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Evaluation of indicators for higher education: development of tools

Levantamento e acompanhamento de indicadores do ensino superior: desenvolvimento de ferramentas

Evaluación de indicadores para la enseñanza superior: desarrollo de herramientas

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Abstract: The main aim of this article is to contribute to the latest assessment that artificial intelligence can help in the collection, integration and monitoring of data and indicators for undergraduate courses, such as dropout and retention. Its starting point is the understanding that the phenomenon of dropout is not merely an individual student's decision, but takes place in the academic, personal and professional context of the student who drops out. Furthermore, retention is an indicator that can serve as a predictor of the dropout phenomenon. In this way, the methodology consists of describing the development of an interactive database tool, i.e. for analyzing data and observing data and indicators from an undergraduate course at a public federal university. Among the main results, it should be noted that although it seems easy to build a tool like this, its success in tackling dropout and retention requires an institutional policy adopted by the university.

Keywords: data analysis; evasion in higher education indicators; graduation; Federal Higher Education Institution (IFES).

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Resumo: O objetivo principal deste artigo é contribuir com a avaliação mais recente de que a inteligência artificial pode auxiliar no levantamento, integração e acompanhamento de dados e indicadores de cursos de graduação, tais como evasão e retenção. O seu ponto de partida é a compreensão de que o fenômeno da evasão não é mera decisão individual do estudante, mas ocorre em um contexto acadêmico, pessoal e profissional deste estudante que evade. Ademais, a retenção é um indicador que acompanha a evolução do fenômeno da evasão. Dessa forma, a metodologia consiste em descrever o desenvolvimento de uma ferramenta de banco de dados interativa, ou seja, é, de análise e observação de dados e indicadores de um curso de graduação de uma universidade federal pública. Dentre os principais resultados, destaca-se que, apesar da aparente facilidade em construir uma ferramenta como essa, seu êxito quanto ao enfrentamento da evasão e da retenção requer uma política institucional adotada pela universidade.

Palavras-chave: análise de dados; indicadores de evasão; graduação; Instituição Federal de Ensino Superior (IFES).

Resumen: El objetivo principal de este artículo es contribuir a la última valoración de que la inteligencia artificial puede ayudar en la recogida, integración y seguimiento de datos e indicadores de los programas de grado, como el abandono y la retención. Su punto de partida es la constatación de que el fenómeno del abandono no es una mera decisión individual del estudiante, sino que tiene lugar en el contexto académico, personal y profesional del estudiante que abandona. Además, la retención es un indicador que puede servir para predecir el fenómeno del abandono. De esta forma, la metodología consiste en describir el desarrollo de una herramienta de base de datos interactiva, es decir, de análisis de datos y observación de datos e indicadores de un curso de grado de una universidad pública federal. Entre los principales resultados, cabe destacar que, aunque parezca fácil construir una herramienta de este tipo, su éxito en la lucha contra el abandono y la retención requiere una política institucional adoptada por la universidad.

Palabras clave: análisis de datos; indicadores de abandono; graduación; Institución Federal de Enseñanza Superior (IFES).

1 Introduction

Administrative activities are part of the teaching practice. For the preparation of this article, the authors' experience in coordinating an undergraduate program was an essential aspect. Thus, within the scope of their responsibility for overseeing and managing the course, certain activities related to dropout and retention issues are carried out, such as assessing the course's performance in periodic evaluations, for instance, the National Student Performance Exam (ENADE), on-site evaluations, and monitoring the trajectory of the program and its students. Furthermore, although these concerns are present in the academic literature, in the management plans of educational institutions, in regulatory bodies, or the Ministry of Education (MEC), there are gaps in the conceptualization and understanding of the causes of dropout and retention. Consequently, this affects the use and effectiveness of strategies and specific policies aimed at addressing these issues.

The reforms initiated during Fernando Henrique Cardoso's administration in the 1990, according to Carvalho (2009), resulted in a kind of cost-benefit analysis between the values and beliefs of policy managers under the general policy guidelines defined by the Ministry of Education (MEC). The 2000 and 2010 were marked, although not without criticism and challenges, by a revitalization of the budget and policies aimed at expanding Federal Institutions of Higher Education (IFES). After the 2016 coup, under Michel Temer (2016-2018) and Bolsonaro (2019-2022), the privatization perspective within the public sphere of higher education gained greater momentum, with the Future-se program and the increased involvement of private business groups being notable examples.

Although the debate on dropout and retention was not excluded from the public policy agenda or academic discussions, it can be considered that it was addressed according to the educational perspective of each government.

In 2020, the College of Undergraduate Deans of Federal Institutions of Higher Education (COGRAD–IFES) held the first Ecograd Workshop, where a group of researchers gathered specifically to identify the causes, consequences, and most appropriate measures for analyzing the phenomenon of dropout and retention in higher education. During this first workshop, indicators to measure the quality of undergraduate programs were also discussed. The strategy then consisted of fostering an 'undergraduate ecosystem,' in which information and indicators from higher education are integrated, using historical series and data from the Higher Education Census, along with data from the IFES, to address aspects such as the quality of undergraduate courses, dropout causes, and the employability of graduates. Previously, the Ministry of Education (MEC), the Directorate of Educational Statistics (DEED), and the Anísio Teixeira National Institute of Educational Studies and Research (Inep) (2017) prepared a document presenting the methodology for calculating higher education flow indicators based on

data from the Higher Education Census. This methodology includes, mainly in the discussion of dropout and retention, the dimension of the educational trajectory.

Dropout and retention have multiple causes, but the mapping, gathering of indicators, and their monitoring are considered essential actions to mitigate them (Silva; Cabral; Pacheco, 2020). With this concern in mind, some public higher education institutions have invested in Data Science. Among these initiatives, the following stand out: "Sabiá" from the Federal Rural University of Pernambuco (UFRPE) – a dashboard (an interactive database) that integrates student data and tracks indicators to support decision-making in addressing dropout issues; "SISSA" from the Federal University of Goiás (UFG) – a big data platform that integrates student data, monitors indicators, and allows students to track their academic performance, as well as offering an interactive chatboard space; and the "Integra Project" from the Federal University of Santa Maria (UFSM) – an application that grants course coordinators access to data and indicators, enabling them to assess students at higher risk of dropping out.

An undergraduate program generates a large amount of data over an extended period, as certain assessments require tracking over multiple semesters and years. A dashboard facilitates the manipulation and communication of this data, making it a highly valuable management tool for undergraduate programs, even though it does not allow for inferential conclusions.

The main objective of this article is to present the dashboard developed for an undergraduate program by its own coordination team. The article also aims to highlight the key conceptual aspects related to dropout and undergraduate indicators, as well as describe the measurement methods. In addition to this introduction and the final considerations, the article is composed of a second section covering the conceptual aspects and measurement methods, and a third section detailing the dashboard's methodology and describing its functionality.

2 Conceptual aspects

The phenomenon of dropout has been studied across various major fields of knowledge, such as Psychology, Sociology, and Economics, and is increasingly emerging as an international concern among different actors – both public and private – due to the growing demand for workforce skills and competitiveness (Barroso *et al.*, 2022). The classical literature on dropout, notably Tinto (1975), begins to consider dropout within the student's pre-higher education trajectory through the longitudinal model of school dropout. Learning difficulties or deficiencies in specific subjects are identified as potential causes of dropout in higher education, particularly in the first year of the program. Based on Tinto (1975), learning difficulties or challenges in keeping up with the content of the subjects in higher education curricula are pointed out as causes of

dropout. These difficulties do not arise spontaneously when the student enters higher education; rather, they may reflect prior experiences up until their admission. In Tinto's (1975) model, distinctions are made regarding the behavior, performance, and perceptions of undergraduate students toward their educational institution. These distinctions are: (1st) temporary or permanent withdrawal from the institution, marked by more than two years of absence from school; and (2nd) the decision to drop out, whether by the student's own choice or by the institution's decision due to academic failure. Pinheiro, Ribeiro, and Fernandes (2023) note that Tinto's (1975) model is a way of analyzing the dropout phenomenon based on the level of interaction between students and people within the educational institution, as well as the perceived sense of belonging to the values of university life.

Tinto (1993) classified students into four different profiles: (i) those who remain in higher education and complete their curricular requirements; (ii) those who stay in higher education but transfer between institutions; (iii) students dismissed from higher education by the institution due to academic failure; and (iv) those who choose to withdraw from higher education. Barroso et al. (2022) assess that, based on Tinto's studies (1975; 1982; 1993), the following variables can be identified for the study and evaluation of the dropout phenomenon: (a) attributes prior to entering higher education, such as family background, individual characteristics, and previous learning experiences; (b) goals and commitments before and after entering higher education; (c) institutional experiences related to the academic and social systems; and (d) academic and social integration.

Regarding this distinction, Barroso *et al*. (2022) suggest that the following socioeconomic variables can be made explicit as factors influencing student behavior: (a) parental characteristics, such as educational level and place of family residence; (b) gender; (c) race; (d) individual experiences in terms of outcomes, learning, and school performance; and (e) aspirations generated from these prior experiences. A student's academic and social integration would result from institutional experiences, both formal and informal, within the formal academic system – experiences in terms of academic performance, with informal academic experiences often involving interactions with professors, for example – and within the formal social system, where extracurricular academic activities occur, while informal experiences involve peer interactions (Tinto, 1975, 1993). The accumulation of experiences that students bring with them upon entering higher education, coupled with their interaction and experiences within the institution, can ultimately determine whether or not they remain in higher education. Casanova (2018) argues that the concept of integration can be used as a way to assess students' adaptation to higher education, and Tinto (2017) prescribes this integration as a goal that educational institutions should strive for.

> In summary, we can point out that the student integration model considers both the academic and social dimensions. The academic dimension relates to the student's sense of belonging to the institutional environment, considering factors such as academic performance and a positive experience with the course and its content. In this context, if a student receives below-average grades or faces difficulties with the teaching methodology and content presented in class, these issues may influence their decision to leave the course. The social integration, on the other hand, refers to the student's social experiences and relationships, such as friendships, involvement in extracurricular activities, and informal relationships with professors and others involved in the program (Pinheiro; Ribeiro; Fernandes, 2023, p. 6).

Tinto model (1975) has faced several criticisms over time (Tinto, 1982), among which the need for ethical caution in how higher education institutions address dropout rates stands out, as well as the importance of reinforcing academic and professional support services for students from the moment they begin to question their decision. Pinheiro, Ribeiro, and Fernandes (2023) add that Tinto (1975) model does not take into account the socioeconomic realities of countries like Brazil, even though it serves as a starting point for such analyses, or the emphasis on the notion of 'rites of passage' in remaining in higher education (Prado, 2022). Despite these limitations, the model continues to be recognized in the academic literature on dropout (Ambiel, 2015; Esteban *et al*., 2017), and Prado (2022), building on Braxton, Milem e Sullivan (2000), notes that it has retained an "almost-paradigmatic" status. Other theoretical models can also be cited, such as those of Bean (1980), Astin (1984), and Coulon (2017), which are based on and engage in dialogue with Tinto (1975) model.

Pinheiro, Ribeiro, and Fernandes (2023) differentiate between Tinto (1975) and Bean (1980) models by noting that the latter includes both environmental and individual factors in the process leading to withdrawal from higher education. Casanova (2018) views Bean (1980) model as a study of the possibility and intention to remain or leave higher education, with an emphasis on individual decision-making. In Bean (1980) "student attrition model", both exogenous and endogenous variables are considered as determining factors for dropout, including: (i) background variables – students' experiences prior to entering higher education; (ii) organizational variables – related to the higher education institution itself; (iii) personal variables; (iv) environmental variables – aspects related to work and family; and (v) attitudinal variables – the certainty of the students' choice.

In Astin (1984) model, emphasis is placed on the student's effort in their academic experience, in terms of physical or psychological energy – referred to as the degree of involvement – such that the greater the effort expended during their undergraduate studies, the higher the probability of persistence. In Coulon (2017) model, developed from research conducted in the 1980s with students at Paris 8 University

during their first months at the institution, it is observed that in this initial period, students need to "learn to be a student," which triggers a process of distress. According to Prado (2022), this process is divided into the following stages: (i) estrangement – learning how the institution functions and its rules; (ii) learning – beginning to align their own learning with their sense of belonging to the institution; and (iii) distress – when they gain greater autonomy and take on a more active role. In this process, as in other models, the institution can contribute, through direct mechanisms, to whether or not students remain enrolled.

There is no single model to explain and evaluate the phenomenon of dropout, which also contributed to Andifes (1996) adopting three dimensions – or three concepts – of dropout in the 1990s, which are still used today: micro-dropout – changing courses within the same university; meso-dropout – changing universities; and macro-dropout – completely leaving the educational system. According to Ristoff (1999), these dimensions require different levels of management intervention and reflect a non-utilitarian view of the dropout phenomenon. A student's academic life unfolds according to their choices, influenced by external and internal factors within the university, which may represent nothing more than the search for a profession that better aligns with the student's aspirations. Retention combines and coordinates factors that trigger a learning process, and as Prado (2022) emphasizes, the educational institution can act insightfully by providing resources such as pedagogical support – though this is not the only resource available.

From this perspective, dropout can no longer be analyzed as an isolated phenomenon, unrelated to the social and institutional context. Dropout can occur as a result of unmet human aspirations that the institution fails to address. Identifying and measuring dropout has been approached through various definitions to understand its multiple meanings (Santos Junior, 2016). For instance: "the student's departure from the institution before completing their course" (Baggi; Lopes, 2011, p. 370); or "the student's definitive withdrawal at any stage of the course" (Abbad; Carvalho; Zerbini, 2006, p. 2). Polydoro (2000) considers temporary withdrawal from enrollment as a type of dropout, even if it is temporary. In this view, Carvalho (2018) emphasizes that retention and dropout are directly related phenomena. Temporary withdrawal from higher education is considered by Inep (Brasil, 2017) in the methodology for calculating school flow indicators as a way to assess the predictability of student retention.

A student facing vulnerability in their studies and academic life often ends up interrupting their enrollment at the university. The institutional strategies adopted by the university to address this student vulnerability are directly related to their retention. There is also concern about the budgetary impact of dropout in public universities, which encourages studies on this topic and garners attention in institutional management projects.

The requirement by oversight bodies, such as the Federal Court of Accounts (TCU) in the case of Federal Institutions of Higher Education (IFES), to publish management reports, develop Institutional Development Plans (PDI), and provide accountability regarding efficiency indicators intensifies the focus on dropout and retention as measures of public spending efficiency.

However, a purely quantitative portrait of dropout is insufficient for its understanding and mitigation. Ambiel (2015) conducted a study that developed a 'Scale of Reasons' for the occurrence of dropout in higher education, systematizing various publications on the topic, which resulted from research using official MEC data, as well as surveys conducted with students and faculty on aspects such as family influences on career and study choices, adaptation and belonging to the chosen program, and socioeconomic factors, down to the specificities of certain programs, such as Nursing and Psychology, for example. In Table 1, Carvalho (2018) presents an organized framework that systematizes the different dimensions that can explain dropout. It is important to clarify that the dimensions and elements described in Table 1 are also identified in other studies, such as Park (2007) and Cislaghi (2008). The listed dimensions and elements align with theoretical models concerning the dropout phenomenon.

Table 1 - Dropout: dimensions and elements

Dimension	Elements
Student Skills and Interests	Socioeconomic family level
	Family influences
	Level of career satisfaction
	Deficient basic education
	Lack of information about the program and profession
	Low academic performance
	Level of integration and interaction in academic life
	Lack of vocational guidance
Internal Environment	Priority given to research over teaching
	Lack of adaptation process to university life
	Limited interaction: students with each other and with faculty
	Pedagogical and didactic organization
	Low attendance and student retention
	Long and outdated curricula
	Devaluation of teaching and passive acceptance of dropout
External Environment	Financial difficulties
	Professional commitments
	Family commitments
	Personal and health issues
	Job market

Source: Carvalho (2018).

Dropout also has a psychosocial dimension, linked to difficulties in adaptation and the conflicts caused by low academic performance among students. Previous levels of education and the students' socioeconomic context must also be considered when analyzing dropout (Baggi; Lopes, 2011).

There is no single concept or indicator for dropout and retention. Additionally, the understanding that dropping out of an undergraduate program and delays in completion are issues that have been evaluated by institutions such as the MEC, Andifes, and IFES since the 1990. Starting in the 2000, IFES began to intensify their policies for identifying dropout, retention, and addressing these challenges.

3 The role of the institution (IFES) in addressing dropout and retention

The National System for the Evaluation of Higher Education (SINAES) (Brasil, 2004) was introduced as a legal framework for systematizing the foundations for the creation of a higher education evaluation policy, reinforcing a managerialist approach ("new management") in assessing the quality of higher education. Terms such as "efficacy" and "effectiveness," commonly used in public policy evaluation programs, are frequently employed to measure the quality of education and assess dropout and retention rates in public higher education.

In this way, the evaluation of education becomes guided by these assessments. Coimbra, Silva, and Costa (2021, p. 5) emphasize that these basic terms are essential for the conception of an evaluation program:

> [...] efficiency, from this perspective, assesses the best possible cost/benefit ratio for achieving the objectives established in the program. Effectiveness, according to the authors, evaluates the extent to which the program meets its goals and objectives. Finally, effectiveness measures whether the project has (positive) effects on the external environment in which it intervened, in technical, economic, sociocultural, institutional, and environmental terms.

The authors argue that an evaluation system is interconnected with the goals and principles assumed by the educational institution, including its 'social responsibility' Given its complexity, the starting point for addressing dropout should be guided by principles such as social responsibility, democratic values, respect for difference and diversity, and the aim of building a more just society. Coimbra, Silva, and Costa (2021) emphasize that a program to address dropout and retention must position students as the protagonists of their academic journey within the institution.

In the case of IFES, although each institution develops its own goals and principles for addressing dropout and retention, these actions are interconnected with SINAES, which, however, does not present a well-defined and objective indicator for

evaluating higher education, nor a criterion for assessing institutional data on dropout within the external evaluation frameworks. The REUNI program (Brazil, 2007) – decree no. 6,096/2007 – clearly outlines the objective of reducing dropout rates. Institutions that adhered to REUNI committed to monitoring the reduction of these rates and increasing student mobility, and it is important to distinguish between these two aspects.

> I- Reduction of dropout rates, filling vacant spots, and increasing admission opportunities, especially during the evening period;
> II - Expansion of student mobility, through the implementation of curricular systems and degree frameworks that allow for the creation of educational pathways, utilizing credit transfer and enabling student movement between institutions, courses, and higher education programs; [...] V - Expansion of inclusion and student assistance policies; [...] (Brasil, 2007, s/n).

Carvalho (2018) emphasizes that, with the operationalization of SINAES starting in 2004, the Institutional Development Plan (PDI) of universities became a key management tool, as well as a means for monitoring the efficiency and effectiveness of higher education in IFES. Dropout rate indicators are not isolated from other indicators, such as the Graduation Success Rate (TSG). However, there is no single proposed indicator for dropout and retention. Complementary to the PDI are the Institutional Pedagogical Project (PPI) and the policies within the framework of the National Education Plan (PNE). These documents provide avenues and tools for the strategic and effective management of student academic performance – retention, graduation – as well as dropout.

Coimbra, Silva, and Costa (2021) highlight the document "General Guidelines for the Institutional Self-Evaluation Roadmap", which states that IFES are responsible for describing planned activities for the evaluation of graduates and/or faculty, in addition to studying dropout. It is up to IFES, within the scope of their self-evaluation, to establish working groups focused on studying dropout, and this project aims to contribute from this perspective as part of that broader concern.

In SINAES documents for the evaluation of undergraduate programs, the role of course coordinators is frequently mentioned. Within the organizational structure of institutions, undergraduate program coordinators are generally tasked with ensuring the programs operate according to institutional and legal parameters. Additionally, they can play a key role in collecting data, tracking student progress, and tabulating and analyzing the situation, whether expressed in indicators or not, as well as monitoring the course's development. Therefore, within an institution's organizational structure, coordinators are well-positioned to identify the phenomena of dropout and retention – its causes, scope, and consequences – with greater clarity.

Diogo *et al*. (2016) evaluate dropout and retention by considering the perceptions of undergraduate course coordinators at a public higher education institution regarding the determinants of these issues and the identification of intervention strategies. This approach aims to systematize the shared responsibility between students, faculty, and the institution. Tontini and Walter (2014) map out teaching-learning methodologies that can predict or forecast the probability of dropout.

Regarding interventions to reduce high dropout and retention rates, Furtado and Alves (2012) argue that professional guidance activities and extracurricular programs designed to support learning need to be considered within educational institutions. Bardagi and Hutz (2009) observe that student involvement in curricular and extracurricular activities that promote integration with the university environment has a positive effect on students' commitment to their course. Student assistance programs are another avenue for enabling students to remain in the institution, though not necessarily in the course they initially enrolled in.

These arguments highlight the necessity for higher education institutions – and in the context of this article, the IFES – to maintain integrated systems with data on variables that trigger and explain dropout. These variables must also be measurable to establish strategies for monitoring and intervening in more critical cases.

4 Dropout and retention – measurement methodologies

A study published by PROGRAD-Unifesp, using data from the Education Census, indicated that the average dropout rate in federal universities in 2014 ranged between 10.7% (UFBA and UFMG) and 20.8% (UFPA). However, dropout is such a complex phenomenon that it cannot be fully understood solely through a rate. In other words, the analysis of dropout rates in IFES should not only seek a minimum threshold of concern but should also aim to understand the underlying phenomena that contribute to dropout.

Even without a universally accepted definition, dropout and retention need to be defined with minimal parameters. Their multiple causes make it even more essential that any strategy to address these issues begins with an understanding that is grounded in the institution's reality.

> The conceptual definition of what one seeks to measure is a fundamental step in the measurement process. The importance of the concept lies in the need to understand what is being measured. When we ask why a particular event or phenomenon of interest occurs, we must first define what is meant by that event or phenomenon. Regarding the phenomenon of student dropout in higher education, we have seen that there is no consensus on the use of various terms (Freitas, 2016, p. 42).

Evaluating the methods used to measure dropout and retention is essential. Careful measurement and accurate identification of the "extent" of dropout are necessary both to capture the true meaning of this phenomenon, beyond merely a loss of enrollment, and to prevent biased interpretations of the university's role in it.

For dropout cases, it is essential to consider intervention strategies that promote an understanding of the causes, meaning the reasons associated with the phenomenon. As Freitas (2016) emphasizes, the database used is made up of official data, aggregated by entrants, available spots, and graduates, without including individual tracking of those who drop out. The commonly used ratios aim to portray dropout as either success or failure. Table 2 seeks to systematize the methodologies used.

Table 2 – Measurement of dropout

References	Definition	Calculation
Paredes (1994)	Uses the "concept of course performance," calculated as the ratio between graduates and available spots.	$\%E = 100\% - \frac{graduates}{spots}$
Silva Filho *et al.* (2007)	Total dropout measures the number of students who, having entered a certain course, institution, or education system, did not obtain a diploma after a certain number of years.	$E_n = 1 - \frac{(M_n - I_n)}{(M_{n-1} - C_{n-1})}$
Special Commission on Dropout Studies - ANDIFES (1996)	Students who, at the end of a complete generation period, had not graduated and were no longer enrolled in the course.	$\%E = \frac{N_i - N_d - N_r}{N_i} * 100$
Serpa; Pinto (2000)	Dropouts as the variation in enrollments excluding new entrants and graduates.	$E_x = I_{x+1} - (M_{x+1} - M_x) - C_x$
Braga; Peixoto; Bogutchi (2003)	Data from cohorts still within the maximum time for completion, referred to by these authors as an "incomplete generation".	$\%E = 100\% - \%graduates - 0{,}06 * (100\% - \%graduates)$
FORPLAD (2015)	Considers the number of new entrants enrolled in a given period and the enrolled and graduated students from the previous period, based on course duration. This is the most widely used indicator by institutions, as it is referenced in official control body documents.	$Ev_p = \left(1 - \frac{M_p - I_p}{M_{p-1} - C_{p-1}}\right) * 100$

Teixeira; Quito (2021)	Flow methodology that allows for adjustments to the maximum and minimum time limits for completion of credit hours.	$Minimum\ Longitudinal\ Dropout\ Rate_{i,n,p} = \frac{\sum_{i=2010}^{np} Eva_{T,n,p}}{ing_{i=T}^{n}} * 100$ $Maximum\ Longitudinal\ Dropout\ Rate_{i,n,p} = \frac{\sum_{i=2010}^{1,5p} Eva_{T,n,p}}{ing_{i=T}^{n}} * 100$

Source: Own elaboration.

The concepts and understanding of the dropout phenomenon have been characterized by focusing on two main aspects: (i) methodologies for measuring or calculating dropout rates in undergraduate programs at IFES, and (ii) determining factors that explain the phenomenon, which can be the subject of strategic planning by IFES (Coimbra; Silva; Costa, 2021). The methodology of MEC, INEP, and DEED (Brasil, 2017), presented in 2004, used the Higher Education Census as a database, covering the period from 2010 to 2014, and utilized individualized data (by CPF) of incoming students. It considered variables such as course, academic degree, minimum and maximum time for program completion (evening, morning, or afternoon), year of admission, students' enrollment status, and characteristics of the educational institution. Regarding enrollment status, this methodology included situations such as students who did not complete the necessary credit hours for program completion, students who did not finish the course due to dropout, abandonment, withdrawal, or transfer, students who completed all credits, students with suspended enrollment, or those who transferred to another program within the same institution. This approach allowed for the calculation of indicators such as retention rate, cumulative completion rate, and cumulative dropout rate to monitor the academic trajectory of students in a given program. MEC, INEP, and DEED (Brasil, 2017) also systematized concepts like dropout itself, defined as the early departure from a program due to the student's withdrawal, identified as a situation of failure since the program was unable to provide the student with the knowledge intended at the time of enrollment.

Although there is no single indicator for dropout and retention, the Graduation Success Rate (TSG) is an indicator with a clear definition, annual calculation (for all IFES, published in their respective annual management reports), and monitoring. It is the responsibility of the TCU (Federal Court of Accounts) to express its evaluation through its annual audit reports. Dropout and retention, considered in TCU reports as "higher education flow indicators", are assessed using the Student Participation Rate (GPE), which measures the evolution of vacant spots in undergraduate programs at IFES. Dropout and retention are not exactly precise indicators tracked by the TCU for IFES.

Their analysis typically occurs when the results of the TSG are presented. For example, using data from the e-MEC database, the TCU calculated indicators for IFES between 2009 and 2018. The TSG indicator showed a slight decline between 2009 and 2013, explained by the considerable influx of students into IFES, followed by a recovery from 2014 to 2017, with a negative variation between 2017 and 2018. According to the TCU report, this decline was attributed to high levels of dropout and retention in IFES. School flow indicators can provide a broader assessment, making the evaluation less limited to simplified analyses.

The Federal Court of Accounts (TCU) conducts audits that evaluate the management and performance indicators of federal universities in Brazil. In a session held in March 2022, a report was produced based on the audit conducted on these indicators. The main conclusion was that there are information gaps and a lack of indicators within the IFES, which prevent a "systemic understanding" and hinder proper coordination and oversight by the Department of Higher Education (Sesu/MEC). Additionally, according to the report, the Secretariat for Higher Education Regulation (SERES) does not systematically monitor the goals of the National Education Plan (PNE) for higher education. At that time, the TCU required the Secretariat to present, within 180 days, a plan for the effective implementation of management and performance indicators for the IFES.

In a TCU report on an audit aimed at evaluating the planning of the distance higher education policy – where oversight involved the Ministry of Education (MEC), the Anísio Teixeira National Institute for Educational Studies and Research (Inep), and the National Council of Education – it was noted that there is a lack of a specific and structured public policy for education as a whole, whether in-person or distance education. Similarly, the inconsistency of the MEC regulation, supervision, and evaluation processes was highlighted. It appears that there is a one-sided relationship between MEC and TCU in understanding the evaluation of higher education in Brazil.

Dropout and retention should not be treated merely as measures of efficiency and evaluation, as TCU Decision n. 408/2002 began to present IFES or even SINAES. Their understanding must be linked to monitoring and addressing these issues. For the measurement of dropout and retention, regardless of the formula used, it is essential that the institution organizes the most accurate possible assessment of the extent of dropout and retention. This assessment should be based on principles and parameters that combine the most widely accepted definitions found in public policy documents with the specific context of the institution.

Defining forms or categories of dropout, such as dismissal, abandonment, withdrawal, official withdrawal, expulsion, cancellation due to denial, cancellation due to income denial, cancellation of enrollment – court injunction, internal transfer, transferred, and death – are categories used in that institution. Teixeira and Quito (2021)

emphasize that using these categories allows for a clearer understanding of the student's trajectory, complementing the interpretation of dropout and retention indicators and aligning with the multidimensional nature of these phenomena.

Coulon (2017) considers that the bonds, commitments, and interpersonal relationships established by the student within the higher education institution are essential for combating or addressing dropout, as are the pathways the institution provides to deepen and develop these aspects. The existence of support centers for pedagogical and psychological guidance, along with student retention programs, are examples of these pathways.

4.1 Tools for collecting and monitoring indicators

Although the dropout phenomenon involves many variables and interpretive nuances, addressing it does not allow for ambiguities. Tools that integrate data across different variables are increasingly required and used to develop assertive measures to control dropout. However, it is not just about controlling dropout rates. Monitoring student performance and observing undergraduate programs in their key dimensions – such as semester enrollments, enrollments and passing rates by subject, new student intake, withdrawals, graduations, among others – constitutes the element that can represent the most efficient and effective way to mitigate dropout and retention issues.

Table 3 – Examples of dropout and retention measurement programs at IFES

Institution	Program – description	Main results or features	Year of creation – implementation and involved Units
UFSM – Federal University of Santa Maria	Integra – Application	Tracks students' academic journey from enrollment to departure. Course coordinators can assess students at higher risk of not completing the course and access the course observatory.	2018 Undergraduate Dean's Office (PROGRAD), Planning Dean's Office (PROPLAN), and Data Processing Center (CPD)
UFG – Federal University of Goiás	SISSA – AI-based Platform	Integrates data to predict students' academic performance ('success'), provides data analysis and indicator formulation, academic support through tutor training, and student assistance, including chatbot interaction.	Funded by MEC, SETEC, and SESU. Implemented by UFG and CEIA. 11 other IFES use the platform: IFBA, IFRO, IFSP, IFB, IFSUL, UNIPAMPA, UNIFEI, UFSCar, UFPA, and UFERSA.

UFRPE – Federal Rural University of Pernambuco	Sabiá (System of Academic Business Intelligence and Analytics)	Centralizes and integrates data, enabling the extraction of various summary reports of indicators for undergraduate courses and the university, including infographics.	UFRPE – data Observatory coordination laboratory
MEC – Federal Network for Professional, Scientific, and Technological Education	Nilo Peçanha Platform – PBI Dashboard	Gathers and publishes statistical data and indicators. Unlike previous examples, it is not solely focused on dropout and retention indicators.	Entire federal network of professional, scientific, and technological education
MEC, INEP, and DEED	Higher Education Census Database for Longitudinal Academic Path Indicators – School Flow Indicators	Supports discussions on higher education outcomes by presenting indicators chronologically and based on student status – retention, withdrawal, and completion.	Educational Statistics Department/INEP/MEC, using Higher Education Census data since 2009. Not a tool like the others, but provides replicable concepts and indicators.

Source: Own elaboration.

In general, the initiatives listed in Table 3 are based on the concept that dropout and retention need to be evaluated ex-ante, not just ex-post. It is essential for educational institutions to continuously collect and monitor data and indicators, something that the Internet of Things (IoT) and, consequently, artificial intelligence make possible.

Diogo *et al*. (2016), in their investigation into course coordinators' perceptions of dropout and retention in undergraduate programs, highlight that the reality of undergraduate courses in Brazil is quite heterogeneous, partly due to the infrequency of institutional evaluations. The authors emphasize that implementing strategies to address this situation is a difficult task, especially due to the unclear role of course coordinators, given the responsibilities assigned to this position.

5 Development of the database for an undergraduate program – description

The initiatives described in Table 3 can be considered institutional projects encompassing all undergraduate programs. The initiative that will be described in this section was developed within the scope of a single undergraduate program. It was registered in the university's integrated academic system as a technological development project, as it involved the creation of a process to monitor the status of a specific undergraduate program through the development of a system.

The strategy adopted in the undergraduate Economics program at the Institute of Applied Social Sciences of the Federal Rural University of Rio de Janeiro, as presented in this article, highlights that the indicators are more descriptive in nature, meaning they do not have an inferential character and do not constitute econometric or multivariate statistical models. As Diogo *et al*. (2016) point out, inferential indicators would provide a more robust analysis of the factors that help explain the phenomenon. This represents a limiting factor in the analysis presented here.

The motivation for its development and construction came from the course coordination's understanding that addressing dropout and retention requires an objective tool for gathering, integrating, systematizing, and interacting with data. It is essential, therefore, to track student progress throughout the undergraduate program and understand their academic trajectory.

Considering the discussion presented in the previous sections on the concepts of dropout and retention and the ways to measure them, it was understood that, in this case, dropout refers to the student's decision to leave the undergraduate program ("cancellation of enrollment") before completing it. Retention, on the other hand, refers to the mismatch between the chronological period and the curricular matrix, as well as performance by subject. The explanation of both phenomena, in turn, involves different variables and motivations.

The design for its development consisted of: (i) understanding the scale of this phenomenon in the program and, thus, identifying the best ways to measure it; (ii) ensuring that the program maintains a consistent flow of student admissions and graduations; and (iii) facilitating the implementation of pedagogical support projects for the program's students. For dropout, all the formulas presented in Table 2 were calculated for the program, and the different results obtained from each one led to discussions whose conclusions will only emerge over the long term. For retention, the results showed that students nearing the end of the program – about to complete their degree – have been delaying graduation, particularly the defense of their final thesis, as they seek to secure job opportunities or complete non-mandatory internships.

The data analysis system – or dashboard – contains data from the Economics program and was developed using Microsoft Power BI's free version. It was built after years of data collection and tabulation by the course coordination team, incorporating both quantitative and qualitative data that aim to address the complexity of the issue.

In its first stage, the system serves as an in-depth observatory for the program. In its second stage, currently underway, interaction mechanisms between students and the coordination team will be developed to identify dropout risks. In Figure 1, the dashboard of the program is displayed. It is important to note that the layout, presentation, and available data are reviewed at the end of each semester. At the beginning of the last three terms, meetings were held with the student body and the coordination team

to present and discuss the program's data. The coordination team prepares reports on the program's data and indicators, which are reviewed in meetings with the Structuring Teaching Core (NDE) and program council, and subsequently made available on the program's website.

Figure 1 – Dashboard cover for the undergraduate program

Source: The authors in Power BI Desktop, 2023.

For the first stage of the program's dashboard, as described in this article, data collection has been conducted since 2017 from the systems of the Federal Rural University of Rio de Janeiro, namely: SIGAA and Academic Kiosk, covering the period from 2009 to 2022. The data includes: incoming students by semester, enrollment cancellations and adjustments, completions and graduations, gender, age range, active enrollments, and enrollments in curricular components by semester, as well as temporary withdrawals. Additionally, it includes semester performance in courses, considering: approvals, failures and their reasons, class average for each course, academic performance (similar to a course's average coefficient and by class, considering the year and semester of entry), as well as the graduation rate for each class.

Between 2018 and 2022, the course coordination administered questionnaires to students and faculty using Google Forms. These questionnaires addressed dimensions such as socioeconomic profile, study routines, reading habits, difficulties with courses, perceptions of the program, expectations, and sense of belonging.

Other data sources came from information collected from students regarding internships and scholarships, previously recorded in control spreadsheets. It is the responsibility of the coordination team to verify whether these activities align with the class schedules and meet the legal requirements for providing signatures and authorization for internships and extension projects.

AVALIAÇÃO
e-ISSN: 1982-5765 | Revista da Avaliação da Educação Superior

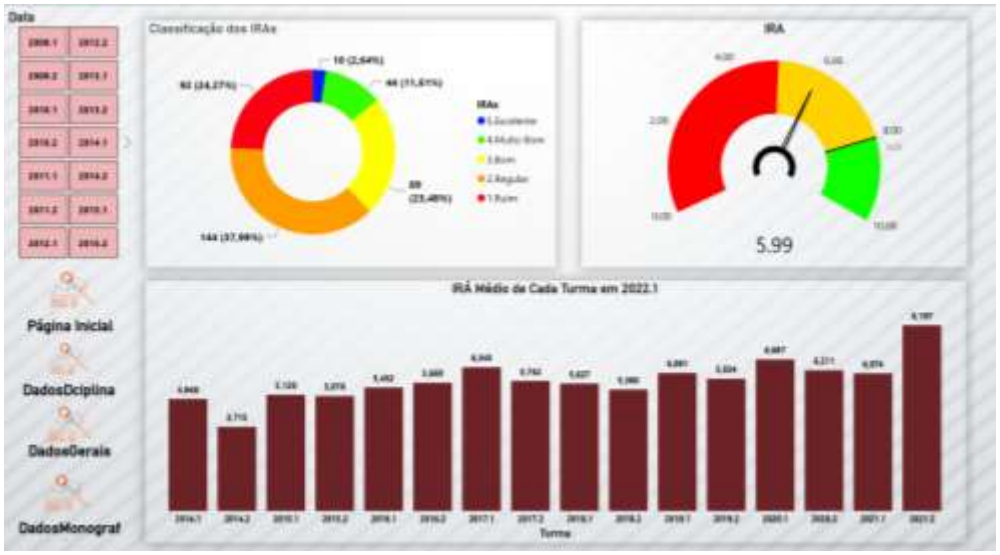
All the information was compiled and organized in the data analysis system (course dashboard) into different spreadsheets according to their respective categories: courses, general data, cancellations, monographs, and student profiles. Each database contains records for a specific period and columns that clarify the context of the facts. Once the databases were organized and systematized, the data was exported to Power BI to enable a more dynamic and efficient data cross-referencing process.

To create the charts, mathematical formulas were developed within Power BI to process the data and transform it into more accessible information, using simple mathematical frameworks such as averages, sums, subtractions, counts, and products. The exception was the Retention Index, which used the FORPLAD/ANDIFES Index, a slightly more sophisticated method, with data filtered by period or course.

The ultimate goal in creating each chart is to enable a horizontal comparison between periods, allowing for the assessment of indicator trends. The Power BI report was divided into eight pages, with the first serving as an introduction and the remaining pages dedicated to each generated data set. The layout of each page is organized using charts, predominantly line, column, and donut charts, as well as indicators displayed in cards, small specific spaces used to present measures. These can be either general measures, which remain unchanged regardless of filter selection, or relative measures, which may vary depending on the selected filter.

In Figure 2, you can see the presentation of the 'general' data for the course, such as: the number of enrolled students and the average Academic Performance Index (IRA) for the program and per class.

Figure 2 – Dashboard 1: general course data

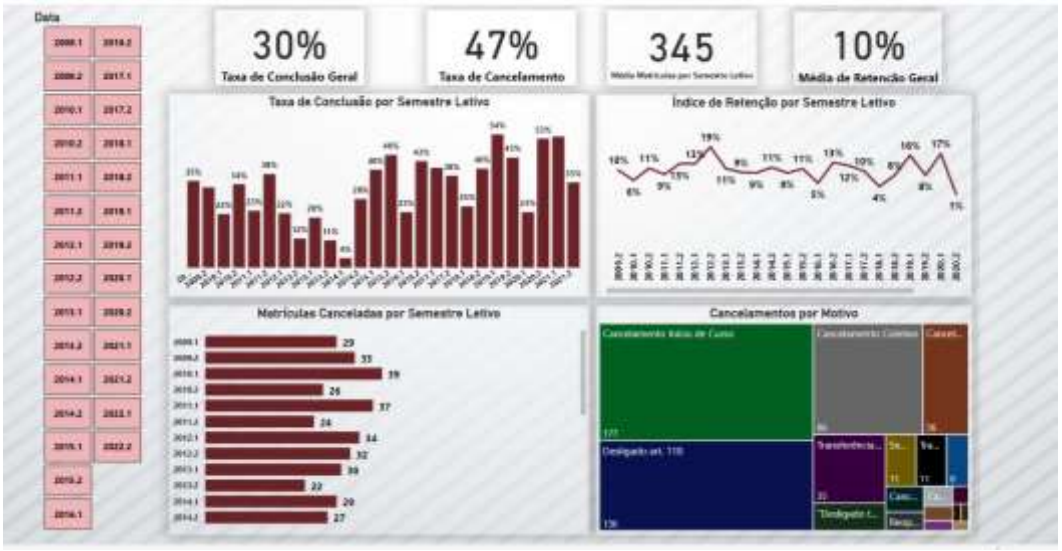


Source: The authors in Power BI Desktop, 2023.

AVALIAÇÃO
e-ISSN: 1982-5765 | Revista da Avaliação da Educação Superior

Figure 3 presents another level of the course dashboard, providing indicators such as: course completion rate, cancellation rate, retention, graduation success rate, and dropout rate. These indicators are displayed over a long period of time and are also segmented by class, considering the year and semester of entry.

Figure 3 – Dashboard 3: course completion and cancellation data and rates



Source: The authors in Power BI Desktop, 2023.

Reports and cards are prepared by the course coordination for the dissemination of this information and to monitor both students and faculty in the program. Additionally, during meetings of the Structuring Teaching Core (NDE) and the course council, these data and information are presented in the form of reports for joint review and evaluation.

A teaching project led by the course coordination for student pedagogical support is connected to this database, proposing actions such as study planning, semiannual meetings with different classes based on the calculated indicators, among others. As part of the second phase of this dashboard development project, the coordination collects data on each student, including their Academic Performance Index (IRA), percentage of total course workload completed, year and semester of entry, and pending curricular components. This data collection has been carried out each semester by the coordination since the second semester of 2016, even before the dashboard was developed. Based on this student profile, those who are considered to be in a critical situation regarding dropout are invited for a meeting with the coordination, during which a plan for course completion is jointly developed. A critical situation is defined by the coordination as students with a course workload completion percentage 15% below the expected level. For students with a low IRA, the invitation also involves an

individual conversation, along with a study habits guide and a questionnaire for students to report their study habits and learning difficulties.

Some extension activities, as part of the course's extension policy, have been organized and carried out since 2018 with the aim of contributing to enhancing students' sense of belonging and identification with the program. Notable examples include: "The Economist's Profession," "Case Studies on Economic Issues," and "Economics in Local Schools," among others. It is also worth mentioning that the number of students undertaking curricular internships, which are not mandatory in our program, has been consistently high. For example, between 2020 and 2022, 25% of the total enrolled students were engaged in internships.

Teixeira, Castro e Zoltowski (2012) argue that dropout is not merely an individual decision made by the student. It is also the result of their interaction with other actors and factors related to the process of obtaining a degree, such as family members, faculty, media, funding institutions, student assistance policies, the surrounding society of the IFES and the student's residence, and the job market. Warns that, in addition to a deficient prior education, this learning process can lead to discouragement, often tied to difficulties in organizing study time.

6 Considerations

Monitoring the progress of an undergraduate program requires the systematic collection of data and indicators. When this data collection spans a longer historical series, the volume of data and information to be presented makes interpretation more complex. Tools made possible by internet-based interfaces facilitate the manipulation of this data and these indicators. This article presented the case of developing a dashboard to serve as an interactive database for an undergraduate program. Reports have been generated and shared with the student and faculty community to help shape perceptions related to the program. Theoretical models on the dropout phenomenon generally emphasize that it is a broad process, involving individual, social, economic, and institutional factors. Student retention in higher education is closely linked to how the educational institution influences this process. Thus, initial diagnostics, such as the one developed and presented in this article, are important tools for the institution's intervention.

It is important to note that the collection and systematization of data from an undergraduate program should not be treated as a way to standardize programs across the board. The distinct identity of higher education in its various fields of knowledge must be valued. Similarly, the use of tools like Power BI for managing undergraduate programs should be understood as a way to grasp their dynamics, not merely as a measure of efficiency. It is crucial to recognize that the numbers and indicators alone do not fully reflect the quality of an undergraduate program.

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Authors' contributions

Rubia Cristina Wegner – The project coordinator played an active role in the development of the tool for data collection and monitoring, as well as in the selection and calculation of the indicators. Additionally, the coordinator contributed to the writing of the text.

Antônio José Alves Junior – The deputy project coordinator actively participated in the analysis and discussion of the data.

Marcelo Pereira Fernandes – The deputy project coordinator actively participated in the revision and writing of the text.

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