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An Engineering Architecture for Analyzing the Zone of Proximal Development of Public School Students in Brazil

Matheus Nascimento, Vagner Silva, Gabriel Souza, Kauã Lima, Jean Turet, Victor Diogho Heuer de Carvalho, Thyago Nepumoceno
Federal University of Alagoas
Group of Engineering in Decision-Making and Artificial Intelligence

INTRODUCTION & AIM

In the didactic approach, Lev Bygotsky developed what he would classify as ZDP: Zone of Proximal Development, whose main objective wold be to measure student learning. This demonstrate how data engineering can facilitate the classification of ZDP for use in brazilian public schools.

Therefore, the use of mining tools, like Scrapy or Beautiful Soup, was essential for collecting students' pedagogical data from the platforms of the Alagoas state government. With the data in hand, it was up to the teacher to define the student's learning zones, based on teaching goals under the subject syllabus: assessments, activities and playful moments for the student's understanding of the subject studied.

This, with the influence of the teacher and the information collected from the student, it was possible to create a machine learning model, specifically a supervised classification model, which evaluates the student's performance and returns the current learning level, taking into account their pedagogical needs to be delivered to the teacher.

With the application, public school teachers were able to diagnose students according to their pedagogical needs, directly influencing student performance when these needs were met. This data architecture was able to directly meet a need that is still evident in public schools in the state of Alagoas in Brazil.

METHOD

The methodology used addresses pillars that range from data collection to assessment using Item Response Theory. Thus, it is possible to measure attributes for calculating the ZPD.

The pillars used are listed below:

1. Data Collection
Use of tools such as Scrapy and Beautiful Soup to extract pedagogical information, such as grades and activities performed by students.

2. Data Enrichment and Cleaning
Calculation of the average of the assessments.
Creation of metrics that weigh academic and social performance.
Removal of incomplete or irrelevant data.

3. Identification of the ZPD
Application of machine learning models based on IRT to calculate the student's ability (θ).

$$P(U_{ij} = 1|\theta_j) = c_i + (1 - c_i)\frac{1}{1 + e^{-Da_i(\theta_j - b_i)}},$$

4. Scaffolding Facilitation
The model suggests personalized strategies for each student, allowing the teacher to adapt their teaching based on the identified learning stage

RESULTS & DISCUSSION

The implementation of the system based on the Zone of Proximal Development (ZPD) and Item Response Theory (IRT) demonstrates significant impacts in the following aspects:

Decision Making
The system provides clear and accurate data on student progress, allowing teachers and managers to make more informed decisions. Identifying gaps in learning makes it possible to prioritize pedagogical actions and allocate resources strategically.

Support for School Education
By automating the ZPD classification, the system facilitates individualized monitoring of students, promoting targeted pedagogical interventions. This strengthens the role of the teacher as a mediator of learning, ensuring adequate support for the needs of each student.

Educational Investments
The analysis generated by the system guides more assertive educational investments, prioritizing areas with the greatest need for development. In addition, the applied technology proves to be an efficient tool for maximizing the results of educational policies.

Scaffolding
The proposed model optimizes the scaffolding process, offering insights into the level of support needed for each student. This allows teachers to adapt their teaching strategies, creating a more efficient and inclusive learning environment.

CONCLUSION

The development of a system based on the Zone of Proximal Development (ZPD) and Item Response Theory (IRT) can bring significant advances to the Brazilian educational context, especially in monitoring learning in public schools. By integrating advanced data analysis technologies with well-founded pedagogical theories, the proposed system offers a robust set of tools to improve teaching effectiveness, addressing historical gaps in basic education.

When they identifying key learning gaps, managers can direct investments to specific areas, whether in teacher training, purchasing teaching materials, or developing complementary technologies. In addition, the model reinforces the need to prioritize initiatives that integrate data science and education.

By automatically classifying students according to their respective ZPDs, the system helps teachers provide the necessary support more accurately and assertively. This approach strengthens the role of the teacher as a mediator of learning, allowing innovative pedagogical interventions in a personalized manner.

FUTURE WORK / REFERENCES

- Beautiful Soup(2024): https://beautiful-soup-4.readthedocs.io/en/latest/
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- Scrapy(2023): https://scrapy.org/