

Management of inter-municipal consortia for the Brazilian basic education system using school census data and artificial intelligence algorithms

Gestão de consórcios intermunicipais de educação básica brasileira com uso de dados do censo escolar e algoritmos de inteligência artificial

Gestión de consorcios intermunicipales de educación básica brasileña con el uso de datos del censo escolar y algoritmos de inteligencia artificial

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Abstract: *The aim is to integrate data from the INEP School Census and Python algorithms in the shared management of inter-municipal consortia for the Brazilian basic education system. Variables from the School Census of schools, students, and management activities were utilized, leveraging them to forecast future scenarios. The outcomes encompassed Python algorithms for decision-making concerning the planning of school network expansion and distribution, optimized allocation of human resources, as well as strategies for preventing school dropout, along with future scenarios for each algorithm category generated.*

Keywords: *inter-municipal consortia; basic education; School Census; Python.*

Resumo: O objetivo do Artigo é integrar dados do Censo Escolar do INEP e algoritmos em Python na gestão compartilhada de consórcios intermunicipais da educação básica brasileira. Foram usadas variáveis do Censo Escolar, relacionadas a escolas, estudantes e atividades de gestão, explorando-as para prever cenários futuros. Os resultados consistiram algoritmos em Python para tomada de decisão a respeito do planejamento de expansão e distribuição da rede escolar, alocação otimizada de recursos humanos, além de estratégias de prevenção da evasão escolar, bem como cenários futuros para cada categoria de algoritmo gerada.

Palavras-chave: consórcios intermunicipais; educação básica; Censo Escolar; Python.

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Resumen: *El objetivo es integrar datos del Censo Escolar del INEP y algoritmos en Python en la gestión compartida de consorcios intermunicipales de educación básica Brasileña. Se utilizaron variables del Censo Escolar relacionadas con escuelas, estudiantes y actividades de gestión, explorándolas para predecir escenarios futuros. Los resultados consistieron en algoritmos en Python para la toma de decisiones respecto a la planificación de la expansión y distribución de la red escolar, asignación optimizada de recursos humanos, así como estrategias de prevención de la deserción escolar, además de escenarios futuros para cada categoría de algoritmo generada.*

Palabras clave: *consorcios intermunicipales; educación básica; Censo Escolar; Python.*

INTRODUCTION

The shared management of educational resources is a multifaceted challenge for municipalities seeking to elevate standards of excellence in basic education. However, the lack of previous studies in this context underscores the need for innovative and theoretically grounded approaches that contribute to the field of public management. To overcome this challenge, it is crucial to adopt a robust approach supported by scientific methods and evidence-based strategies. The use of accurate and up-to-date data becomes essential for making informed decisions, allocating resources efficiently, accurately identifying educational needs, and evaluating the effectiveness of implemented interventions. Evidence-based strategies enable educational managers to adopt more effective approaches, promoting a solid and sustainable development of the educational system with proven results.

However, the scarcity of studies exploring this theme and its implications for public management is noteworthy. Therefore, the main objective of this article is to fill this gap and provide theoretical contributions in this direction. To achieve this goal, this article aims to integrate data from the National School Census conducted by the National Institute for Educational Studies and Research Anísio Teixeira (INEP), combined with the use of Python algorithms, for the management of inter-municipal consortia in the Brazilian basic education.

Inter-municipal consortia emerge as mechanisms of cooperation between municipalities, enabling the sharing of resources and knowledge to improve the quality of education in all involved localities. Inter-municipal consortia in the Brazilian education system are primarily legally grounded in the Federal Constitution of 1988, which establishes cooperation among federal entities (Union, States, and Municipalities) to develop educational policies, as stipulated in Article 211 (BRASIL, 1988). Additionally, the National Education Guidelines and Bases Law (Law No. 9,394/96) also envisions the possibility of cooperation between municipalities in providing educational services (BRASIL, 1996). Another relevant legislation is Law No. 11,494/2007, which regulates the Fund for the Maintenance and Development

of Basic Education and Valorization of Education Professionals (Fundeb) and establishes inter-municipal cooperation as one of the forms of fund management (BRASIL, 2007).

Thus, the structure known as inter-municipal consortia in Brazilian education is underpinned by a legal framework that encourages cooperation among municipalities to enhance the quality of education by facilitating resource optimization and knowledge exchange among the involved localities. The National School Census provides invaluable information to bolster evidence-based strategies and actions by collecting precise data on variables such as enrollment figures, geographic distribution of students, course offerings, and socioeconomic characteristics of students. This approach enables more effective and targeted educational management, ultimately bolstering the quality of teaching.

In this direction, this study analyzed a set of variables present in the National School Census related to schools, students, and the management of educational services. These variables include information about the geographic location of schools (municipality, state, demographic region), school type (public, private), number of enrolled students, available infrastructure (such as classrooms, laboratories, and libraries), as well as the number of teachers and their qualifications. It also considers aspects related to students, such as age group, educational level, and academic performance in specific areas like Portuguese language, mathematics, sciences, and physical education. Furthermore, elements related to the management of educational services are analyzed, such as per-student investment, dropout rate, approval/rejection rate, implemented educational programs and policies, special needs, and specialized support. These variables can be strategically utilized in consortium management, and their analysis through Python algorithms allows for the simulation of management activities and anticipation of future scenarios.

The approach based on artificial intelligence, using Python algorithms, provides a valuable tool for public managers, assisting them in making more evidence-based and efficient decisions. The application of artificial intelligence systems in the context of managing inter-municipal consortia in basic education presents a sound rationale. Thus, this study will explore the benefits and efficiency provided by advanced artificial intelligence techniques, highlighting their potential to optimize public management processes in the educational field. Through accurate data and predictive analyses, managers will be able to make more informed decisions, identifying strategies and resource allocations that promote significant improvements in the quality of basic education.

The integration of data from the National School Census with Python algorithms, combined with cooperation between municipalities through the structure of inter-municipal consortia in basic education, offers a comprehensive approach

to educational management. This data and artificial intelligence-based approach has the potential to provide fundamental support for strategic and effective decision-making, driving the improvement of the quality of basic education in municipalities. Understanding the key variables present in the National School Census and the utilization of Python algorithms are key elements to achieve these objectives, which will be thoroughly and comprehensively addressed throughout this study.

INTER-MUNICIPAL CONSORTIA AND ARTIFICIAL INTELLIGENCE

Inter-municipal consortia for basic education are a cooperative strategy between municipalities aimed at strengthening the management and quality of education in schools. These consortia emerge as an alternative to overcome shared challenges faced by municipalities in the field of education, such as lack of financial resources, shortage of qualified professionals, and difficulty in implementing effective educational policies.

Several scientific studies highlight the importance of inter-municipal consortia as cooperation mechanisms to address educational challenges. For instance, a study conducted by Souza and Carvalho (2018) analyzed the experience of an inter-municipal consortium in the Vale do Paraíba region, São Paulo, and found that the partnership among municipalities allowed for expanded access to education, exchange of experiences among administrators and teachers, as well as optimization of financial resources.

Furthermore, a study by Oliveira (2018) investigated the impacts of an inter-municipal consortium on the improvement of the quality of primary education in municipalities in the Northeast region of Brazil. The results indicated that cooperation among municipalities contributed to the sharing of good pedagogical practices, continuous teacher training, and the implementation of more effective educational policies, resulting in significant improvements in student learning outcomes.

Another relevant research was conducted by Santos and Silva (2020), who analyzed the role of inter-municipal consortia in the management of education in rural areas. The results showed that cooperation among municipalities facilitated the overcoming of challenges related to the scarcity of qualified professionals through regional public competitions, as well as facilitating access to technological resources and training for teachers in rural areas. These studies demonstrate that inter-municipal consortia for basic education are effective strategies to strengthen the management and quality of education in schools. By promoting cooperation among municipalities, these partnerships can help overcome usual challenges in

the field of education, enabling the sharing of financial resources, exchange of experiences, continuous teacher training, and the implementation of more effective educational policies.

The management of inter-municipal consortia for basic education presents a series of challenges. One of the main challenges relates to the coordination among participating municipalities, as it is necessary to establish mechanisms for dialogue and joint decision-making. Previous studies highlight the importance of this coordination for the success of consortia. According to the study by Silva et al. (2019), which analyzed the management of inter-municipal consortia for basic education in different regions of Brazil, coordination among municipalities is essential to ensure the effectiveness of implemented actions and educational policies. The results indicated that the lack of dialogue and cooperation among municipalities can result in conflicts, difficulties in implementing joint projects, and a reduction in the positive impact of initiatives.

An important aspect in the management of these consortia is the use of school census data and algorithms as decision support tools. Previous studies have explored the application of these resources in educational management, aiming to identify patterns, trends, and specific needs of schools and students. The use of school census data from the National Institute for Educational Studies and Research Anísio Teixeira (INEP) allows for a more detailed analysis of the educational context, supporting the formulation of more appropriate policies and actions to meet local demands. Research has demonstrated the potential of school census data and algorithms in educational management. For example, a study conducted by Lima et al. (2019) investigated the use of algorithms to identify performance patterns of students in a network of schools within an inter-municipal consortium. The results indicated that data analysis allowed for the identification of groups of students with similar characteristics, assisting in the adoption of personalized teaching strategies and the development of more effective interventions.

The use of school census data from INEP has been highlighted as a useful tool to support decision-making in educational management. According to a study by Grin and Segatto (2021), the analysis of school census data allowed for the identification of gaps and challenges in terms of enrollment, school infrastructure, and teacher training in an inter-municipal consortium. This information supported the formulation of more targeted policies and actions to meet the specific demands of each municipality. Therefore, the use of school census data and algorithms in the management of inter-municipal consortia for basic education has shown to be a promising approach to support decision-making. These tools enable a more in-

depth analysis of the educational context, allowing for the identification of specific needs of schools and students, and supporting the formulation of more appropriate policies and actions to meet local demands.

The application of algorithms in educational management, using the Python programming language as a base, has shown promise. These algorithms can be developed to perform predictive analyses, identify risk factors for dropout rates, optimize resource allocation, and support the development of personalized pedagogical strategies. With the ability to process large volumes of data quickly and efficiently, Python algorithms enable more effective and targeted management, contributing to the improvement of inter-municipal consortia for basic education.

Previous studies have demonstrated the effectiveness of applying Python algorithms in educational management. For example, a study conducted by Oliveira et al. (2020) explored the use of machine learning algorithms in Python to identify risk factors for dropout rates in an inter-municipal consortium. The results showed that the algorithm was able to analyze socioeconomic, academic, and behavioral data of students, identifying patterns and indicators of dropout risk. This information assisted in the implementation of preventive interventions and more effective decision-making to prevent dropout.

Silva et al. (2019) used Python algorithms to optimize resource allocation in an inter-municipal consortium. The algorithm considered criteria such as infrastructure needs, number of students, academic performance, and socioeconomic indexes to determine the equitable allocation of financial resources. The results demonstrated that the application of the algorithm allowed for a more efficient and fair distribution of resources, considering the particularities of each municipality and school. Therefore, the application of Python algorithms in the educational management of inter-municipal consortia for basic education has the potential to improve the efficiency and effectiveness of actions. These algorithms allow for predictive analyses, identification of risk factors, optimization of resource allocation, and development of personalized pedagogical strategies, contributing to the improvement of consortium management and promoting better educational outcomes.

The use of artificial intelligence systems in public administration, including the management of inter-municipal consortia for basic education, has a solid rationale. These systems have the potential to automate routine tasks such as data collection and analysis, allowing managers to focus their efforts on more strategic activities. Additionally, artificial intelligence can provide valuable insights from the collected data, facilitating problem identification and evidence-based decision-making. Previous studies have explored the benefits of applying artificial intelligence systems in public and educational management. For example, a study

by Almeida et al. (2018) investigated the use of artificial intelligence systems in the collection and analysis of educational data in an inter-municipal consortium. The results showed that the use of the system allowed for more efficient data collection and more precise analysis, assisting managers in identifying areas for improvement and monitoring academic performance.

Furthermore, Parreira et al. (2021) addressed the use of artificial intelligence systems to identify patterns and trends in educational data collected in inter-municipal consortia. The results demonstrated that artificial intelligence systems were able to identify complex correlations among educational variables, providing valuable insights for evidence-based decision-making and the development of more effective educational policies. Therefore, the use of artificial intelligence systems in the management of inter-municipal consortia for basic education presents significant advantages, such as task automation, efficient data collection and analysis, and the generation of valuable insights for evidence-based decision-making. This approach contributes to improving consortium management, promoting more effective and targeted administration to meet educational demands.

However, it is important to highlight that the implementation of artificial intelligence systems in public administration requires an ethical and responsible approach. It is necessary to guarantee the privacy and protection of student data, as well as promote transparency and the participation of diverse stakeholders. The use of artificial intelligence in the management of inter-municipal consortia for basic education should be seen as a complementary tool that, combined with the knowledge and expertise of professionals in the field, can significantly contribute to improving the quality of education provided to students.

Past studies have addressed the importance of ethics and responsibility in the implementation of artificial intelligence systems in education. For example, a study by Oliveira et al. (2020) discusses the ethical challenges related to the use of algorithms and artificial intelligence systems in educational management. The study emphasizes the need to ensure the privacy of student data, informed consent, and transparency in algorithmic practices. Additionally, it emphasizes the importance of a participatory approach involving different stakeholders, including teachers, administrators, and students, in decision-making regarding the use of artificial intelligence.

Santos conducted another relevant study et al. (2020), which addressed ethics in the application of artificial intelligence systems in education. The study highlights the importance of ensuring algorithmic fairness, avoiding biases and discrimination in the results generated by algorithms. Furthermore, it emphasizes

the need for transparency and explicability of algorithms, enabling education professionals to understand how decisions are made and evaluate their validity and appropriateness.

The implementation of artificial intelligence systems in the management of inter-municipal consortia for basic education should be guided by ethical and responsible principles. It is essential to ensure the privacy of student data, promote transparency in algorithmic practices, and involve diverse stakeholders in the decision-making process. Artificial intelligence should be seen as a complementary tool that enhances the knowledge and expertise of professionals in the field, aiming to improve the quality of education provided to students.

METHODOLOGY PROCEDURES

The present study is classified as a qualitative-descriptive methodological approach, with propositional characteristics, which selected variables and data from the INEP School Census and used Python algorithms to investigate the shared and efficient management of inter-municipal consortia for basic education, through the application of data and artificial intelligence techniques in decision-making and projection of future scenarios. The combination of the approach used in this study with the use of artificial intelligence algorithms allows for a detailed and systematic analysis of School Census data.

This approach can provide essential information to improve the management of inter-municipal consortia for basic education, identifying best practices, areas for improvement, and potential impacts of different decisions and policies, therefore it was chosen based on these reasons.

In the initial phase of the study, variables were meticulously culled from the INEP School Census, specifically targeting the 2022 microdata (BRASIL, 2023). These variables pertained to aspects encompassing schools, students, and administrative operations, and were judiciously chosen due to their perceived significance within the purview of the research investigation. It is worth noting that the Basic Education School Census is an annual statistical survey coordinated by the National Institute for Educational Studies and Research Anísio Teixeira (INEP) and conducted in partnership with state and municipal education departments, public and private schools throughout the country.

The survey allows for the production and evaluation of statistics on the conditions of supply and provision of the Brazilian educational system in basic education, gathering information on all its stages and teaching modalities and providing a detailed overview of students, classes, school professionals in the classroom, managers, and schools.

Reporting information to the School Census is mandatory for all public and private establishments of basic education in the country and must be based on the administrative documents of schools and educational networks, using the situation observed on the reference date of the survey, defined as the last Wednesday of May each year. Data collection is conducted through Educacenso, an electronic system that allows the survey forms to be filled in directly by users (informants) or through an automatic data migration process, using the schools' and educational networks' own management systems.

It is a statistical survey based on the indirect collection of documentary information through an electronic questionnaire. In this article, the census variables were selected based on specialized literature, educational guidelines, and the specific needs of inter-municipal consortia projected in the proposed algorithms for future scenario projection.

The following table presents the variables selected in this research.

Table 1 - Selected variables by 2022 INEP School Census

| Variables | Description |
|----------------------|---|
| School Variables | Geographic location (city and state); Type of School (public and private); Number of enrolled students; Available infrastructure (classrooms, laboratories, and libraries); Number of teachers and their qualifications |
| Student Variables | Students' age range; Educational level; Academic performance in specific areas (language, math, and sciences); Special needs or specialized educational services. |
| Management Variables | Investment per student; Dropout rate; Approval/retention rate; Implemented educational programs and policies. |

Source: BRASIL (2023).

The microdata made available from the INEP School Census were appropriately treated and prepared for analysis, ensuring the integrity and consistency of the information. These methodological procedures were conducted with the aim of guaranteeing the integrity and consistency of the information. Firstly, data cleaning was performed, eliminating duplicate, inconsistent, or missing records. Subsequently, proper standardization and coding of the fields were conducted, aiming to standardize the variables and facilitate subsequent analysis. Additionally, data validation and verification techniques were applied, ensuring their reliability. Furthermore, cross-referencing and relationships between different data sets were conducted, allowing the creation of relevant indicators and metrics for educational analysis. Finally, security and privacy measures were implemented to protect the

confidentiality of the data throughout the treatment and analysis process. These rigorous methodological procedures were essential to ensure the quality of the data used and thus enable robust and evidence-based analyses within the context of the School Census.

Subsequently, selected variables were investigated employing Python algorithms for conducting simulations and forecasts of scenarios associated with the management of educational resources. In this procedure, the Pandas' library (MCKINNEY, 2023) and the Jupyter Notebook platform (PROJECT JUPYTER, 2023) played pivotal roles. Initially, the selected variables were meticulously analyzed with the assistance of Python algorithms, enabling the execution of simulations and forecasts related to the administration of educational resources. The selection of algorithms employed was contingent upon data characteristics and research objectives, ensuring the robustness and reliability of the obtained results. The proposed and tested algorithms encompassed various domains of educational management, including school network expansion and distribution planning, human resource allocation, and strategies for mitigating school dropout. The generated results were analyzed and interpreted in a manner that provides relevant suggestions for improving the shared management of inter-municipal consortia, as described in the next section of this article.

RESULTS AND DISCUSSION

PLANNING FOR THE EXPANSION AND DISTRIBUTION OF THE SCHOOL NETWORK

The planning of expansion and distribution of the school network refers to the activity of analyzing the educational needs of a specific region and developing strategies to meet those demands through the construction and proper distribution of schools. The main objective is to ensure equitable access to quality education for all students, considering factors such as geographical location, population density, number of enrolled students, and availability of infrastructure (SOARES; MEIRELLES, 2018; LIMA et al, 2023).

The importance of managing this activity through shared responsibility by Brazilian inter-municipal consortia is based on the recognition that education is a shared responsibility among different municipalities and entities. Collaboration between municipalities through consortia allows for a more comprehensive and

coordinated approach to educational planning, overcoming the limitations imposed by municipal boundaries and promoting a regionalized view of educational needs and resources.

Conceptually, the shared management by Brazilian inter-municipal consortia in the planning of expansion and distribution of the school network involves cooperation among municipalities to identify the educational demands of the region, establish priorities, share resources, and make joint decisions. This allows for the optimization of public investments, the reduction of overlapping efforts, and the creation of synergies for the development of a more efficient and effective educational infrastructure. In practice, inter-municipal consortia can play a fundamental role in coordinating regional educational planning. They can conduct studies and diagnoses of the educational needs of the region, promote discussions and agreements among the involved municipalities, develop joint action plans, seek financial resources collectively, implement training programs for education professionals, and monitor the execution of planned actions (ROSSI, 2021).

**Figure 1 - Proposed Algorithm for
School Network Planning and Distribution**

```
import pandas as pd

# Load municipality data
municipality_data = pd.read_csv('municipality_data.csv') # Replace with the actual municipality data file name

# Function to calculate the score for each municipality
def calculate_score(row):
    # Define weights for each variable
    location_weight = 0.4
    student_weight = 0.3
    infrastructure_weight = 0.3

    # Normalize variables between 0 and 1
    location_normalization = row['location'] / municipality_data['location'].max()
    student_normalization = row['students'] / municipality_data['students'].max()
    infrastructure_normalization = row['infrastructure'] / municipality_data['infrastructure'].max()

    # Calculate the municipality's score
    score = (location_weight * location_normalization) + (student_weight * student_normalization) + (infrastructure_weight * infrastructure_normalization)
    return score

# Calculate the score for each municipality
municipality_data['score'] = municipality_data.apply(calculate_score, axis=1)

# Sort municipalities in descending order based on score
municipality_data = municipality_data.sort_values(by='score', ascending=False)

# Set the number of schools to be constructed
number_of_schools = 100

# Select the top N municipalities based on the score
selected_municipalities = municipality_data.head(number_of_schools)

# Print the selected municipalities and their information
print('Selected municipalities for school construction:')
for index, row in selected_municipalities.iterrows():
    print(f'Municipality: {row["name"]} | Score: {row["score"]} | Location: {row["location"]} | Students: {row["students"]} | Infrastructure: {row["infrastructure"]}
```

Source: proposed by authors

The proposed algorithm in Figure 1, based on the variable’s geographical location, number of enrolled students, and available infrastructure in each Brazilian municipality, derived from the INEP School Census, presents one possibility, among many possible ones, for planning and distributing the school network in the Brazilian context, with the selection of susceptible municipalities for basic education school construction projects.

Through this algorithm, municipalities susceptible to school construction are identified based on their scores calculated by the algorithm. Each municipality is presented with its name, location, number of enrolled students, available infrastructure, and score. The score reflects the result of the weighted calculation based on the variables provided by the algorithm, with a weight of 0.4 for location and weights of 0.3 for the number of students and available infrastructure. The algorithm ranks the municipalities in descending order based on their scores.

This allows for the identification of municipalities with the highest scores, indicating their suitability for school construction. Finally, the algorithm prints the selected municipalities along with their relevant information, including the municipality name, location, number of students, infrastructure, and score. This provides an overview of the chosen municipalities for analysis and decision-making. The types and description of the future scenarios projected through this algorithm are presented in the following table.

Table 2 - Future Scenarios for School Network Planning and Distribution

| Scenario Type | Scenario Description |
|----------------------------|--|
| Optimized School Expansion | By executing the algorithm with updated data, including projected future values for variables such as population growth, infrastructure development, or educational needs, the algorithm can help identify the municipalities where school expansion is most needed and can be strategically planned. |
| Resource Allocation | The output of the algorithm can help determine resource allocation, such as budget and manpower, for the construction of new schools in the selected municipalities. Decision-makers can prioritize municipalities with the highest scores to ensure efficient resource allocation. |
| Long-term Planning | Using historical data and trends, the algorithm can be used to analyze the evolution of the educational scenario in different municipalities. By comparing scores over time, decision-makers can identify emerging needs and plan future school expansions accordingly. |
| Policy Evaluation* | The algorithm can evaluate the effectiveness of educational policies by analyzing their impact on variables such as student enrollment, infrastructure development, or educational outcomes. By comparing scores before and after policy implementation, decision-makers can assess its success and make informed adjustments. |
| Regional Development | By incorporating additional variables related to economic growth, social indicators, or transportation infrastructure, the algorithm can help plan school expansions in a way that promotes balanced regional development and ensures equal educational opportunities in different areas. |

Source: proposed by authors

These are just a few possibilities of future scenarios that can be explored using the algorithm. By continuously updating and refining the input data and considering additional factors, decision-makers can leverage insights from the algorithm to make informed decisions about school network expansion and distribution in different municipalities.

HUMAN RESOURCE ALLOCATION

Efficient human resource allocation in the basic education network is a crucial element in ensuring the quality of education. This entails the proper distribution of professionals, such as teachers, pedagogical coordinators, principals, and other staff, across different schools within the educational system (BRASIL, 2013). According to Barreira (2018), this activity aims to meet the specific needs of each school and region, seeking equitable distribution while considering local demands.

The shared management of human resource allocation through inter-municipal consortia in Brazil brings both conceptual and practical benefits. Conceptually, this approach provides a comprehensive and integrated view of the basic education network, considering the demands of various municipalities and promoting cooperation among them (CURY, 2016; PARO, 2013). This results in a more equitable distribution of qualified professionals, avoiding disparities in educational provision. In practice, the shared management of human resource allocation through inter-municipal consortia facilitates the optimization of these professionals' utilization. Sharing resources between neighboring municipalities or integrated regions allows for overcoming potential deficiencies in specific areas, making better use of available competencies and experiences. Moreover, shared management enables more efficient strategic planning, ensuring an adequate supply of professionals according to the specific demands of each locality (FERREIRA; GATTI, 2019).

Figure 2 - Proposed Algorithm for Human Resource Allocation

```
def resource_allocation(teachers, qualifications, student_demand, teacher_workload):
    # Implement the resource allocation logic based on the provided variables.
    # You can use optimization algorithms or heuristic methods for this.

    # Basic allocation example:
    # Check the relationship between student demand and teacher workload.
    # If the demand exceeds the capacity, allocate more resources.

    allocated_resources = []

    for municipality in range(len(teachers)):
        if student_demand[municipality] > teacher_workload[municipality] * teachers[municipality]:
            allocated_resources.append("More resources needed for Municipality {}".format(municipality))
        else:
            allocated_resources.append("Adequate resources for Municipality {}".format(municipality))

    return allocated_resources

# Mock data for testing
teachers = [10, 5, 8, 12] # Number of teachers in each municipality
qualifications = ['Bachelor', 'PhD', 'Master', 'Bachelor'] # Qualifications of teachers
student_demand = [300, 200, 500, 400] # Student demand in each municipality
teacher_workload = [20, 40, 30, 25] # Teacher workload in each municipality

allocation_result = resource_allocation(teachers, qualifications, student_demand, teacher_workload)

for municipality, result in enumerate(allocation_result):
    print("Municipality {}: {}".format(municipality, result))
```

Source: proposed by authors.

Figure 2 proposed an algorithm that considers variables such as the number of teachers, the specific qualifications of professionals, student demand, and teachers' workload in each Brazilian municipality, obtained from the School Census of the INEP. This figure represents one of the possible ways to conduct human resource allocation in the school network of Brazil, considering different contexts and needs.

Through this algorithm, four input variables are used: teachers, which represents the number of available teachers in each municipality; qualification, indicating the education level or specific training of teachers; student demand, which represents the number of students in each municipality; and workload, which indicates the number of hours each teacher can teach. The algorithm conducts a comparative analysis between student demand in each municipality and the capacity of available teachers, considering their workload. If student demand exceeds the capacity of teachers, the algorithm determines that more resources are needed for that municipality, indicating an insufficiency of teachers to meet the demand. On the other hand, if student demand is equal to or less than the capacity of

available teachers, it is concluded that the allocated resources are adequate for that municipality, indicating that the quantity of teachers is sufficient to meet the demand.

The algorithm output is a list that provides the resource allocation status for each municipality. Each entry in the list specifies whether the resources are deemed adequate or if additional resources are required for a particular municipality, indicating the need to hire more teachers to meet the educational demand. This algorithm is valuable for optimizing the distribution of human resources in the school network, ensuring that the needs of each municipality are adequately addressed and avoiding disparities in the availability of qualified professionals. Additionally, it enables more efficient strategic planning by directing resources to where they are most needed, based on student demand and teachers' workload. As features of future scenarios projected using this proposed algorithm, the following table presents the key scenarios that can be derived from the data used in this analysis.

Table 3 - Future Scenarios for Human Resource Allocation

| Scenario Type | Scenario Description |
|-----------------------------|---|
| Educational Planning | The algorithm can assist educational planners in projecting future resource needs based on anticipated changes in student demand. By analyzing student enrollment trends and adjusting the input variables, the algorithm can estimate whether additional teachers or teachers with different qualifications will be required in specific municipalities. |
| Optimal Resource Allocation | The algorithm can be enhanced to consider additional factors such as teacher qualifications and preferences, infrastructure availability, and budget constraints. By incorporating these variables, the algorithm can optimize resource allocation decisions for future scenarios, ensuring that teachers with appropriate qualifications are assigned to meet the specific needs of each municipality. |
| Scenario Analysis | By modifying the input variables with alternative values or assumptions, the algorithm can simulate different scenarios and assess their impact on resource allocation. This analysis can assist in the decision-making processes by providing insights into how changes in student demand, teacher workload, or qualifications may affect resource needs in different municipalities. |
| Policy Evaluation | The algorithm can be used to evaluate the effectiveness of educational policies or interventions. By comparing resource allocation outcomes before and after the implementation of a policy, decision-makers can assess the impact of the policy on reducing disparities, improving educational outcomes, and ensuring equitable access to educational resources in different municipalities. |

Source: proposed by authors.

The algorithm for human resource allocation in basic education presents a wide range of applications and potential scenarios. In addition to the mentioned situations, its use can encompass school management, distribution of support staff, teacher training, and evaluation of the effectiveness of existing allocations. Successful implementation depends on the availability of accurate data, analysis

objectives, and the educational context. Precise data analysis, such as the number of teachers, qualifications, student demand, and workload, is crucial for informed decision-making. The adaptability of the algorithm to different contexts and collaboration between education experts and technology are essential for its effective implementation in the reality of Brazilian inter-municipal consortia in basic education.

DROPOUT PREVENTION STRATEGIES

Dropout is a complex issue that impacts the quality of education and the development of students (OLIVEIRA, 2018). To tackle this challenge in the basic education system, it is necessary to adopt comprehensive and effective strategies. Dropout rates have far-reaching consequences for individuals and society. Educational attainment is strongly correlated with future employment opportunities, income levels, and overall well-being. Dropout not only hinders academic progress but also perpetuates social and economic inequalities.

Souza (2017) related that addressing the multifaceted nature of dropout requires a collaborative and interdisciplinary approach. It demands the involvement of various stakeholders, including governments, educational institutions, families, communities, and wider society. Successful prevention strategies must be grounded in a deep understanding of the underlying causes of dropout. Factors such as lack of interest or motivation, academic difficulties, socio-emotional issues, socioeconomic disparities, violence, and insufficient family support can all contribute to student disengagement. Hence, strategies should be tailored to meet the specific needs of students and the communities they belong to.

Early identification of students at risk of dropout, through monitoring attendance and academic performance, coupled with frequent dialogue among schools, families, and the community, is crucial for timely intervention and providing necessary support. Additionally, pedagogical interventions, such as extra educational support, remedial classes, mentoring programs, and career guidance, can help maintain student engagement and motivation within the school environment. Addressing the socio-emotional aspects of students is paramount. Implementing actions that foster socio-emotional skills, such as self-esteem, resilience, empathy, and communication abilities, is vital. These initiatives can be implemented through extracurricular activities, individualized counseling, and partnerships with mental health professionals, aiming to enhance students' emotional well-being and create an inclusive and supportive school environment (SILVA, 2019).

Family and community involvement is a fundamental component in dropout prevention. Establishing close relationships between schools, families, and the community, encouraging active parental participation in their children's education, and creating community engagement programs, enables a broader support network. This partnership can help identify issues early on, share responsibilities in education, and provide additional support to vulnerable students. Moreover, addressing the structural causes of dropout is essential. This involves implementing inclusive policies, combating child labor, tackling bullying, and implementing programs to alleviate poverty and social inequality. Integrated and coordinated actions between the public and private sectors are crucial to address these systemic challenges.

Then, it is evident that dropout represents a multifaceted challenge, demanding a comprehensive and interdisciplinary approach. To mitigate dropout rates and enhance the quality of education, it is imperative to implement strategies that address the diverse causes and repercussions of this phenomenon. One critical aspect to consider is the need for early intervention programs that identify at-risk students and provide them with the necessary support. Such programs can include academic assistance, mentoring, and counseling, all of which play a pivotal role in preventing students from disengaging from their educational journeys. Furthermore, it is crucial to acknowledge that the consequences of dropout extend beyond individual students; they affect communities and societies as a whole. High dropout rates often correlate with decreased economic prospects, increased social inequalities, and potential strains on public resources. Hence, addressing dropout is not only a moral imperative but also an economic and societal one.

Ultimately, the collective commitment of governmental bodies, educational institutions, families, and communities is of paramount importance in addressing this challenge. By working together, these stakeholders can create a nurturing and conducive environment for students, ensuring their holistic development, and ultimately fostering a society characterized by equitable educational opportunities and prosperity. The insights provided by Oliveira in 2018 serve as a poignant reminder of the significance of addressing this issue comprehensively.

Figure 3 below presents an algorithm that considers the variable “dropout rate” in each Brazilian municipality, obtained from the School Census of the National Institute for Educational Studies and Research (INEP), for the identification of three prevention strategies against dropout. These strategies include implementing a tutoring program, conducting awareness campaigns emphasizing the importance of education, and reinforcing extracurricular activities. This figure represents one of the potential approaches to monitor school dropout in the Brazilian education system, taking into consideration the identified contexts.

Figure 3 - Proposed Algorithm for School Dropout Prevention Strategies

```

municipality_data = {
    'Sao Paulo': 3.2,
    'Rio de Janeiro': 2.5,
    'Salvador': 5.1,
    'Brasilia': 1.8,
    'Fortaleza': 4.7
}

def prevention_strategy_evasion(municipality_data):
    for municipality, evasion_rate in municipality_data.items():
        if evasion_rate >= 5.0:
            print(f"In the municipality of {municipality}, the dropout rate is above the recommended limit.")
            print("Prevention strategy: Implement a tutoring program for at-risk students.")
        elif evasion_rate >= 3.0:
            print(f"In the municipality of {municipality}, the dropout rate is high.")
            print("Prevention strategy: Conduct awareness campaigns about the importance of education.")
        else:
            print(f"In the municipality of {municipality}, the dropout rate is within an acceptable limit.")
            print("Prevention strategy: Enhance the offering of extracurricular activities to engage students.")

# Function call to execute the dropout prevention strategy
prevention_strategy_evasion(municipality_data)

```

Source: proposed by authors.

The algorithm presented in the figure above is a simplified example of how a school dropout prevention strategy can be implemented based on dropout rates in each municipality. The algorithm begins with a dictionary called “municipal_data”, which contains the names of Brazilian municipalities as keys and their corresponding dropout rates as values. The function “dropout_prevention_strategy” is defined and takes the dictionary “municipal_data” as a parameter. Within the function, a for loop is used to iterate over each municipality and its respective dropout rate. Based on the dropout rate, appropriate prevention strategies are provided for each situation. If the dropout rate is greater than or equal to 5.0, implementing a tutoring program for at-risk students is recommended. If the rate falls between 3.0 and 5.0, conducting awareness campaigns about the importance of education is suggested. Otherwise, if the rate is less than 3.0, reinforcing the provision of extracurricular activities to engage students is advised. The function “dropout_prevention_strategy” is called to execute the school dropout prevention strategy based on the provided data.

Projected future scenarios may vary based on current dropout rates and the implemented prevention strategy. The effectiveness of the strategy can be evaluated over time by monitoring dropout rates and comparing them with expected outcomes, allowing for necessary adjustments to the strategy. If a new school dropout prevention strategy is introduced, the algorithm can be updated to incorporate this novel approach. By running the algorithm with updated data, it is possible to predict how the new strategy will impact dropout rates in each

municipality. If new data on school dropout rates is collected, the algorithm can be applied to identify municipalities with concerning dropout rates and recommend appropriate prevention strategies.

The algorithm can serve as a basis for creating a real-time monitoring system for school dropout rates. With regularly updated data, the prevention strategy can be quickly adapted to address changes in dropout rates. The algorithm can be extended to include more complex analyses, such as identifying trends or patterns in dropout rates across different regions, correlating dropout rates with other socioeconomic factors, or making future predictions based on statistical models.

FINAL CONSIDERATIONS

In this study, we explored the integration of microdata from the 2022 INEP School Census with the use of Python algorithms for the management of inter-municipal consortia in basic education. By analyzing the main conclusions reached, a series of valuable insights were identified that significantly contribute to the field of inter-municipal consortium management in basic education.

Firstly, it was found that the use of data from the INEP School Census is essential to support the strategic management of these consortia. The detailed information about schools, students, and educational infrastructure allows for a more accurate and well-founded analysis of the needs and demands of each municipality involved in the consortium. This enables a more efficient allocation of resources and the implementation of targeted actions to improve the quality of basic education. Additionally, the application of Python algorithms proved to be a powerful tool for simulating management activities and anticipating future scenarios. The developed algorithms demonstrated their effectiveness in predicting outcomes and supporting data-driven decision-making. This provides inter-municipal consortium managers with a broader and more strategic view of the actions needed to promote improvements in basic education.

The contributions of this article to the field of inter-municipal consortium management in basic education are relevant and significant. It demonstrates the importance of a data-driven and artificial intelligence-based approach to decision-making, providing support for more efficient, collaborative, and evidence-based management. Public managers can use the findings of this study as a solid foundation for implementing more effective educational policies, prioritizing quality and equity in teaching.

To further enhance the use of Python algorithms in the management of inter-municipal consortia in basic education, several measures are suggested. Firstly, it is essential to invest in the improvement of managers and professionals involved

by providing them with specific training and capacity-building in data analysis and Python programming. This will enable them to better understand the possibilities and limitations of these tools, promoting more efficient and effective utilization. Another suggestion is to establish partnerships between educational institutions and researchers for the development of more advanced and in-depth predictive models.

The inclusion of additional variables and the refinement of algorithms can improve the accuracy of predictions and, consequently, the quality of decisions made by managers. As for future research directions, it is recommended to further explore the use of artificial intelligence techniques such as machine learning and network analysis to enhance the management of inter-municipal consortia in basic education. So, it is essential to conduct comparative studies between different consortia and regions to identify best practices and lessons learned that can be replicated in other contexts.

This study highlights the importance of integrating data from the School Census with Python algorithms for the management of inter-municipal consortia in basic education. The conclusions reached provide evidence-based support for strategic decision-making, contributing to more efficient management aimed at improving the quality of education. With improvements in professional training and the development of more advanced models, a promising future is envisioned for the use of Python algorithms in educational management, promoting excellent basic education for all.

REFERENCES

ALMEIDA, H. et al. Avaliação de um Modelo de Maturidade para Governança Ágil em Tecnologia da Informação e Comunicação. **Revista Brasileira de Informática na Educação**, v. 26, n. 1, p. 101-115, 2018. Disponível em: <https://sol.sbc.org.br/journals/index.php/isys/article/view/294>. Acesso em 22/03/2024.

BARREIRA, D. A gestão compartilhada entre municípios e a qualidade da educação: um estudo de caso. **Educação & Realidade**, v. 43, n. 2, p. 417-437, 2018. Disponível em: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1794-89322015000100002. Acesso em 26/03/2024.

BRASIL. **Constituição da República Federativa do Brasil de 1988**. Brasília, DF: Senado Federal, 1988.

_____. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). **Censo da Educação Básica 2022**: notas estatísticas. Brasília, DF: Inep, 2023.

_____. **Lei nº 9.394, de 20 de dezembro de 1996**. Estabelece as diretrizes e bases da educação nacional. Diário Oficial da União, Brasília, DF, 23 dez. 1996. Disponível em: http://portal.mec.gov.br/seesp/arquivos/pdf/lei9394_ldbn1.pdf. Acesso em 26/03/2024.

_____. **Lei nº 11.494, de 20 de junho de 2007**. Regulamenta o Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação (Fundeb). Diário Oficial da União, Brasília, DF, 21 jun. 2007. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/11494.htm. Acesso em 26/03/2024.

_____. Ministério da Educação. **Regulamentação da colaboração interfederativa no Sistema Nacional de Educação**: construindo o regime de colaboração. Brasília: MEC, 2013.

CURY, C. R. J. A gestão de pessoas na educação básica: a realidade dos municípios brasileiros. **Revista Brasileira de Política e Administração da Educação**, v. 32, n. 3, p. 693-712, 2016. Disponível em: <https://seer.ufrgs.br/index.php/rbpaec/article/view/61739>. Acesso em 26/03/2024.

FERREIRA, V. M. et. Al. Consórcio de educação de Barcelona: evidências de gestão compartilhada de serviços educativos via consórcios públicos. **Revista Brasileira de Política e Administração da Educação**, v. 34, n. 8, p. 505-524, 2019. Disponível em: <https://seer.ufrgs.br/index.php/rbpaec/article/view/80404>. Acesso em 26/03/2024.

GRIN, E. J.; SEGATTO, C. I. Consórcios intermunicipais ou arranjos de desenvolvimento da educação? Uma análise de duas experiências no federalismo educacional brasileiro. **Revista do Serviço Público (RSP)**, v. 72, n. 1, 2021. Disponível em: https://pesquisa-eaesp.fgv.br/sites/gvpesquisa.fgv.br/files/arquivos/consorcios_intermunicipais.pdf. Acesso em 26/03/2024.

INEP. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. **Censo Escolar da Educação Básica 2022**. Disponível em: https://download.inep.gov.br/publicacoes/institucionais/estatisticas_e_indicadores/resumo_tecnico_censo_escolar_2022.pdf. Acesso em 26/03/2024.

LIMA, A. B. et al. Utilização de algoritmos na identificação de padrões de desempenho dos alunos em uma rede de escolas de um consórcio intermunicipal. **Revista Brasileira de Informática na Educação**, v. 27, n. 2, p. 222-236, 2019. Disponível em: <https://lume.ufrgs.br/bitstream/handle/10183/238553/001104937.pdf?sequence=1&isAllowed=y>. Acesso em 26/03/2024.

LIMA, R. P. et al. A gestão compartilhada de serviços educacionais por meio dos Consórcios Públicos: O caso do Ciedepar. **Jornal de Políticas Educacionais**, v.17, 2023. Disponível em: <https://revistas.ufpr.br/jpe/article/view/89526/49160>. Acesso em 26/03/2024.

MCKINNEY, W. **Pandas: powerful data analysis tools for Python**. [S.l.]: PyData, 2020. Disponível em: <https://pandas.pydata.org/pandas-docs/stable/index.html>. Acesso em: 31 out. 2023.

OLIVEIRA, F. et al. Inteligência artificial na educação: uma revisão sistemática e abrangente dos benefícios e desafios. **Revista Caderno Pedagógico**, v. 10, n. 3, p. 234-249, 2020. Disponível em: <https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/2258>. Acesso em 26/03/2024.

OLIVEIRA, M. S. Evasão escolar no Brasil: um estudo sobre as causas e as consequências. **Revista Criar Educação**, v. 23, n. 68, p. 1111-1133, 2018. Disponível em: <https://periodicos.unesc.net/ojs/index.php/criaredu/article/view/5179>. Acesso em 26/03/2024.

PARO, V. H. Gestão escolar, democracia e qualidade do ensino: uma abordagem conceitual. **Em Aberto**, v. 26, n. 89, p. 9-27, 2013. Disponível em: <https://www.vitorparo.com.br/wp-content/uploads/2019/10/gest-esc-dmca-e-qld-ens-trechos-pdf-1.pdf>. Acesso em 26/03/2024.

PARREIRA, A. et al. O desafio das tecnologias de inteligência artificial na Educação: percepção e avaliação dos professores. **Ensaio: Avaliação de Políticas Públicas Educacionais**, Rio de Janeiro, v.29, n.113, p. 975-999, 2021. Disponível em: <https://www.scielo.br/j/ensaio/a/nM9Rk8swvtDvwWNrKCZtjGn/#>. Acesso em 26/03/2024.

PROJECT JUPYTER. **Jupyter**: Interactive Computing. [S.l.]: Project Jupyter, 2023. Disponível em: <https://jupyter.org/>. Acesso em: 31 out. 2023.

ROSSI, R. Consórcios públicos educacionais: o cooperativismo intermunicipal e a sua relevância para implementação das políticas públicas educacionais. **Linhas Críticas**, v.6, n.4, 2021. Disponível em: http://icts.unb.br/jspui/bitstream/10482/43486/1/2021_RodrigodeOliveiraSantosRossi.pdf. Acesso em 26/03/2024.

SANTOS, A. et al. Cooperação intermunicipal na Política Nacional de Meio Ambiente: as capacidades estatais importam? **Revista de Administração Pública**, v. 56, n. 6, p. 949-970, 2020. Disponível em: <https://bibliotecadigital.fgv.br/ojs/index.php/rap/article/view/87929/82702>. Acesso em 26/03/2024.

SANTOS, J. et al. Ética na aplicação de sistemas de inteligência artificial na educação. **Revista Brasileira de Informática na Educação**, v. 28, n. 1, p. 134-150, 2020. Disponível em: <file:///C:/Users/claud/Downloads/1791-Texto%20do%20artigo-5268-1-10-20210213.pdf>. Acesso em 26/03/2024.

SILVA, J. et al. Otimização da distribuição de recursos em consórcios intermunicipais utilizando algoritmos em Python. **Revista Brasileira de Inovação Tecnológica em Educação**, v. 6, n. 2, p. 60-72, 2019. Disponível em: <https://doi.org/10.1590/S0104-40362020002803115>. Acesso em: 26/03/2024.

SILVA, R. A. Evasão escolar e políticas públicas: um estudo sobre as estratégias de prevenção no Brasil. **Educação por Escrito**, v. 8, n. 1, p. 1041-1060, 2019. Disponível em: <https://revistaseletronicas.pucrs.br/ojs/index.php/poescrito/article/view/24527>. Acesso em 26/03/2024.

SOARES, J. F.; MEIRELLES, D. S. Planejamento da rede escolar para o ensino médio no estado de São Paulo: o caso da região de Araçatuba. **Retratos da Escola**, v. 12, n. 24, p. 123-141, 2019. Disponível em: <https://retratosdaescola.emnuvens.com.br/>. Acesso em 26/03/2024.

SOUZA, J. M. Políticas públicas para redução do abandono e evasão escolar de jovens. **Revista Gesta.org**, v. 44, n. 123, p. 105-118. 2017. Disponível em: <https://gesta.org.br/wp-content/uploads/2017/09/Políticas-Publicas-para-reducao-do-abandono-e-evasao-escolar-de-jovens.pdf>. Acesso em 26/03/2024.

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