AI-Assisted UML Learning: Toward Ethical Integration of Generative Artificial Intelligence in Software Engineering Education

Aprendizaje de UML Asistido por IA: Hacia una Integración Ética de la Inteligencia Artificial Generativa en la Educación en Ingeniería de Software

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Abstract- This paper presents a web-based chatbot platform designed to support the teaching of UML domain modeling in software engineering education. Leveraging locally executed generative AI (DeepSeek-v2), the tool provides students with anonymized, interactive feedback and problem generation capabilities while preserving data privacy and promoting ethical AI use. The platform fosters autonomy, digital literacy, and critical reflection, offering a scalable and sustainable solution for integrating AI into higher education.

Keywords: Artificial Intelligence, UML, Software engineering

Resumen- Este artículo presenta una plataforma de chatbot web diseñada para apoyar la enseñanza del modelado de dominios UML en la educación en ingeniería de software. Utilizando inteligencia artificial generativa ejecutada localmente (DeepSeek-v2), la herramienta ofrece a los estudiantes retroalimentación interactiva y generación de ejercicios de forma anónima, preservando la privacidad de los datos y promoviendo un uso ético de la IA. La plataforma fomenta la autonomía, la alfabetización digital y la reflexión crítica, ofreciendo una solución escalable y sostenible para la integración de la IA en la educación superior.

Palabras clave: Inteligencia Artificial, UML, Ingeniería del software

1. INTRODUCTION

The teaching and learning of software engineering heavily rely on students' ability to develop abstract thinking and conceptual modeling skills. In particular, understanding and applying the Unified Modeling Language (UML) for domain modeling represents one of the most complex learning objectives in the first software engineering courses offered in the bachelor's degree in computer engineering at the University of Salamanca. Students frequently encounter substantial difficulties when engaging with UML modeling practices, primarily due to the high level of abstraction required and the scarcity of suitable problem statements—whether solved or unsolved—that support meaningful practice (Engels et al., 2006; Starrett, 2007).

In this evolving context, the present work explores the educational potential of generative AI technologies, specifically large language models (LLMs), to support the teaching of UML domain modeling. Building on the foundations laid by previous innovation projects, this study introduces a web-based system that leverages text and image generation models to provide problem statements, generate class diagrams, and analyze student-submitted diagrams. The proposed tool not only enhances students' learning experience by enabling interactive and adaptive feedback but also opens new opportunities to critically reflect on the ethical use of AI in educational settings (García-Peñalvo & Vázquez Ingelmo, 2023).

By combining technical scaffolding with pedagogical reflection, this work proposes a dual-purpose approach: improving the acquisition of UML modeling skills while fostering students' digital and ethical literacy (García-Holgado et al., 2021). The system incorporates a teacher-supervised feedback mechanism to ensure controlled use of the AI assistant and to mitigate possible issues related to hallucinations or misinformation generated by the model. This initiative aligns with broader institutional objectives aimed at promoting active learning, improving instructional quality, and integrating digital tools into hybrid learning environments.

This article presents a proposal that illustrates how generative AI can be integrated into software engineering education, offering both a practical contribution to curriculum innovation and a critical lens for analyzing the implications of emerging technologies in teaching and learning processes.

The rest of this paper is organized as follows. Section 2 provides the context of the integration. Section 3 showcase pilot results of the chatbot. Finally, section 4 discusses and concludes the work.

2. CONTEXT & DESCRIPTION

This project addresses a practical and pedagogical challenge: how to provide meaningful support for students learning UML class diagrams in Software Engineering courses while ensuring ethical, private, and reliable use of artificial intelligence. Rather

than replacing existing teaching methods, the proposed system aims to complement classroom learning by offering an interactive environment for self-paced practice, personalized feedback, and the generation of domain modeling exercises.

The core objective of this initiative is to develop a web-based chatbot platform that enables students to explore UML modeling through natural language queries, receive explanations of diagrams, generate new problem statements, and engage in critical reflection on their own learning process. The tool is designed to be used autonomously by students, while also allowing instructors to provide asynchronous guidance through a feedback mechanism — all without compromising student privacy.

A distinctive feature of this platform is the integration of the DeepSeek-v2:7b model (Liu et al., 2024), which runs locally without the need to rely on external AI services. This technological shift not only enhances data sovereignty and system reliability, but most importantly, it reinforces a strong commitment to student privacy and ethical AI integration in education. Unlike cloud-based solutions, the local execution ensures that no student data is transmitted or processed by third-party servers, eliminating privacy concerns that are common in AI-enhanced learning tools.

Moreover, the platform incorporates an anonymized user architecture, meaning that instructors cannot identify which student is behind each conversation. This design choice supports an open and safe learning environment, encouraging students to explore, ask questions, and make mistakes without fear of judgment. It also ensures fairness in feedback and reinforces a pedagogical approach grounded in respect, inclusivity, and ethical responsibility.

The system is intended primarily for undergraduate students in Software Engineering programs, but its modular architecture allows easy adaptation to other educational settings and topics involving modeling or conceptual design.

To implement this solution, the project follows a structured work plan, divided into four main tasks:

- **T1 – Project Management**
  - A1.1 Team coordination
  - A1.2 Project monitoring
  - A1.3 Dissemination of processes and results
  - A1.4 Final report
- **T2 – Chatbot Implementation**
  - A2.1 Needs analysis
  - A2.2 System design
  - A2.3 Development, deployment, and maintenance of the chatbot using DeepSeek-v2
- **T3 – Integration into Software Engineering Courses**
  - A3.1 Presentation to students
  - A3.2 Integration into continuous assessment and final practical activities
  - A3.3 Instructor feedback on anonymized student interactions
- **T4 – Evaluation of Results**
  - A4.1 Implementation of evaluation instruments (e.g., surveys, questionnaires)
  - A4.2 Collection of usage indicators and interaction logs
  - A4.3 Analysis of data to assess pedagogical impact

The development process is based on agile methodologies, particularly SCRUM, enabling flexible, iterative progress and continuous refinement based on user feedback. Technologically, the platform combines Django for the web interface, PostgreSQL for data management, PlantUML for diagram generation, and DeepSeek-v2 as the core AI engine executed locally.

3. RESULTS

As a result of the development phase, a fully functional web-based platform has been successfully implemented. The system provides students with a user-friendly interface to interact with a locally executed AI model, enabling the generation and analysis of UML class diagrams, the creation of domain modeling exercises, and the explanation of diagrams either through natural language queries or image uploads.

The chatbot integrates DeepSeek-v2 as its core engine, allowing the entire interaction to take place without dependence on external servers. This technological shift guarantees a high level of data protection and system autonomy, and significantly reduces the risk of privacy breaches. The system architecture has been designed to operate in an **anonymized mode**, ensuring that student identity is not linked to individual interactions. This feature enhances the pedagogical integrity of the platform, supporting unbiased and confidential learning experiences.

From a functionality perspective, the platform supports:

- Generation of domain modeling problems tailored to UML class diagrams (Fig. 1).
- Interactive feedback on student-created diagrams.
- A built-in feedback mechanism for instructors to comment on student queries without knowing their identity (Fig. 2).

To better illustrate the functionality of the platform, a typical interaction flow is as follows: a **student** accesses the chatbot interface and submits a natural language request, such as "*Can you give me a UML problem about a library management system?*" or "*What elements should a class diagram for a social network include?*" The **chatbot**, powered by the locally executed DeepSeek-v2 model, responds by generating problem statements, hints, or theoretical-practical explanations to guide the student's independent practice. The model does not evaluate the students' diagrams but provides material to foster self-assessment and skill development.

Additionally, **instructors** can review student interactions through an anonymized interface and insert feedback messages manually, which are then displayed to the respective student within their chat history. This feedback is separate from the model's responses and is designed to support personalized guidance without compromising student privacy.

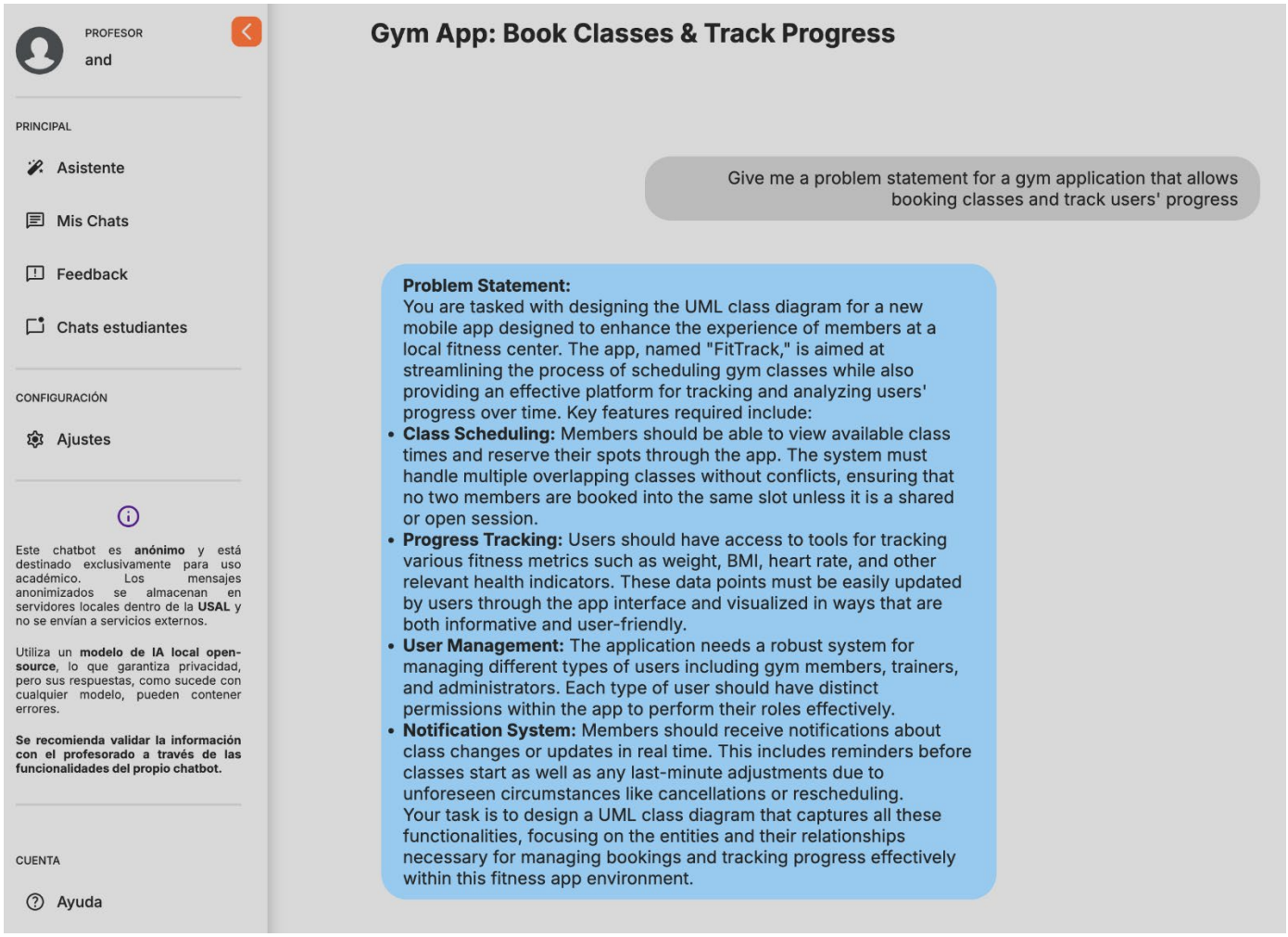

Fig. 1. Example of use of the chatbot where the user asks for a problem statement.

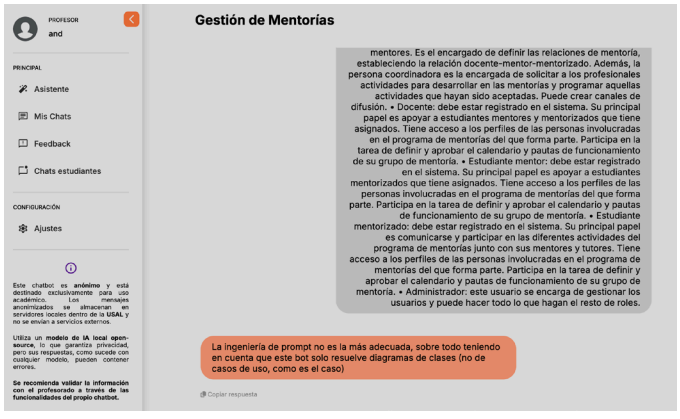

Fig. 2. Example of use of the feedback functionality, where the teacher can access students' chats to provide expert feedback.

All key components have been integrated and tested, and the system is now ready for deployment in actual Software Engineering courses. Preliminary testing confirms that the platform is stable, responsive, and capable of supporting the expected volume of student interaction.

The next phase of the project will focus on evaluating the educational impact of the tool. A mixed-methods approach is planned, combining interaction data from the platform with structured surveys and feedback instruments to assess student engagement, learning outcomes, and perceptions of AI-assisted learning. Special attention will be given to analyzing the effect of the anonymized architecture on student confidence and participation.

The evaluation will also explore the instructors' perspective regarding the usability of the system, the quality of the feedback workflow, and the practical implications of integrating such a tool into the teaching process.

Future iterations of the platform may include new interaction modes (e.g., voice-based interfaces), further customization of feedback options, and broader applications beyond UML modeling.

4. Conclusions

The development of a web-based educational chatbot for UML modeling represents a sustainable and adaptable solution to some of the longstanding challenges in teaching conceptual modeling in software engineering courses. By combining technical functionalities with pedagogical and ethical considerations—particularly the use of a locally executed AI

model (DeepSeek-v2) and anonymized student interactions—this initiative demonstrates a feasible pathway toward responsible and effective integration of artificial intelligence in higher education.

The platform's architecture has been designed to ensure long-term sustainability, both in terms of technical maintenance and educational value. The use of open-source technologies such as Django, PostgreSQL, and PlantUML facilitates future updates and reduces dependencies on proprietary tools. Moreover, the local execution of the AI model ensures data privacy and reduces operational costs associated with cloud-based services, making the system scalable and cost-effective for educational institutions.

The solution is highly transferable to other contexts and disciplines, particularly those involving modeling, structured problem-solving, or domain analysis (e.g., systems analysis, business process modeling, or object-oriented programming). With minimal adaptation of the system prompts, the chatbot could also be applied in fields such as engineering design, information systems, or even digital humanities, where diagrammatic reasoning and conceptual representation are relevant.

While preliminary deployment has confirmed technical stability, the educational validation phase is currently ongoing and will be completed at the end of the academic year. However, from a pedagogical perspective, the platform aims to promote student autonomy, ethical digital literacy, and formative assessment practices. The anonymized architecture encourages honest engagement and reduces anxiety around peer or instructor judgment, creating a more inclusive and supportive learning environment (Barr, 2017).

Based on the development process and initial implementation, several recommendations can be drawn for educational institutions or instructors considering the adoption of similar AI-enhanced systems:

- Ensure local execution or controlled hosting of AI models to preserve privacy and institutional data sovereignty.
- Integrate AI tools into structured teaching scenarios, aligned with the curriculum and supported by instructor-led feedback loops.
- Provide training and guidance for both students and instructors, emphasizing the critical and reflective use of AI rather than its passive consumption.
- Design systems with modularity and scalability in mind, allowing future expansion to other domains or functionalities.

In conclusion, this initiative's goal is to offer not only a technical tool but also a model for sustainable, ethical, and pedagogically sound AI integration in education—one that can inspire further innovation across disciplines and institutions.

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REFERENCES

Barr, M. L. (2017). Encouraging college student active engagement in learning: Student response methods and anonymity. *Journal of Computer Assisted Learning, 33*(6), 621-632.

Engels, G., Hausmann, J. H., Lohmann, M., & Sauer, S. (2006). Teaching UML is teaching software engineering is teaching abstraction. Satellite Events at the MoDELS 2005 Conference: MoDELS 2005 International Workshops Doctoral Symposium, Educators Symposium Montego Bay, Jamaica, October 2-7, 2005 Revised Selected Papers 8,

García-Holgado, A., García-Peñalvo, F. J., Therón, R., Vázquez-Ingelmo, A., Gamazo, A., González-González, C. S., Iranzo, R. M. G., Silveira, I. F., & Forment, M. A. (2021). Development of a SPOC of computer ethics for students of computer science degree. 2021 XI International Conference on Virtual Campus (JICV),

García-Peñalvo, F. J., & Vázquez Ingelmo, A. (2023, 12/2023). What Do We Mean by GenAI? A Systematic Mapping of The Evolution, Trends, and Techniques Involved in Generative AI. *International Journal of Interactive Multimedia and Artificial Intelligence, 8*(Regular Issue), 7-16. https://doi.org/10.9781/ijimai.2023.07.006

Liu, A., Feng, B., Wang, B., Wang, B., Liu, B., Zhao, C., Dengr, C., Ruan, C., Dai, D., & Guo, D. (2024). Deepseek-v2: A strong, economical, and efficient mixture-of-experts language model. *arXiv preprint arXiv:2405.04434*.

Starrett, C. (2007). Teaching UML modeling before programming at the high school level. Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007),