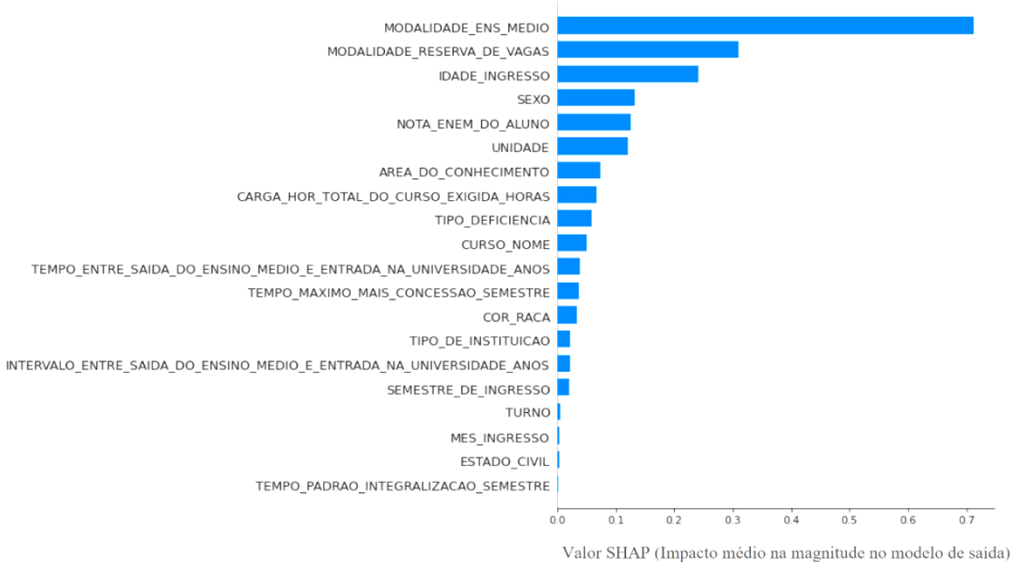
Table 3 - Predictive performance of the learning models for the target variable (completion of the undergraduate course)

Model	ACC (%)	F1-score (%)	CM	ROC curve (%)
			[[TN FP] [FN TP]]	
LR	66.07	67.46	[[174 110]	72.87
			[81 198]]	
KNN	59.15	60.48	[[157 127]	62.11
			[103 176]]	
RF	75.84	75.97	[[212 72]	80.61
			[64 215]]	
LGBM	76.2	76.24	[[214 70]	80.01
			[64 215]]	
XGBoost	76.38	76.54	[[2013 71]	80.71
			[62 217]]	

Legend: CM = Confusion matrix. TN True Negative = True Negative. FP False Positive = False Positive. False Negative = False Negative. TP True Positive = True Positive.
Source: Authors' data, 2024

After using XGBoost to identify the input variables that predicted the completion of the course, it was possible to identify those that were most important for the researched outcome using the SHAP method. The importance classification of each of the input variables, considering their absolute mean values, is shown in Figure 1.

Figure 1 - Classification of the importance of each input variable for the completion of higher education by students with disabilities, based on the SHAP method.



Source: Authors' data, 2024

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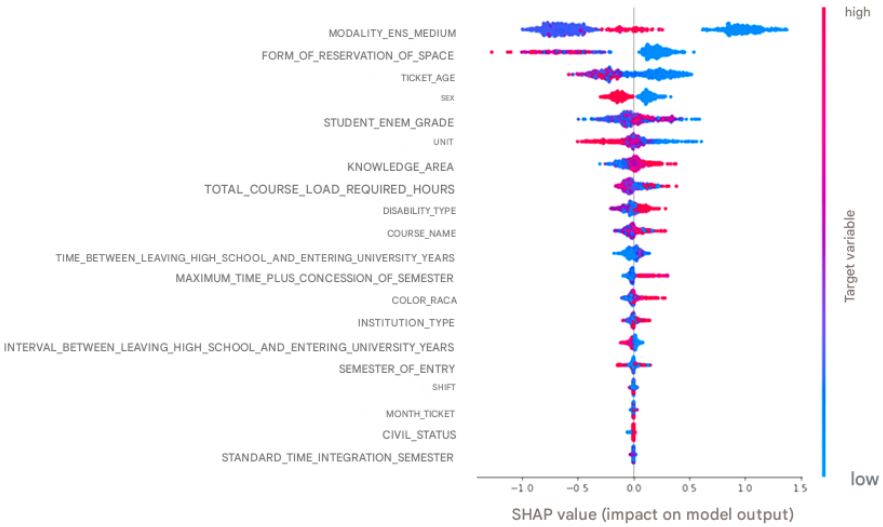
Figure 2 shows the actual relationship of each variable that showed the greatest impact on the outcome studied. The modality of High School/regular education; the modality of entry/broad competition; age/minor and age/younger; gender/female; and the grade in the selection process/highest grade were the predictor variables with the greatest positive relationship for the completion of the undergraduate course for students with disabilities. At the same time, the High School/EJA or Supplementary modality; the modality of admission/reservation of vacancies; age/oldest; gender/male; and the grade in the selection process/lowest grade were the predictor variables with the highest negative relationship for the completion of the undergraduate course for students with disabilities.

Regarding the type of disability, this variable does not present itself as the one with the greatest predictive value for the completion of the course. However, it was identified that visual impairment and Autism Spectrum Disorder (ASD) are predictive variables with a positive relationship for the completion of the undergraduate course for students with disabilities when compared to hearing and physical impairment.

Regarding the variable time between leaving high school and entering university, the shorter this time, the greater the chance of completion of the course by students with disabilities. About the area of knowledge of the chosen course, the courses in the Applied Social areas; Engineering and Linguistics, Letters and Arts are positive predictors for the target variable for this audience.

Figure 2 - Main predictor variables and their effects on the target variable (completion of the undergraduate course) from the SHAP method.



Source: Authors' data, 2024

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DISCUSSION

The results obtained showed that it is possible, from the use of AI, to identify with moderate accuracy (>70%) the predictive variables for the completion of Higher Education by students with disabilities. The predictive variables with the greatest impact on the completion of higher education by students with disabilities were: the type of high school attended, form of admission, age at university entry, gender, and grade obtained in the selection process, indicating, as described by Heräjärvi et al. (2022), that the completion of studies by young people with disabilities involves a dynamic interaction between personal and environmental/contextual factors.

Among the environmental factors, the variable with the greatest weight and high impact on the completion of Higher Education was the modality of High School attended by students with disabilities. Therefore, the importance of this period of study for the conclusion of the undergraduate course is highlighted (Karamouzis; Vrettos, 2008). Mendes (2013) reports that High School is a phase that has unique characteristics in the schooling process, due to the transitional aspect between basic education and higher education, that is, it is a period of preparation for entering university. Therefore, the guidance, intervention, and support offered by the school to students with disabilities in this critical and transitional moment are essential to provide better conditions for adaptation and development throughout high school and at the subsequent level of education. The characteristics of the environment can, therefore, facilitate or hinder the academic path of young people with disabilities (Barbosa, 2017).

In this study, it was identified that attending high school in the EJA or Supplementary format is a predictive factor for not completing the undergraduate course. Although the principles proposed by the National Policy on Special Education in the Perspective of Inclusive Education (PNEEPEI) should be transversal at the different levels and modalities of education (Kassar, 2011), it is not known, for example, to what extent they are being offered in EJA and Supplementary. It can be assumed that the training, resources, and educational services offered in these contexts do not meet the demands of these students and hinder the opportunities to complete the course at a higher level.

Another predictor variable with a high impact identified in the study was the modality of vacancy reservation. Students with disabilities who entered through a reservation of vacancies have a lower chance of completing their higher education. The Quota Law for admission to Higher Education has as its main criterion the completion of High School in a

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public school, complemented by other aspects of vulnerability such as income, race, and disability (Barbosa, 2017). The quality of public education and, consequently, the training offered are called into question, which confirms the findings of other studies.

Ferrari and Sekkel (2007) report that the major problem for students with disabilities to reach the end of higher education is the quality of the public education offered. Mendes (2013) and Cabral (2017) draw attention to the gaps in the school path in basic education, which represent important gaps in training in basic subjects. These gaps remain after entering university, and difficulties persist, to the point of preventing the advancement of studies at this level of education. Therefore, the simple expansion of universities is not enough – since the problem begins, in fact, in basic education (Zago, 2006). A past of good results in High School is essential for access to Higher Education and its completion (Barbosa, 2017; Zago, 2006). The student's previous knowledge, when solid, is fundamental for the understanding, organization, memorization, and consolidation of new knowledge (Pinto; Slender; Martins, 2015).

Another important aspect of the researched outcome was the score obtained in the selection process – National High School Exam (ENEM) and entrance exam – for university admission. This variable is directly related to the contextual factors discussed above, as the quality of basic education is reflected in the results obtained in the selection tests of all students, but especially of students with disabilities since the necessary support is also insufficient. In addition, another aspect to be considered is the absence or precariousness of the necessary adaptations to the specific demands of each candidate with disabilities and the possible difficulties encountered during the entrance exams and ENEM (Santos, 2012). Therefore, the adjustments made in the selection processes to meet the specificities of people with disabilities can mitigate the existing difficulties, but the challenges remain (Nozu; Bruno; Cabral, 2018).

The contextual predictor variables are related to the quality and modality of training offered in the path before entering university. Thus, being present in the classroom does not mean inclusion. It is necessary to offer quality education and resources such as adaptations of spaces, among other supports, as described by Guimarães et al. (2021). A mapping of the current situation of the school context at the secondary level in the different modalities (EJA, Supplementary, regular education) to identify the strengths and weaknesses should be carried out to improve policies and actions aimed at students with

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disabilities with consequent expansion of their possibilities and continuity of studies at higher levels.

As for the predictive variables related to personal factors that directly impacted the outcome studied, age at university entry and gender stand out. The lower the student's entry age, the greater the possibility of completing the undergraduate course. This result is in line with data from the Higher Education Census (INEP, 2023) which shows that the younger the student's age, the greater the number of graduates – it should therefore encourage earlier entry into university. Although admission is late for the vast majority of students with disabilities, these students are often the first family members to enter a university (Cabral, 2017). For this to occur, it is important to work on the perception of candidates with disabilities about their ability to enter Higher Education. Many, as well as their families, may think that completing high school is enough, or that higher education is not for them, often postponing the desire for continuing education (Van Petten et al., 2018). This perception of less value, associated with the experience by this public of basic education in a public institution where they face several problems, can lead to an early dropout (Souza; Brandalise, 2017), eventually minimized by the possibility of entering Higher Education from the Quota Law.

To minimize this issue, actions for vocational guidance aimed at this audience can be an interesting strategy. According to Ciavatta and Ramos (2011), high school is a crucial period for young people to develop motivation to produce socially, and professional guidance at this stage of life is decisive, especially so that those with a disability have prior guidance on how to enter the university and later in the job market. According to Assis (2020), the experience of career guidance offers students with disabilities a more positive perspective about the future as well as the way to proceed in search of adequate training for work autonomy.

Regarding gender, some studies suggest that male students with disabilities may have behavioral problems that can hinder the learning process in basic education with a consequent impact on Higher Education as shown in this study (Crawford et al., 2018; Osgood; Foster; Courtney, 2010), others have not identified associations between sex and learning (Simpson; Rose; Ellis, 2016), and, therefore, this aspect should be better studied.

Regarding the area of knowledge, Cabral (2017) points out that, in the transition from high school to university, there may be an intrinsic relationship between the student's choice of course and the barriers experienced or the facilitating situations at the time of

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entering university. On the other hand, in this study, it was observed that students with disabilities enrolled in 74 of the 91 courses offered by the institution, covering all areas of knowledge. This fact seems, as reported by Van Petten et al. (2018), to call into question the intrinsic relationship between the choice of the area of knowledge and the barriers and facilitators themselves. It also stands out as a predictive factor of non-completion in the areas of health, exact sciences, and humanities. Students with disabilities enrolled in courses in these areas of knowledge had a high number of occurrences (lockout), which can later lead to withdrawal or exclusion from the higher education course.

For Silva (2021), non-participation and non-academic involvement are some of the possible causes of dropout in general. This is due to the lack of incentive for extra-class activities; regular classes; and issues related to good academic coexistence and socio-academic and interpersonal relationships. Torres-Coronas and Vidal-Blasco (2019) report that the university has an even greater challenge due to the need for specific adaptations of an increasingly diverse population, and this scenario can be further aggravated for students who have a disability. Bitencourt, Silva, and Xavier (2022), in a study with students in the exact sciences area, found that, in general, occurrences occur in the first three periods and are even more relevant and significant in the first and second periods, with higher rates in mathematics degree courses, followed by administration, computer science, electrical engineering, and financial management. They also highlight the need for the university to seek the involvement of the student in the first periods of the course and to follow and monitor the student at risk of dropping out throughout the academic trajectory (Bernardo et al., 2017; Silva et al., 2022; Silva Filho; Araújo, 2017).

Regarding the type of disability, this is not a significant predictive variable for the completion of higher education by these students. Thus, the perception that disability itself constitutes a barrier to the participation of these people in different contexts, including education, is called into question and should be a point of discussion, as well as considered in the formulation of public and institutional actions and policies (Bernardes, 2012). However, knowing the relative predictive value of this variable, especially at the time of admission to the university, is essential to direct internal actions, use of didactic-pedagogical resources, and intervention as early as possible to facilitate and provide greater participation of students in the course and favor the completion of Higher Education.

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At the time of admission to the university, the student brings with him the educational history of the previous phases and his life context, and, according to Karamouzis and Vrettos (2008), this is a crucial and indicated moment to carry out predictive studies through AI. Lima and Cabral (2020) also point out that the identification of the characteristics of students and contexts, from a biopsychosocial perspective, should be carried out from the first academic semesters and in their respective transitions. This process enables the planning and use of resources aimed at curricular accessibility, which is indispensable for students with disabilities. With the use of AI, it is possible to identify early the predictive factors with the greatest impact on success in this path, indicating to the institution the need to intervene with complementary actions in the perspective that the dismissal does not occur. Karamouzis and Vrettos (2008) state that knowing the forecast of the student's academic path seems to be an excellent first step to intervene to contribute to their permanence and academic participation, with consequent completion of the course. For the management of the university, the resources aimed at minimizing barriers of any nature must be directed to help the vulnerable student complete his academic trajectory.

Finally, it is worth reflecting on the capacity of the educational system, at its different levels, to reconcile quality education with education for all, ensuring the effective participation of the public in society.

CONCLUSION

This study was able to identify, with moderate accuracy, some factors, often neglected, that directly influence the completion of higher education by students with disabilities; and to highlight the dynamic interaction between personal and contextual factors. This research points to basic education as a place of urgent action, with a view to quality education; and support for people with disabilities, to prepare them for insertion in higher levels of education and future professional performance. It offers educational institutions an overview of areas and courses that require a diagnosis to identify barriers and facilitators for the inclusion of students with disabilities and, based on this, define specific support actions for students and the work team. It also provides guidance on the types of disabilities that should be monitored since their entry and in a more systematic way by the Accessibility and Inclusion Centers.

The early identification of these variables can better guide institutional actions and minimize barriers – whether physical, pedagogical, communication or even attitudinal – to

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help vulnerable students complete their academic careers. This result makes it possible to identify, at the time of admission of the student with disabilities to the university, those who are more or less likely to present difficulties in their academic trajectory, and the university should intervene as early as possible to help them obtain graduation.

As a limitation of the study, the composition of the database with students with disabilities with different ways of identifying the condition of disability is pointed out, which can impact on different characteristics of the public per period. Given the relevance of the theme and its impact on institutional policy, it is suggested that this study be replicated in other university environments, to identify such factors more comprehensively; and the approach even to the regional specificities of a continental country like Brazil.

AI should not be understood as the only answer to solving questions such as the one discussed in this study, but it can be an important tool that – associated with other tools, strategies, and actions – implies positive differences for the academic trajectory in Higher Education for students with disabilities, mitigating dropout and contributing to their citizenship and professional training.

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