Personalized Language Learning: A Multi-Agent System Leveraging LLMs for Teaching Luxembourgish

Demonstration Track

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ABSTRACT

The integration of Artificial Intelligence (AI) into education is transforming language learning. Current chatbot-based tools primarily focus on vocabulary acquisition and conversation, overlooking the holistic needs of effective language learning, such as grammar, reading, and listening skills. These limitations are further compounded by the challenges of low-resource languages like Luxembourgish. This demonstration[1] presents a Multi-Agent System (MAS) powered by Large Language Models (LLMs), integrated with Retrieval-Augmented Generation (RAG) to address these challenges. Our system personalizes learning by employing specialized agents for specialized tasks, ensuring a comprehensive and adaptive experience. To mitigate inaccuracies, human-on-the-loop (here teacher) validation enhances content quality and aligns with pedagogical standards inspired by the National Institute of Languages of Luxembourg (INL). Attendees will experience interactive demonstrations showcasing how the system delivers tailored educational experiences through innovative agent workflows and user-centric design.

KEYWORDS

Language learning; MAS; LLMs; RAG; Personalized learning

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1 INTRODUCTION

Language learning enriches lives by fostering cultural understanding, opening doors to global career opportunities, and enhancing cognitive abilities such as memory, problem solving, and mental flexibility [4, 8]. However, effective language acquisition goes beyond vocabulary memorization and conversational exercises; it requires a comprehensive approach involving pedagogy, diverse teaching methods, reliable content, and meaningful human interaction [1–3, 6, 10]. Moreover, this method often exposes learners to inaccuracies or "hallucinations" further complicating the learning process and hindering the development of reliable language skills [9, 13]. The work in [5] provides structured and gamified language learning, yet lacks advanced content and nuanced translations. Enhancements could include complex lessons and customizable course uploads for a more personalized learning experience.

Luxembourgish, as one of Luxembourg's official languages, is spoken by a relatively small population [14] and faces significant barriers in terms of the availability of linguistic data. The scarcity of structured educational resources and AI-driven solutions for Luxembourgish [7, 12, 15] adds a layer of complexity to the development of effective learning systems. Learners not only encounter difficulties in accessing comprehensive learning tools, but also face a lack of tailored pedagogical support aligned with their needs [11].

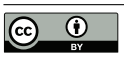
To address these limitations, we present a MAS powered by LLMs, such as GPT-4, and enhanced by RAG. Our approach breaks the learning process into specialized tasks handled by individual agents focusing on conversation, grammar, reading, and listening. This system ensures adaptive and personalized learning experiences while incorporating teacher-on-the-loop validation to maintain pedagogical integrity and mitigate inaccuracies often associated with AI-generated content. Inspired by INL's pedagogical book, our system enables effective learning for low-resource languages.

2 SYSTEM DESCRIPTION

2.1 Architecture

At the heart of our system lies a MAS architecture. Unlike traditional single-agent chatbots, it leverages the collaboration of multiple agents, each focusing on distinct areas of language learning, to ensure a personalized and holistic user experience. These agents work collaboratively to simulate the dynamic interactions of a human tutor, ensuring that learners receive adaptive real-time support tailored to their evolving needs. As illustrated in Figure 1 (MAS Architecture part), the architecture includes the following agents:

[1] https://www.youtube.com/watch?v=5bxVHsuK-Hs



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(1) **Communicator Agent**: Interacts with the user to collect their preferences, retrieve profiles and progress, and provide recommendations for a personalized learning journey.
(2) **Orchestrator Agent**: Manages workflow by retrieving content, validating it with the teacher, then organizing it into a structured sequence, and preparing it for delivery.
(3) **Tracker Agent**: Monitors user and agents activities, ensuring seamless transitions between learning tasks and agents.
(4) **Tutor Agents**: Specialized agents targeting the key learning:
   (a) **Conversational Agent**: Facilitates interactive dialogues, vocabulary enrichment, and role-playing exercises.
   (b) **Reading Agent**: Guides users through reading exercises and encouraging the usage of contextual vocabulary.
   (c) **Listening Agent**: Enhances listening comprehension with interactive audio exercises and feedback.
   (d) **Grammar Summary Agent**: Delivers grammatical explanations and rules to reinforce correct language usage.
   (e) **Q&A Agent**: Engages learners with interactive questions and evaluates responses for deeper comprehension.

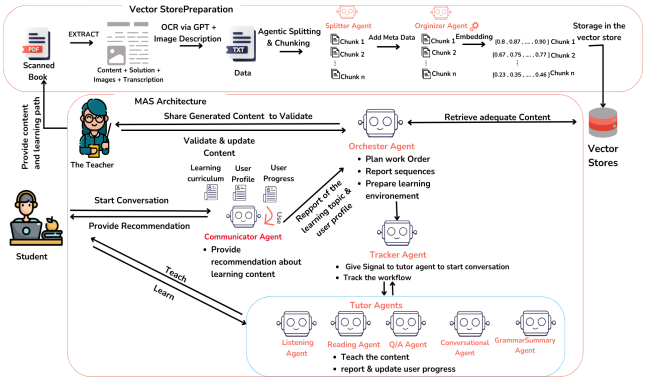

Figure 1: Collaborative Learning via Agent Communication and RAG-Based MAS for Language Learning [11]

2.2 Algorithms

To ensure accuracy and adaptiveness, the system employs the following key methodologies.

(1) **RAG**: A robust knowledge built from INL book. As illustrated in Figure 1 (Vector Store Preparation part), Splitter Agent chunks chapter topics, while Organizer Agent structures them by chapter and topic, storing them in a vector stores.
(2) **OpenAI's API Assistance**: Serves as the foundation, allowing us to structure interactions, sequence conversations, and maintain control over the user experience.
(3) **Fine-tuning**: Refine AI responses, training it on the knowledge base to align its behavior with our unique needs. This allows for more precise and nuanced responses.
(4) **Prompt Engineering**: Shapes the AI's behavior by carefully designing prompts. This ensures tone, style, and output consistency, providing more predictable interactions.
(5) **LangGraph**: An advanced extension of LangChain, organizes agent interactions into stateful workflows. Nodes and ToolNodes represent agent and agent tools, respectively, while edges facilitate inter-agent communication and user-agent interactions.

2.3 Software Design

The project is actively under development, with a functional demo showcasing key features currently in progress, including:

- **Backend**: Python-based with FastAPI and LangGraph for UI-core integration and agent workflows.
- **Frontend**: A React-based user interface allows learners to access lessons, track progress, and interact with tutor agents.
- **Text-To-Speech**: Enables listening exercises and speaking skills.
- **Data Management**: User data, including progress and preferences, is stored securely to personalize future interactions.

3 DEMONSTRATION SETUP

In this demonstration, the system highlights a personalized and interactive learning journey tailored to a learner's progress and preferences. A learner 'John', who has already started his learning path, logs into the system after completing Topic 1 of Kapitel 1 in his previous session. Upon authentication, the **Communicator** greets the learner and presents two options: *(i)* review his progress from the last session or *(ii)* proceed to the next topic.

The learner selects the second option, and the **Orchestrator** immediately retrieves the recommended learning materials for Topic 2 of Kapitel 1. The content is tailored to the learner's past performance and preferences. The **Tracker** organizes the learning materials into a structured sequence and assigns specific tasks to the corresponding **Tutor Agents** based on the learner's preferences. During the demo, the **Tracker** selects two activities:

- **Interactive Dialogue Practice** where the **Conversational agent** engages the learner in interactive dialogues designed to improve vocabulary skills by incorporating words, phrases and grammatical structures from Topic 2.
- **Listening Comprehension task**, where the **Listening agent** delivers an audio-based activity, followed by interactive comprehension questions to test understanding.

Throughout the process, each **Tutor Agent** provides real-time feedback, tracks completed tasks and updates the **Tracker** with the learner's progress. Once all tasks for Topic 2 are completed, the **Tracker** updates the learner's profile with the new achievements. The **Communicator** then presents a summary of his progress, highlighting areas of strength and suggesting the next steps.

4 CONCLUSION

This demo presents a novel application of MAS for Luxembourgish language learning, leveraging GPT-4 and RAG to create a structured, adaptive, and engaging educational experience. By addressing the unique challenges of low-resource languages, this approach lays the foundation for more inclusive and effective AI-driven learning systems with the critical elements of human interaction and pedagogy. Future efforts will focus on scaling the framework, refining multimodal capabilities, and automating validation processes to extend the benefits of this approach to a wider audience.

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