Developing a Chatbot for Process Modelling Learning: contributions for active learning in engineering education

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Abstract

Technological advancements such as generative artificial intelligence (AI) chatbots have gained popularity, partly due to their ability to provide iterative access to extensive information. This has impacted the education field, introducing new opportunities and challenges in learning, teaching, and assessment. This article intends to present the development and deployment of a chatbot designed to foster students' learning regarding process modelling and Business Process Model and Notation (BPMN). Developed with a low-code tool from the Microsoft suite, this approach for building chatbots may be replicable in other contexts of higher education. This is an exploratory study with 18 students enrolled in a Master's Program in Engineering and Operations Management. Moreover, 6 professionals with experience in using BPMN used the ChatBot and gave an additional and complementary perspective from an expert point of view. The main objective is to evaluate the effectiveness of the ChatBot to mimic real-world interactions and make a contribution to the learning process. Through this exploration, the article aims to discuss potential uses of the chatbot, exploring the development steps, users' feedback, limitations, and opportunities for enhancement. This work underscores how emerging technologies facilitate the swift creation of specialized bots for diverse applications, sidestepping the need for intricate programming expertise. More than just enhancing student engagement by encouraging inquiry and the use of AI tools, the use of chatbots has the potential to significantly lighten the teaching load, a cited barrier in the adoption of active learning.

Keywords: Active Learning; Engineering Education; Process Modelling; Chatbot.

1 Introduction

Active learning approaches are an area of significant study that has been gaining more relevance in recent years. There are various approaches, each offering unique advantages and challenges, but overall, students gain more autonomy while teachers transition into roles more focused on supporting the learning process and less as transmitters of knowledge (Das Neves et al., 2021). Numerous studies indicate positive results from integrating active learning with other approaches such as project management and gamification (Freeman et al., 2014; Lopes & Aquere, 2021; Pereira et al., 2018; Theobald et al., 2020). Potential gains from its application include increased motivation, better integration of theory and practice, and the development of transversal communication skills (Das Neves et al., 2021; Lopes et al., 2021). However, there are challenges related to student engagement, students' insecurities about their autonomy, and an increased workload (Das Neves et al., 2021), with communication being a critical issue (Aquere et al., 2012). Furthermore, for proper application, teachers need to develop skills such as teamwork, empathy, feedback, and use of new technologies (Das Neves et al., 2021), with evidence linking teacher participation in training and research on the topic to the application of active learning in their classes (Lima et al., 2024).

Moreover, there is a rise in studies related to the education of skills demanded by Industry 4.0, termed by some authors as Education 4.0 (González-pérez & Ramírez-montoya, 2022; Souza & Debs, 2024). Much of this research focuses on engineering education and often involves technologies like artificial intelligence (AI), augmented reality, the Internet of Things, robotics, and virtual reality (Souza & Debs, 2024). In this context, simulations are one approach that has potential to enhance student experiences and develop skills such as managing large volumes of data (Lima et al., 2023). Further, research suggests that blended learning, e-learning, and gamification are the most effective methodologies for developing concepts of Education 4.0 (Souza & Debs, 2024).

Specifically, chatbots have gained more relevance in recent years. Their main uses are identified in higher education, particularly in the fields of social science, computer science, and engineering (Lins et al., 2023; Meloni et al., 2023; Ramandanis & Xinogalos, 2023a). They can take on roles of supporting teachers, assisting students, or even handling administrative activities (Ramandanis & Xinogalos, 2023b). However, developing these conversational agents involves several steps (Ramandanis & Xinogalos, 2023a), and it's important to allow flexibility so the bots can be configured without the need for programming skills (Rooein et al., 2022). Other challenges include user acceptance, the need for educator training, and ensuring all students have access to technology (Ramandanis & Xinogalos, 2023b). Nonetheless, their use can complement traditional learning methods by providing a unique learning opportunity (Rooein et al., 2022).

Thus, this paper aims to present the development and application of a chatbot for supporting teaching and learning of Business Process Model and Notation (BPMN) and process modelling, based on a case study in a master's class in engineering and operations management. The paper details the step-by-step process used, user perceptions, potential advantages and challenges, and future research to enable the use of this tool by teachers without a technology background.

2 Methodological Approach

This paper is an exploratory case study applied in a master's course in engineering and operations management for teaching process modelling in BPMN. A case study is an empirical approach that gathers data from a specific system and analyses it in depth (Gil, 2002). Its goal is to deepen understanding of a problem and develop related hypotheses and theories (Mattar, 2005).

In the development of chatbots, numerous stages can be identified, which should be adapted according to the complexity level, objectives, and tools used. In their literature review, Ramandanis and Xinogalos (Ramandanis & Xinogalos, 2023a) suggest an approach with 12 main steps, along with various recommendations and best practices identified from the analysis of 73 studies related to the development of educational chatbots. However, the authors themselves emphasize that each researcher should adapt the stages and methods they prefer, according to their context. Therefore, since one of the goals of this investigation is to develop chatbots in a practical manner, the mentioned approach was simplified to just six steps: initial analysis, definition of characteristics, design, implementation, testing, and evaluation.

3 Chatbot Development and Application

3.1 Initial Analysis

The initial analysis aims to gather information and analyse both the tools for developing the chatbot and the context in which it will be applied. This stage includes gathering technical and financial requirements for software use (e.g., licenses), examples of chatbots developed in the literature, and characteristics of the course to be implemented, such as the number of students, classroom infrastructure, study topics, and main challenges.

In the context of developing this paper, the authors sought tools that were available at no cost and that required reduced development time, making replication feasible for teachers without technical knowledge in computing. Although there are generative AI solutions that allow for the automatic training of models using a reference document, their use would require individual licensing for each student, which would be impractical. Therefore, the choice was made to use Power Virtual Agents, a tool included in the Microsoft suite that allows for the modelling of workflows, incorporates AI Copilot, and is accessible through Microsoft Teams, to this university.

Regarding the course, the application was directed to the master's class in Production Management Processes. This course is part of the master's in industrial and systems engineering, with about 35 students, and covers topics such as process modelling, bill of materials, and production process management.

3.2 Definition of Characteristics

The definition of characteristics is the stage where the initial scope of the chatbot is finalized. Key aspects to define include the purpose and role of the application, the conversation flows, the tools the chatbot will use, and the training approach to be adopted.

As mentioned earlier, Microsoft Power Virtual Agents was chosen for its ease of use, availability, and potential replication in other contexts. Based on the curriculum analysis, it was determined that the chatbot's objective would be to simulate the process of a process mapping interview. To this end, it will assume the role of an employee at a recycling company and must answer students' inquiries in a way that allows them to actively practice developing questions and to gather information, a necessary skill for process modelling. Thus, the chatbot will complement the students' training and assist the teacher by enabling a role-play strategy with a large class without requiring more than one class session. For this purpose, the chatbot will provide general instructions, textual responses, and links to supplementary materials. At the end, it will present the modelled process so that students can verify their responses.

3.3 Design

At this stage, the goal is to design the chatbot by defining the educational material to be used, the robot's interactions, expected behaviours, and vocabulary, among other elements. Necessary adaptations are also made to the previously defined characteristics to ensure coherence in the solution being developed.

Following the definitions from the previous stage, the authors chose a process related to waste recycling to be modelled by the students. As a result, a process model was created along with a document describing the process, which would be used for training the model. Subsequently, a diagram was developed outlining the conversation flows, defining loops, supplementary materials, and features to be incorporated. To simplify implementation, a series of predefined questions were established that guide the robot's behaviour, although they limit user interactions. Table 1 presents the main features planned for the prototype.

Table 1. Chatbot design

Features	**Description**
Presentation	The chatbot should start the interaction by introducing the project, explaining its objectives, and any limitations. If possible, it should ask the user to select their preferred language for communication.
Introduction	The bot should introduce itself by detailing its role and the context within the company. It should then provide users with various options to guide the next steps of the interaction.
Mapping Process Tips	The bot should offer general tips on process mapping, which are generated using artificial intelligence. These tips should aim to provide foundational advice and encourage best practices.

Features	Description
Indicating Supplementary Materials	The bot should provide links to the class LMS, websites for additional resources, and suggest contacting the instructor for more personalized guidance.
Describing the Recycling Process	The bot should open a series of options for user interaction, such as an overview of the process, stakeholders involved, activities, and triggers. It should provide answers progressively as the user interacts with each option. If the bot lacks an answer, it should suggest that the user speaks with another employee or the instructor for more information.
Closure	The bot should thank the user for their interaction and provide the results of the exercise, including an image of the BPMN process and a complete description (from the file used in its training). It should also present a feedback survey and contact information from the developers.
General Characteristics	The bot should be programmed with user-friendly language, perform validations with the user, and accept free-text commands for actions such as restart, report an error, and end the conversation.

3.4 Implementation

The implementation stage involves developing the chatbot using the chosen tool to produce a functional version. This phase typically requires knowledge of programming tools and may necessitate the use of other technologies as challenges arise. It also includes training the robot, where various techniques such as predefined questions and machine learning can be employed.

In the context of this development, the features listed in Table 1 were implemented. Additionally, triggers were added for free-form inputs for words like "restart," "bye," and "end" to enhance usability. Concurrently, artificial intelligence was used to generate an image of Lateco, the name given to the bot. Figure 1 illustrates the implementation process and the final version of the prototype.

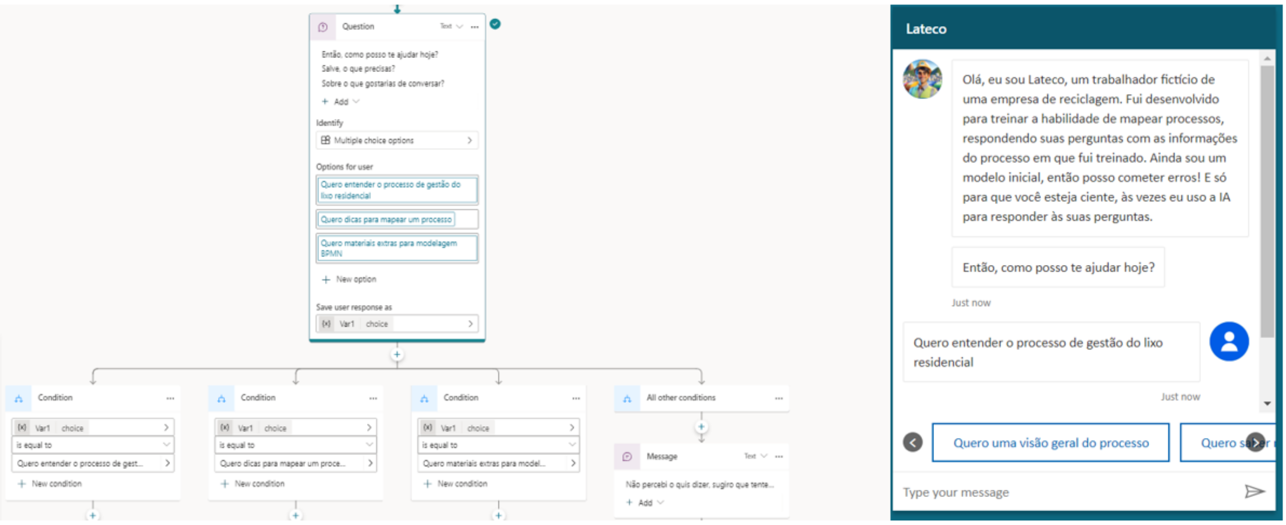

Figure 1. Development and Prototype of the Chatbot.

3.5 Testing

Testing is the phase where the current version of the chatbot is verified, and it can be conducted with different stakeholders, such as students, experts, and teachers. It is crucial in this stage to have clear guidelines for use and to collect data for evaluation and the development of improvements.

In the case of Lateco, testing was conducted in two ways: synchronously with students and asynchronously with industry professionals. The synchronous session involved a process modelling exercise where students were required to interview the chatbot and map out the process based on the information received, lasting approximately 1 hour and 15 minutes. The lead developer was present during the session to provide guidance, answer questions, and identify problems and difficulties experienced by the students. The asynchronous test involved distributing the chatbot's access link and guidelines to industry professionals experienced in process modelling, to gather insights from individuals who have modelled processes using traditional tools. In total, about 30 people tested the chatbot.

3.6 Evaluation

Finally, evaluation involves collecting and analysing feedback from all stakeholders involved in the use and development of the chatbot. Methods such as interviews, questionnaires, or even student performance can be used for this purpose. Criteria that might be assessed include the accuracy of the responses, usability, and fulfilment of expectations.

For this implementation, a questionnaire was set up to be sent by the bot at the end of the interaction, aiming to characterise the user's profile (whether a student or industry professional), familiarity with using chatbots, prior knowledge of process modelling, and to analyse the bot's use. About 30 people used the bot, with 24 responding to the evaluation questionnaire. Additionally, some unstructured interviews were conducted with volunteer participants who engaged with the initiative and expressed interest in providing more in-depth feedback than what the questionnaire could capture. In the next section, the key findings will be presented and discussed.

4 Results and Discussion

The questionnaire described was answered by 24 participants, including 18 master's students and 6 industry professionals. Among the master's students, 6 reported having basic knowledge of process modelling, 7 claimed intermediate knowledge, and 5 were first-time learners during the theoretical lessons of the course. In the case of industry professionals, 5 asserted having advanced process modelling knowledge, and 1 had basic knowledge.

Regarding familiarity with using chatbots, students and professionals had average scores of 2.78 and 4.33 respectively on a scale of 1 to 5, where 1 signifies "never use" and 5 means "use regularly." Concerning the use of the Lateco chatbot, participants rated various statements on a scale of 1 to 5, which are presented in Figure 2.

From the graph, we can see that the users' experience was predominantly positive. The first statement was better received by the students, possibly because they have less experience with process mapping, while the professionals did not consider it a relevant tool to improve question-making. Additionally, the fact that the application had preset, suggested questions may have limited the users' experience in formulating their own questions. On the other hand, the second statement suggests that the professionals better recognize the potential of this approach compared to traditional methods, perhaps due to their prior experience learning BPMN in a conventional way, with all fully agreeing that using the tool is preferable to receiving a question in text form. Subsequently, both groups agreed that the chatbot assists in learning and practicing process modelling. However, the ratings on the chatbot's ability to simulate the interview process were the lowest, mainly due to the limitations in questions and responses of the current version. Several participants suggested improvements related to interaction, allowing for more assertive free-text conversations. Finally, the overall experience of the participants was satisfactory, but again with lower ratings from the professionals. This may be related to their greater familiarity with using chatbots, coupled with expectations for a more advanced model.

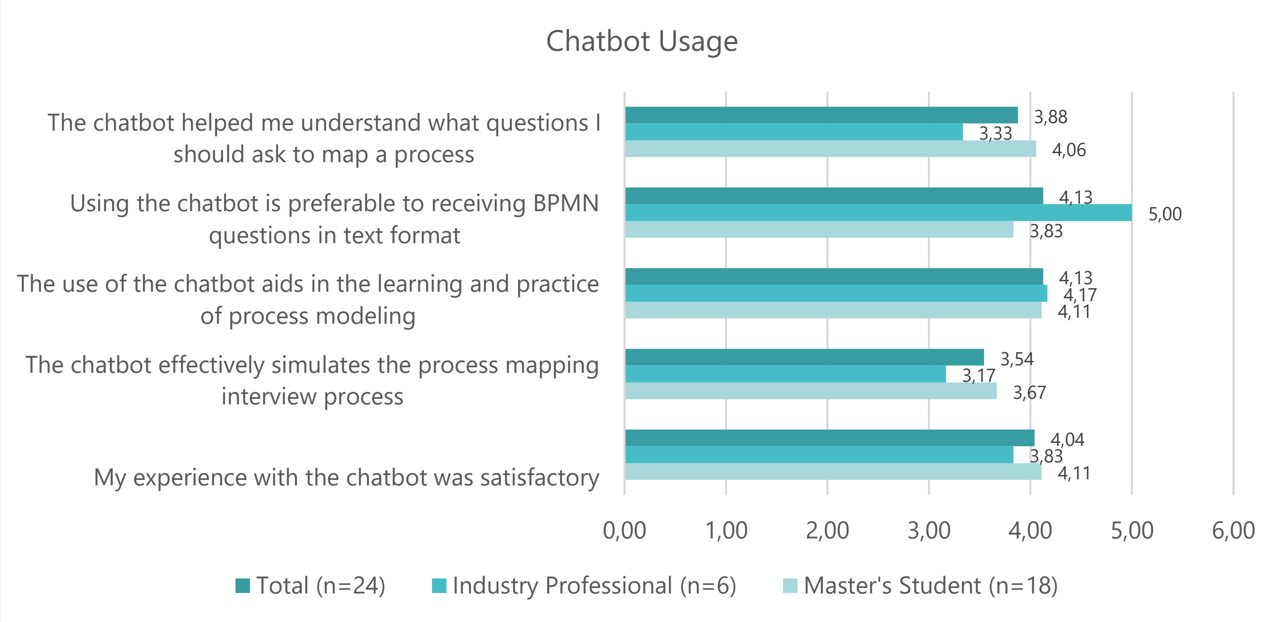

Figure 2. Results Related to the Use of the Chatbot.

In order to better explore the results and learnings, the upcoming sections will summarize the positive aspects, negatives, and suggested improvements indicated by the participants.

4.1 Positive and Negative Points

In summary, the positive aspects of using the chatbot focused on its ability to clarify concepts quickly and objectively, supporting learning in an intuitive and accessible manner. However, criticisms primarily concern the limited nature of interactions and the need for a richer and more detailed experience, suggesting opportunities for improvement in the design of responses and the overall usability of the system. Table 2 summarizes the main findings from the questionnaire and interviews.

Table 2. Positive and Negative Points.

Positive	**Negative**
• Clarifying and Objective: The chatbot is perceived as a tool that clarifies doubts and presents concepts objectively, facilitating learning and understanding of the modelling process. • Intuitive and Easy to Understand: The chatbot's interface is considered intuitive, making the user experience simple and accessible, even for those with less technological experience. • Support in the Learning Process: Participants value the support provided by the chatbot in the practice of process modelling, helping to perceive the processes more clearly and contributing to projects and studies. • Quick Responses: The speed with which the chatbot responds is seen as a positive point, allowing for more dynamic and efficient learning.	• Predefined Responses and Limitations: A recurring criticism was the perception that the chatbot offers many predefined responses, limiting interaction. This can lead to a less personalized. • Interaction Limitations: Users reported difficulties in interacting freely with the chatbot, missing more fluid navigation and responses adaptable to their specific queries. • Lack of Depth and Details: Some participants found the chatbot "insufficiently detailed" and still in an early stage, suggesting that there is room for expansion in terms of content and detailing of the information provided. • User Experience Needs Improvement: There was a need for improvements in the user experience, such as a basic script to guide interactions and avoid the feeling of being "stuck" to listed questions, which could make the interaction more natural and engaging.

Previous research indicates that some students may not like experiences with guided paths, preferring to explore topics more freely, as well as the need for human-like and fluent conversations (Ramandanis &

Xinogalos, 2023b; Rooein et al., 2022). Some suggestions for better interaction design include adding better conversational traits, response speed, and acceptance of oral messages as inputs (Ramandanis & Xinogalos, 2023a), points that could be explored in future versions. Moreover, it is interesting to allow other response formats beyond text messages (Ramandanis & Xinogalos, 2023b). These enhancements aim to refine the chatbot's capabilities to better meet the needs and expectations of its users, making the learning process more engaging and effectively integrated into the educational framework.

4.2 Suggestions for Improvements

The suggestions for improvements to the chatbot and its use in the teaching and practice of process modelling, based on participant feedback, focus on enhancing both the quality of interactions and the richness of content. Here is a summary of the main suggestions mentioned:

- Reducing Limitations in Responses: There is a desire for fewer restrictions in the responses provided by the chatbot, suggesting a need for greater autonomy and the ability to offer more personalized and adaptive conversational style responses to user queries.
- Improving the Quality of Information: Participants highlighted the importance of reducing errors and enhancing the quality of the information provided, indicating that accuracy and reliability are essential for an effective educational resource.
- Advancements in Usability: Suggestions include improvements to the chatbot interface, such as implementing question options in a message format instead of drop-down menus, aiming for a more natural and interactive user experience.
- Interaction with Different Levels of Interlocutors: The possibility of interacting with different profiles within the modelling process, such as analysts and coordinators, was suggested. This could enrich learning by exposing users to varied perspectives within the same context.
- Integration with Specialized Documentation: The idea of feeding the chatbot with specialized documentation and structuring an integrated search engine was mentioned as a way to expand the reach and depth of content available to users.
- Personalization of Learning: It was suggested that the chatbot could offer personalized learning paths based on the needs and knowledge level of users, enhancing the pedagogical effectiveness of the tool.

In summary, the suggestions for improvements involve increasing flexibility in interactions, ensuring information accuracy, enhancing usability, and providing a richer and more personalized learning experience. These improvements aim not only to make the chatbot a more efficient tool for teaching process modelling but also to significantly improve the user experience, making learning more engaging and tailored to individual needs, consistent with previous findings (Ramandanis & Xinogalos, 2023b; Rooein et al., 2022).

5 Conclusion

This paper presented the development and application of a chatbot to contribute to active learning in engineering, specifically for process modelling in BPMN. Although other approaches exist in the literature, the authors proposed a low-effort option using a tool available at many universities, thereby potentially reducing implementation costs. The proposed six-step approach enabled the prototyping and evaluation of the chatbot with both master's students and industry professionals. The results demonstrate the potential of the solution, despite limitations in the current version, particularly related to usability and interaction. Among the main positive points, it is worth highlighting the users' perception of the value of this approach as a complement to the learning process.

While the focus was on exploring user perceptions from the experience, the authors believe that various benefits can be gained in future versions of the chatbot. In addition to the improvements identified, there is potential for benefits in reducing teachers' workload, enhancing student engagement, facilitating activities in different languages, and combining bots with other approaches such as gamification. Naturally, new technology options can also be explored, using more advanced language models, voice interactions, and even virtual reality.

The research also presents a series of limitations, mainly related to the current state of the model. For example, only one process was trained, with predominantly predefined questions, and the application was conducted with a limited number of users. To delve deeper into the results, it is necessary to repeat the approach, iterating through all stages based on the learnings from this initial experiment. Future research could explore the development of chatbots in other educational contexts, altering, for example, the role of the chatbot, the topics covered, and the communication traits. It is also suggested to iterate the current model, to incorporate the suggestions raised and characterize processes beyond what the robot was initially trained on.

Therefore, this article contributes to future approaches using low-code chatbots, aiding teachers to plan, develop, and implement their solutions. With a list of positive and negative comments, and suggested improvements, future research can develop prototypes more capable of meeting stakeholder expectations and assisting in active learning in engineering.

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