Implementación de un asistente inteligente basado en Machine Learning para mejorar el aprendizaje del curso de Química Básica en estudiantes de secundaria de escuelas públicas peruanas

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**Abstract—** This project analyzes the implementation of an Intelligent Assistant based on Machine Learning to enhance the learning process of the Basic Chemistry course for secondary school students in public schools. The aim of this development is to optimize teaching and learning processes through content personalization and automated feedback, facilitating the understanding of key concepts in an interactive and accessible manner. Intelligent educational platforms focused on supporting science learning were investigated, evaluating their ability to adapt to each student's pace and learning style. Additionally, machine learning techniques applied to student performance monitoring and the generation of personalized recommendations were analyzed.

**Keywords**: Intelligent Assistant, Basic Chemistry, Machine Learning, Personalized Learning

**1 Introduction**

The teaching of Basic Chemistry in public secondary schools in Peru faces significant challenges, including a lack of educational resources and diverse student learning styles. These issues often lead to low motivation and poor academic performance. To address this, the development and implementation of an intelligent assistant powered by Machine Learning and Artificial Intelligence is proposed. This system is designed to personalize content, detect learning difficulties early, and provide immediate automated feedback.

The goal is to enhance students’ understanding of fundamental chemistry concepts, increase motivation, and improve academic outcomes. This initiative is part of a broader effort to reduce educational gaps through accessible technological tools, promoting more equitable, inclusive, and effective learning in the Peruvian education system.

**Objectives**

This paper aims to describe the implementation of an intelligent assistant based on ML techniques to enhance the teaching and learning of Basic Chemistry in Peruvian public secondary schools. The specific objectives are:

To integrate a conversational agent using large language models trained on chemistry curriculum content.

To provide students with adaptive explanations and formative assessments in real-time.

To support teachers with analytics on student progress and conceptual gaps.

**Methodology**

The assistant was developed using a fine-tuned version of an open-access large language model, adapted with a dataset constructed from the Peruvian national chemistry curriculum. The development process followed a design-based research methodology with iterative cycles of prototyping, testing, and refinement.

**3.1 Architecture**

The system architecture includes:

* **LLM Core**: Responsible for natural language understanding and response generation.
* **User Interface**: A web-based chat interface optimized for mobile devices and low-bandwidth conditions.
* **Teacher Dashboard**: Visual analytics module showing individual and class-level learning trends.

**3.2 Pilot Testing**

A pilot test was conducted in two public secondary schools in Lima with a total of 120 students. Data collection involved pre- and post-tests, interaction logs, and user satisfaction surveys.

**Results**

Preliminary findings indicate a positive impact on learning outcomes. Students using the assistant showed an average improvement of 18% in post-test scores compared to the control group. Usage logs revealed increased engagement during out-of-class hours, and survey responses highlighted the clarity of explanations and ease of use.

**Table 1** presents the comparative academic performance of students in the experimental and control groups.

Table 1. Comparative Results Between Experimental and Control Groups

|  |  |  |  |
| --- | --- | --- | --- |
| Group | Pre-Test Score (Mean) | Post-Test Score (Mean) | Improvement (%) |
| Experimental | 10.8 | 15.9 | 47.20% |
| Control | 10.5 | 12.1 | 15.20% |

**Table 2** summarizes the most frequent queries made to the assistant during the pilot phase, categorized by topic.

**Table 2. Most Frequent Student Queries by Chemistry Topic**

|  |  |  |
| --- | --- | --- |
| **Topic** | **Example Query** | **Frequency (%)** |
| Chemical Nomenclature | "How do I name this compound?" | 28% |
| Balancing Equations | "Is this equation balanced?" | 22% |
| Atomic Structure | "What is an electron configuration?" | 18% |
| Chemical Bonds | "Difference between ionic and covalent?" | 15% |
| Periodic Table Concepts | "What are groups and periods?" | 10% |
| Others | Miscellaneous | 7% |

**Discussion**

The assistant’s effectiveness lies in its ability to deliver individualized learning experiences within large classroom settings. It supports both reinforcement of prior knowledge and exploration of new content. Teachers reported that the dashboard allowed early identification of learning gaps, informing their classroom strategies.

Challenges encountered included initial resistance to new technology and connectivity issues in some areas. Addressing these will be critical for larger-scale deployment.

**Conclusion**

The implementation of a Machine Learning-based intelligent assistant for Basic Chemistry education in Peruvian public schools represents a significant step toward reducing educational inequities through technology. The system fosters student autonomy, improves conceptual understanding, and equips teachers with actionable insights. Future work will focus on expanding to other science subjects and integrating voice-based interaction for accessibility.

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