

# The Role of Ontologies and Semantic Technologies in Developing Educational Chatbots

Ana Petrovic, Danijela Jaksic, Kristian Stancin

University of Rijeka, Faculty of Informatics and Digital Technologies

Radmile Matejcic 2

Rijeka, Croatia

{apetrovic, danijela.jaksic, kristian.stancin}@inf.uniri.hr

**Abstract.** This paper explores the role of ontologies and semantic technologies in the development of advanced educational chatbots and virtual assistants. It focuses on two research questions: “*What role do ontologies play in making chatbots easier to use, more accurate, and more effective for personalized learning?*”, and “*What are the application domains and case studies that demonstrate the use of ontologies in educational contexts?*”. The study synthesizes findings from a literature review conducted using Google Scholar and Scopus. Findings highlight the application of ontology-driven chatbots in areas such as university admissions, health and nutrition education, programming instruction, cultural heritage learning, and general e-learning environments. The results underscore the value of ontologies in enhancing chatbot performance and personalizing student support.

**Keywords.** ontology, chatbot, education, semantic technology

## 1 Introduction

The integration of ontologies and semantic technologies in the development of educational chatbots and virtual assistants represents a significant advancement in the field of educational technology. These innovations lay solid groundwork for developing smart learning systems that can engage with students, enhance their learning, and effectively respond to educational inquiries. Ontologies are structured frameworks that define the relationships between concepts within a specific domain, enabling machines to understand and interpret the meaning of terms in context. Semantic techniques involve the use of these ontologies, along with natural language processing and reasoning algorithms, to derive meaningful insights from data and support intelligent interactions. Ontologies, which outline the connections between concepts in a particular field, empower chatbots to navigate through complex educational

material and guide students through organized learning resources (Lecce et al., 2010). For example, systems based on semantics have been created to streamline the arrangement of learning materials, simplifying resource management for instructors and allowing students to interactively explore content via chatbots (Lecce et al., 2010).

Additionally, the use of natural language processing (NLP) and artificial intelligence (AI) in educational chatbots allows personalized learning experiences. These systems can simulate human interaction, providing students with immediate feedback and assistance, which is crucial for motivation and cognitive development (MA et al., 2024). The potential of chatbots to serve as virtual teaching assistants is further highlighted by their ability to engage with students using evaluative language and engagement strategies, although challenges such as ideological bias and lack of contextual awareness remain (Van Poucke, 2024).

The development of educational chatbots also benefits from the integration of semantic web frameworks, which facilitate the creation of smart assistants capable of processing and modeling information dynamically. Such frameworks enable the incorporation of voice recognition and ontology-powered inference, making chatbots more effective in educational context (Sermet & Demir, 2020). As educational systems continue to embrace digital transformation, the role of ontologies and semantic technologies in enhancing the capabilities of chatbots and virtual assistants will likely expand, offering new opportunities for innovation in teaching and learning.

The paper is structured as follows: Section 2 describes the methodology, Section 3 gives literature review and answers to set research questions, Section 4 highlights main implications and gives a brief discussion, and Section 5 gives some conclusions.

## 2 Methodology

### 2.1. Research Approach

This study follows a qualitative literature review approach to examine the intersection of ontologies and chatbot development. The research process was guided by a systematic search of two academic databases, Google Scholar and Scopus, to identify relevant and recent publications focused on ontology based chatbots. These two databases were chosen for complementary reasons. Google Scholar provides broad coverage across disciplines and includes grey literature, which ensured that recent and potentially influential works outside traditional journals could be considered. Scopus, on the other hand, is a curated and highly structured database that indexes peer-reviewed journals and conference proceedings, offering more reliable metadata, filtering options, and citation analysis. Using both sources increased the comprehensiveness and balance of the literature search. The following research questions were formulated:

- **RQ1:** *What role do ontologies play in making chatbots easier to use, more accurate, and more effective for personalized learning?*
- **RQ2:** *What are the application domains and case studies that demonstrate the use of ontologies in educational contexts?*

These questions aim to capture both the functional benefits of ontologies in chatbot design and the diversity of their practical applications within educational settings.

### 2.2. Google Scholar

The initial search was conducted on Google Scholar using the query "Ontology chatbot" restricted to article titles and limited to the publication years from 2021 to 2025. The Google Scholar search was intentionally kept simple due to the platform's limited support for complex queries and filtering. This allowed us to capture a broad initial pool of results, even if further manual screening was required.

This search gave a total of 24 results. A first-level screening based on the titles and abstracts was performed to determine relevance and accessibility. The filtering process resulted in: 1 article excluded due to being in a non-English language, 15 articles excluded due to lack of access or availability, and 8 articles deemed potentially relevant for full-text reading.

Following a comprehensive reading of these 8 articles, 7 were selected as relevant and included in the literature review.

### 2.3. Scopus

Compared to Google Scholar, Scopus allows for advanced query construction with precise filters for publication year, subject area, document type, and language. This motivated the use of a more refined and structured query in Scopus to ensure that only peer-reviewed, computer science-oriented, and accessible works were included. This strategy reduced noise in the results and increased the methodological rigor of the review. A more refined and structured query was applied for the Scopus database, defined as follows:

(TITLE-ABS-KEY (chatbots) AND TITLE-ABS-KEY (ontology)) AND PUBYEAR > 2020 AND PUBYEAR < 2026 AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO ( DOCTYPE , "cp") OR LIMIT-TO ( DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "COMP")) AND (LIMIT-TO (LANGUAGE , "English"))

This query aimed to retrieve peer-reviewed conference papers and journal articles published between 2021 and 2025, in the subject area of computer science, written in English, and with open access availability. The search returned 28 results.

Title and abstract screening led to the following categorization: 9 articles selected for full-text review and 19 excluded (including 4 duplicates).

Out of the 9 fully reviewed texts, 7 articles were ultimately included in the analysis.

### 2.4. Selection Outcome

From both databases, a combined total of 14 publications were selected for the literature review: 7 from Google Scholar, and 7 from Scopus. These sources were chosen based on relevance to the topic, accessibility, and their contribution to understanding the role of ontologies in chatbot systems.

While this study employed Google Scholar and Scopus to identify relevant literature, the approach has several limitations. First, relying only on two databases may have excluded potentially relevant works indexed elsewhere or published in venues not covered by these platforms. Second, the search queries, although systematically applied, were constrained by the functionalities of each database and may not have captured all pertinent studies. Third, emerging tools such as AI-powered assistants can increasingly support literature exploration by offering more advanced semantic retrieval and cross-paper reasoning. However, these tools were not employed in this study in order to ensure transparency and reproducibility of results.

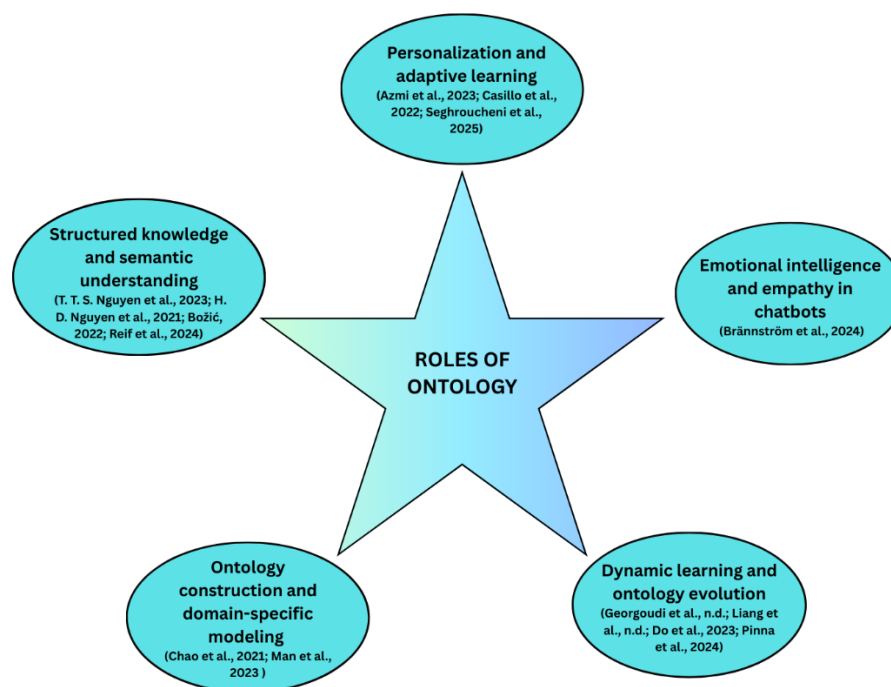


Figure 1. Roles of Ontology

## 3 Literature review

### 3.1. RQ1: What role do ontologies play in making chatbots easier to use, more accurate and more effective for personalized learning?

Based on the literature review, five key roles of ontology were identified that enhance the effectiveness and functionality of chatbots (as illustrated in Fig. 1): Structured knowledge and semantic understanding; Personalization and adaptive learning; Emotional intelligence and empathy in chatbots; Dynamic learning and ontology evolution; Ontology construction and domain-specific modelling.

#### 3.1.1. Structured knowledge and semantic understanding

Ontologies play a key role in helping chatbots understand user queries by providing a structured way to represent domain knowledge. This improves the accuracy, consistency, and relevance of chatbot responses, especially in educational settings.

A university admissions chatbot was developed using a domain-specific ontology that enabled it to generate detailed responses and handle a wide range of student questions. The system can reason over structured data to provide long, meaningful answers. It's also designed to be expandable, allowing new knowledge to be added over time (T. T. S. Nguyen et al., 2023). In the context of programming education, a chatbot was built using the Rela-model ontology,

which represents concepts, relationships, and rules relevant to the curriculum. This structure allowed the chatbot to classify questions accurately and support personalized guidance for students learning to code (H. D. Nguyen et al., 2021). Ontologies also play a role in improving the reliability and scalability of chatbots. By using structured semantic rules, developers can perform metamorphic testing to ensure consistent behaviour and easier system maintenance (Božić, 2022). In more complex environments, ontologies are combined with large language models to make knowledge more accessible. One approach enables users to ask questions in natural language, which the system then translates into SPARQL queries for retrieving accurate information, improving usability for non-expert users (Reif et al., 2024).

These examples show how structured knowledge, enabled by ontologies, supports better understanding, higher accuracy, and more scalable chatbot solutions in education.

#### 3.1.2. Personalization and adaptive learning

Ontologies are widely used to personalize chatbot interactions by adapting content to individual users' needs, preferences, or learning contexts. This makes educational chatbots more engaging, responsive, and effective in supporting user goals.

A chatbot designed to recommend healthy food options for teenagers uses an ontology to deliver personalized suggestions based on individual health conditions and dietary needs. The system applies Semantic Web Rule Language (SWRL) rules to reason over user input, such as calorie goals and medical restrictions, ensuring accurate and tailored advice (Azmi et al., 2023). A chatbot called HeriBot

personalizes educational experiences for museum visitors. By using a purpose-built ontology representing the Archaeological Urban Park of Naples, the system adjusts its tone, language, and depth of information based on user motivations and profiles (Casillo et al., 2022). Ontologies also support adaptive learning by helping chatbots interpret and respond to learners' evolving needs. In e-learning platforms, they enable the conversion of tacit knowledge into structured, usable formats. When combined with NLP, it allows the chatbot to provide responses aligned with the user's intent and the knowledge base. This approach enhances both personalization and content delivery (Seghroucheni et al., 2025).

### 3.1.3. Emotional intelligence and empathy in chatbots

Ontologies can also play a key role in enabling chatbots to understand and respond to users' emotions, making interactions more humanized and supportive, especially in sensitive domains like health and well-being.

A proposed empathy ontology offers a structured way for chatbots to model emotional intelligence by organizing empathy-related concepts into a clear, hierarchical framework. This allows the chatbot to interpret emotional cues more accurately and respond in appropriate way (Brännström et al., 2024).

### 3.1.4. Dynamic learning and ontology evolution

In dynamic learning environments, ontologies are used not only to organize existing knowledge but also to expand and evolve as new information becomes available. This adaptability is crucial for chatbots that operate in changing domains and interact with users in unpredictable ways.

One approach introduces a dynamic ontology extension system that updates the chatbot's knowledge base in response to new user input and shifts in domain content. New entity types and relationships are added automatically, improving the chatbot's ability to provide accurate and up-to-date responses (Georgoudi et al., n.d.). Another study categorizes dynamic learning into tasks such as discovering new user intents and slot values during real-time interactions. This technique, known as ontology expansion, allows chatbots to handle novel inputs and maintain flexibility in unpredictable conversational contexts (Liang et al., n.d.). A hybrid model combines ontological reasoning with an autoregressive language model (XLNet) to fill in gaps where structured knowledge alone is not enough. This allows the chatbot to maintain semantic precision while generating fluent, natural responses (Do et al., 2023). To support long-term learning, a modular framework has been proposed that enables domain-specific chatbots to continuously incorporate new data and improve over time. The use of ontologies in this system allows scalable knowledge integration and sustained relevance across different educational contexts (Pinna et al., 2024).

### 3.1.5. Ontology construction and domain-specific modeling

In some applications, the focus is not just on using ontologies but on constructing them to fit specific domains. These domain-specific models help chatbots understand specialized topics, organize complex information, and deliver relevant responses.

One study applies text mining techniques such as keyword frequency analysis, clustering, and Latent Dirichlet Allocation (LDA) to build an ontology from patent data (Chao et al., 2021). Another example comes from the healthcare education domain, where a chatbot uses a modular ontology system divided into general and user-specific components. The chatbot personalizes information delivery using a layered ontology design and ensures regulatory compliance, including data privacy and GDPR adherence (Man et al., 2023).

## 3.2. RQ2: What are the application domains and case studies that demonstrate the use of ontologies in educational contexts?

This review identifies five key domains where ontologies are applied to enhance chatbot functionality in educational contexts: University admissions; Health and nutrition education; Programming and technical education; Cultural heritage and experiential learning; General educational chatbot systems.

In the domain of **university admissions**, chatbots support students by answering questions about application procedures, entry requirements, and academic offerings. Ontologies are used to structure institutional knowledge, enabling the chatbot to reason and generate accurate, context-aware responses (T. T. S. Nguyen et al., 2023), (Do et al., 2023).

Within **health and nutrition education**, chatbots are designed to provide personalized guidance based on user-specific data. One paper (Azmi et al., 2023) delivers nutrition advice tailored to adolescents' health profiles, while other supports applicants with relevant health program information and ensures privacy and compliance with data regulations (Man et al., 2023).

The **programming and technical education** domain features chatbots that guide learners through course content and problem-solving tasks (H. D. Nguyen et al., 2021). In more informal and experience-based learning contexts, **cultural heritage and experiential learning** benefit from ontology driven chatbots that adapt educational content to the user. One study presents HeriBot, which personalizes museum visits by adjusting language, tone, and content depth based on visitor profiles and motivations (Casillo et al., 2022).

Finally, several papers explore **general educational chatbot systems** that span multiple learning domains or are designed for long-term adaptability. For example, one study focuses on

systems that evolve their knowledge bases dynamically based on user interactions (Georgoudi et al., n.d.). Similarly, there is a study that provides a scalable and reusable architecture that supports chatbot development across varied educational settings (Pinna et al., 2024).

These diverse case studies illustrate how ontology-based chatbots are being successfully applied across formal, informal, and hybrid learning environments.

### 3.3. Findings overview

**Table 1.** presents, for each analysed paper, the role of ontology and its application domain.

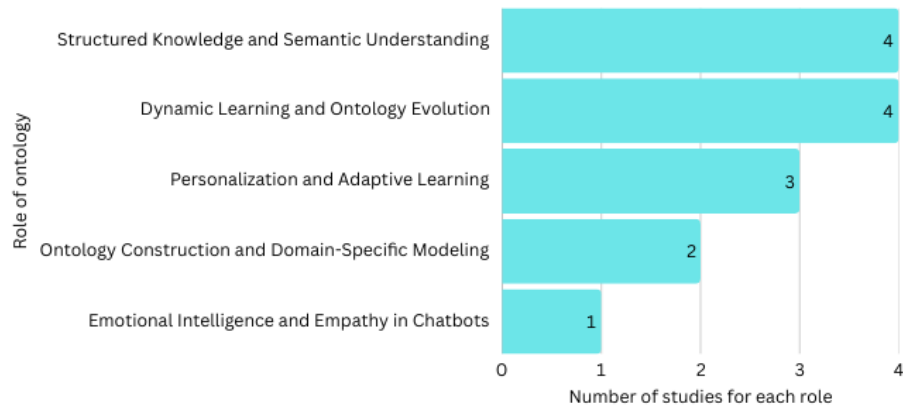
**Table 1.** Paper analysis

| Paper Title                                                                                                                              | Role of Ontology                                | Application Domain                  |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------|
| <i>An Ontology-Based Question Answering System for University Admissions Advising (T. T. S. Nguyen et al., 2023)</i>                     | Structured Knowledge and Semantic Understanding | University Admissions               |
| <i>A Collaboration of an Ontology and an Autoregressive Model to Build an Efficient Chatbot Model (Do et al., 2023)</i>                  | Dynamic Learning and Ontology Evolution         | University Admissions               |
| <i>Recommendation System in the Form of an Ontology-Based Chatbot for Healthy Food Recommendations for Teenagers (Azmi et al., 2023)</i> | Personalization and Adaptive Learning           | Health and Nutrition Education      |
| <i>An Ontology-Based Chatbot to Enhance Experiential Learning in a Cultural Heritage Scenario (Casillo et al., 2022)</i>                 | Personalization and Adaptive Learning           | Cultural Heritage                   |
| <i>Ontology-Based Integration of Knowledge Base for Building an Intelligent Searching Chatbot (H. D. Nguyen et al., 2021)</i>            | Structured Knowledge and Semantic Understanding | Programming and Technical Education |
| <i>A Formal Understanding of Computational Empathy in</i>                                                                                | Emotional Intelligence and                      | Health and Nutrition Education      |

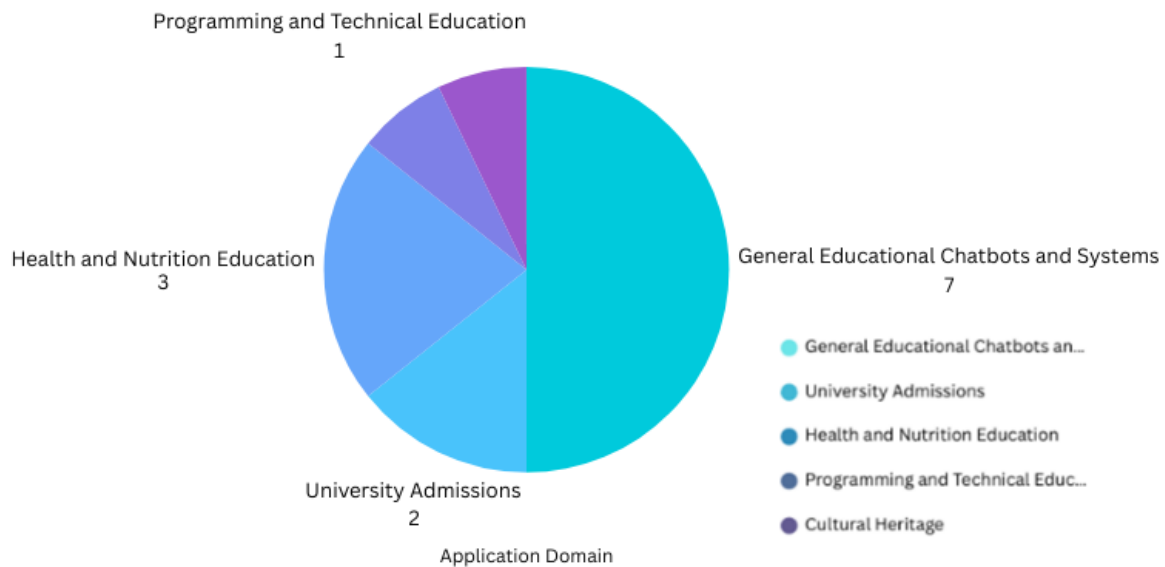
| Paper Title                                                                                                                                                                                             | Role of Ontology                                   | Application Domain                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------------------------------------|
| <i>Interactive Agents (Brännström et al., 2024)</i>                                                                                                                                                     | Empathy in Chatbots                                |                                          |
| <i>Systematic Review and Framework for AI-Driven Tacit Knowledge Conversion Methods and Machine Learning Algorithms for Ontology-Based Chatbots in E-Learning Platforms (Seghroucheni et al., 2025)</i> | Personalization and Adaptive Learning              | General Educational Chatbots and Systems |
| <i>Chatbot-Based Ontology Interaction Using Large Language Models and Domain-Specific Standards (Reif et al., 2024)</i>                                                                                 | Structured Knowledge and Semantic Understanding    | General Educational Chatbots and Systems |
| <i>DYNAMO: Dynamic Ontology Extension for Augmenting Chatbot Intelligence through BabelNet (Georgoudi et al., n.d.)</i>                                                                                 | Dynamic Learning and Ontology Evolution            | General Educational Chatbots and Systems |
| <i>A Survey of Ontology Expansion for Conversational Understanding (Liang et al., n.d.)</i>                                                                                                             | Dynamic Learning and Ontology Evolution            | General Educational Chatbots and Systems |
| <i>The Innovative Use of Intelligent Chatbot for Sustainable Health Education Admission Process: Learnt Lessons and Good Practices (Man et al., 2023)</i>                                               | Ontology Construction and Domain-Specific Modeling | Health and Nutrition Education           |
| <i>Technology Mining for Intelligent Chatbot Development (Chao et al., 2021)</i>                                                                                                                        | Ontology Construction and Domain-Specific Modeling | General Educational Chatbots and Systems |
| <i>Ontology-based Metamorphic Testing for Chatbots (Božić, 2022)</i>                                                                                                                                    | Structured Knowledge and Semantic Understanding    | General Educational Chatbots and Systems |
| <i>A Modular Framework for Domain-Specific</i>                                                                                                                                                          | Dynamic Learning and                               | General Educational                      |

| Paper Title                                                                                | Role of Ontology   | Application Domain   |
|--------------------------------------------------------------------------------------------|--------------------|----------------------|
| <b><i>Conversational Systems Powered by Never-Ending Learning</i></b> (Pinna et al., 2024) | Ontology Evolution | Chatbots and Systems |

The graphs below present an overview of the number of studies that discussed each specific role of ontologies (Fig. 2), as well as the number of publications categorized by their application domains (Fig. 3).



**Figure 2.** Role of ontology for each paper



**Figure 3.** Frequency of application domains

## 4 Discussion and implications

Considering the results of the first research question, the review shows that ontologies significantly enhance the usability, accuracy, and overall effectiveness of chatbots. Ontologies enable a structured representation of knowledge, allowing chatbots to interpret user inputs more precisely. The ability to structure complex information ensures that these systems can deliver personalized experiences. In the field of education, structured knowledge and semantic understanding are key to creating successful learning experiences. This trend is particularly evident in the **4 papers** focused on **dynamic learning and ontology evolution**, **4 papers** highlighting **structured knowledge and semantic understanding**, and **3 papers** dedicated to **personalization and adaptive learning**. These findings suggest a growing need for dynamic ontology models that can continuously evolve to reflect emerging knowledge and user needs. Additionally, incorporating structured knowledge and adaptive learning could be essential to enhancing learning experience.

Ontology-based chatbots are being applied across diverse domains, with a significant focus on **general educational systems** (7 papers), **health and nutrition education** (3 papers) and **university admissions** (2 papers). These systems provide personalized learning experiences and enhance user engagement by adapting to individual needs. Future research can focus on cross-domain applications, where ontologies from various sectors are integrated to enhance chatbot intelligence.

## 5 Conclusion and future work

Ontologies play a foundational role in enhancing the design, functionality, and impact of chatbots in educational contexts. As demonstrated across multiple studies, ontologies provide structured, semantic frameworks that enable chatbots to understand user queries more accurately. The reviewed research highlights that ontologies contribute not only to technical precision but also to pedagogical value.

The main contributions of this paper are insights into the role that ontologies play in making chatbots easier to use, more accurate and more effective for personalized learning, as well as categorization of application domains that demonstrate the use of ontologies in educational contexts.

In domains such as university admissions, programming education, and cultural heritage learning, domain-specific ontologies allow chatbots to deliver contextually relevant information. Furthermore, adaptive and personalized systems enhance learner engagement and support differentiated instruction, especially when combined with natural language processing and rule-based inference.

Future research could explore the use of specific ontologies to support the development of chatbots designed to assist students in higher education institutions within e-learning platforms. Integrating some of the analysed ontologies with existing Learning Management Systems (LMS) could enable automated progress tracking, learning recommendations, and real-time answers to frequently asked questions. At the same time, research should not be limited to ontologies alone. Emerging technologies such as large language models, knowledge graphs, and recommender systems also offer promising opportunities to enhance the intelligence and adaptability of virtual assistants in education.

## Acknowledgements

The research has been co-funded by “uniri-iskusni-drustv-23-209 (3203)” under the project “Development of an e-learning course design model based on recommendations for managing student satisfaction in higher education”

## References

- Azmi, N., Richasdy, D., & Hasmawati. (2023). Recommendation System in the Form of an Ontology-Based Chatbot for Healthy Food Recommendations for Teenagers. *Jurnal Penelitian Pendidikan IPA*, 9(7), 5085–5091. <https://doi.org/10.29303/jppipa.v9i7.4401>
- Božić, J. (2022). Ontology-based metamorphic testing for chatbots. *Software Quality Journal*, 30(1), 227–251. <https://doi.org/10.1007/s11219-020-09544-9>
- Brännström, A., Wester, J., & Nieves, J. C. (2024). A formal understanding of computational empathy in interactive agents. *Cognitive Systems Research*, 85. <https://doi.org/10.1016/j.cogsys.2023.101203>
- Casillo, M., De Santo, M., Mosca, R., & Santaniello, D. (2022). An Ontology-Based Chatbot to Enhance Experiential Learning in a Cultural Heritage Scenario. *Frontiers in Artificial Intelligence*, 5. <https://doi.org/10.3389/frai.2022.808281>
- Chao, M. H., Trappey, A. J. C., Wu, C. T., & Su, Y. A. (2021). Technology mining for intelligent chatbot development. *Advances in Transdisciplinary Engineering*, 16, 123–132. <https://doi.org/10.3233/ATDE210090>
- Do, P. M. T., Nguyen, N. T. A., Ho, D. H. T., & Nguyen, T. T. S. (2023). A collaboration of an ontology and an autoregressive model to build an efficient chatbot model. *International Journal of Intelligent Information and Database Systems*, 1(1). <https://doi.org/10.1504/ijiids.2023.10059348>
- Georgoudi, A., Meditskos, G., Mavropoulos, T., Vrochidis, S., & Kompatsiaris, I. (n.d.).

- DYNAMO: Dynamic Ontology Extension for Augmenting Chatbot Intelligence through BabelNet.
- Lecce, V., Calabrese, M., Soldo, D., & Giove, A. (2010). Semantic Management Systems for the Material Support of E-learning Platforms. *Journal of E-Learning and Knowledge Society*, 6, 61–70. <https://doi.org/10.20368/1971-8829/445>
- Liang, J., Wu, Y., Fang, Y., Fei, H., & Liao, L. (n.d.). A Survey of Ontology Expansion for Conversational Understanding. <https://github.com/liangjinggui/>
- MA, W., MA, W., HU, Y., & BI, X. (2024). The who, why, and how of ai-based chatbots for learning and teaching in higher education: A systematic review. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-024-13128-6>
- Man, S. C., Matei, O., Faragau, T., Andreica, L., & Daraba, D. (2023). The Innovative Use of Intelligent Chatbot for Sustainable Health Education Admission Process: Learnt Lessons and Good Practices. *Applied Sciences (Switzerland)*, 13(4). <https://doi.org/10.3390/app13042415>
- Nguyen, H. D., Tran, T. V., Pham, X. T., Huynh, A. T., & Do, N. V. (2021). Ontology-based integration of knowledge base for building an intelligent searching chatbot. *Sensors and Materials*, 33(9), 3101–3123. <https://doi.org/10.18494/SAM.2021.3264>
- Nguyen, T. T. S., Ho, D. H. T., & Nguyen, N. T. A. (2023). An Ontology-Based Question Answering System for University Admissions Advising. *Intelligent Automation and Soft Computing*, 36(1), 601–616. <https://doi.org/10.32604/iasc.2023.032080>
- Pinna, F. C. de A., Hayashi, V. T., Néto, J. C., Marquesone, R. de F. P., Duarte, M. C., Okada, R. S., & Ruggiero, W. V. (2024). A Modular Framework for Domain-Specific Conversational Systems Powered by Never-Ending Learning. *Applied Sciences (Switzerland)*, 14(4). <https://doi.org/10.3390/app14041585>
- Reif, J., Jeleniewski, T., Gill, M. S., Gehlhoff, F., & Fay, A. (2024). Chatbot-Based Ontology Interaction Using Large Language Models and Domain-Specific Standards. <https://doi.org/10.1109/ETFA61755.2024.10711065>
- Seghroucheni, O. Z., Lazaar, M., & Al Achhab, M. (2025). Systematic Review and Framework for AI-Driven Tacit Knowledge Conversion Methods and Machine Learning Algorithms for Ontology-Based Chatbots in E-Learning Platforms. *International Journal of Interactive Mobile Technologies*, 19(1), 126–139. <https://doi.org/10.3991/ijim.v19i01.51051>
- Sermet, Y., & Demir, I. (2020). A Semantic Web Framework for Automated Smart Assistants: COVID-19 Case Study. *ArXiv*, abs/2007.00747. <https://consensus.app/papers/a-semantic-web-framework-for-automated-smart-assistants-sermet-demir/11ae2ec1f56652c3923fa0b8d30ff0d8/>
- Van Poucke, M. (2024). ChatGPT, the perfect virtual teaching assistant? Ideological bias in learner-chatbot interactions. *Computers and Composition*. <https://doi.org/10.1016/j.compcom.2024.102871>