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# THE ROLE OF EDUCATIONAL CHATBOTS IN ADAPTING EDUCATIONAL SYSTEMS TO THE BANI MODEL: A CAUSAL LAYERED ANALYSIS APPROACH

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***Abstract:*** *This paper analyzes the integration of educational chatbots within contemporary education systems shaped by volatility, complexity, and uncertainty, using the BANI model (Brittle, Anxious, Non-linear, Incomprehensible) as a conceptual lens. The study employs Causal Layered Analysis (CLA) to investigate the symbolic, systemic, and functional significance of conversational technologies in education. A theoretical architecture for a retrieval-augmented generation (RAG) chatbot is proposed, designed to process institutional educational documents and deliver context-aware responses based on semantic matching. The architecture is detailed with a focus on document processing workflows, vector-based indexing, and natural language generation. Potential applications are discussed in higher education with emphasis on benefits such as cognitive support, personalization, reduced information anxiety, and institutional resilience. The analysis highlights how chatbots can address key dimensions of the BANI framework and serve as adaptive instruments within pedagogical ecosystems undergoing transformation. The proposed architecture remains conceptual at this stage, providing a foundation for future empirical validation in real-world institutional settings.*

**Keywords: educational chatbot, artificial intelligence, BANI model, causal layered analysis, adaptive learning**

## 1. Introduction

Accelerated transformations in contemporary education are profoundly influenced by an unstable global framework, where institutions face a climate of volatility, uncertainty, complexity, and ambiguity – synthesized as VUCA (Volatility, Uncertainty, Complexity, Ambiguity) [1],[2], initially used to describe the post-Cold War world. However, in the face of current systemic crises – pandemics, conflicts, accelerated digitalization – the VUCA model becomes insufficient to capture the depth of contemporary tensions. In this context, the BANI model, proposed by Jamais Cascio [3], offers a more adequate conceptual framework, reflecting institutional fragility, informational anxiety, causal discontinuity, and the difficulty of understanding new technological paradigms. Given these increasingly complex challenges, educational systems, academic staff, and students find themselves under considerable pressure, thereby generating an acute need for innovative, adaptable, and scalable pedagogical solutions which are capable of ensuring the continuity, relevance, and critical equity of the educational process in an unstable environment.

One of the most promising emerging solutions is represented by educational chatbots – conversational systems based on artificial intelligence, designed to offer

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personalized support in the learning process through natural, asynchronous, and contextual interactions. More than mere technological extensions, chatbots are becoming adaptive pedagogical tools that can reduce the pressure on academic staff, support self-directed learning, and respond differentially to students' cognitive needs, especially in formal and highly structured educational environments, such as universities.

This paper aims to investigate how these conversational tools can contribute to institutional resilience and adaptability in educational contexts marked by instability. Beyond functional analysis, the research proposes a symbolic and systemic reading of the phenomenon, using the BANI model and the CLA method in an integrated manner. This theoretical and methodological combination allows for a multi-level exploration of the role of chatbots, not only as educational technologies but as indicators of a paradigmatic transition in education – from authority to collaboration, from rigidity to adaptability, from standardization to personalization.

The purpose of this paper is to explore how educational chatbots can support the adaptation of educational systems to the complex challenges captured by the BANI framework, from functional, symbolic, and institutional perspectives. Our inquiry is guided by a central question:

How can Causal Layered Analysis (CLA) be applied to understand and interpret the role of educational chatbots in facilitating institutional adaptation within an educational environment marked by instability, anxiety, non-linearity, and ambiguity?

To answer this question, the research adopts a qualitative, exploratory methodology based on the integrated analysis of specialized literature, curricular documents, and the functional architecture of a conversational chatbot. The paper proposes a coherent articulation between theoretical contextualization, practical exemplification, and the multi-layered interpretation offered by CLA, with the aim of identifying the added value of educational chatbots in the processes of adaptation, personalization, and continuous cognitive support.

## 2. Research Methodology

To answer the research question formulated in the introductory section – regarding the potential of educational chatbots to act as mechanisms of institutional adaptation in contexts dominated by uncertainty – this paper adopts a qualitative, exploratory, and transdisciplinary approach. The primary method used [4], CLA, is a technique developed by Sohail Inayatullah in the field of future studies, which allows the investigation of complex phenomena from a multi-level perspective, combining empirical, structural, cultural, and symbolic dimensions. CLA is considered appropriate for this study because it enables an in-depth interpretation of the role of educational chatbots, not only as functional technological tools but also as vectors of paradigmatic transformation in education. In the context of the BANI model – which characterizes contemporary educational environments through fragility, anxiety, non-linearity, and incomprehensibility – CLA offers a complementary interpretative framework, capable of capturing not only surface reactions but also the deep mechanisms that determine the use and perception of these technologies.

The CLA method [5] analyzes reality on four interdependent levels:

- Litany – the level of superficial discourse and common perceptions ("AI is used to do homework");
- Systemic – the level of institutional structure and educational mechanisms (pressure for digitalization, lack of academic staff, need for asynchronous support);
- Dominant Discourses – the level of ideological and cultural narratives (shift of

focus towards the student, personalized learning, cognitive autonomy);

- Myths and Metaphors – the level of collective imaginary and profound symbolism (the chatbot as an "invisible teacher," "digital mentor," "permanent guide").

This methodological approach allows for the articulation of a multilateral understanding of educational chatbots, as adaptive technological tools, but also as symbols of a new pedagogical architecture, characterized by flexibility, autonomy, and digital mediation. CLA is thus ideal for articulating an integrative reading of educational transformation in the context of global instability.

The research was based on a systematic review of recent scientific literature (2020–2025), using primary academic sources indexed in international databases such as Web of Science, Scopus, SpringerLink, and IEEE Xplore. The selection followed three main criteria:

- Thematic relevance, with an emphasis on: educational chatbots, artificial intelligence in education, conversational models, and curricular adaptation;
- Recency and scientific validity, prioritizing peer-reviewed sources;
- Methodological value, especially for works that integrate the BANI model, symbolic approaches, or scenarios for the educational implementation of AI.

Essential sources include systematic reviews on the application of chatbots in higher education, studies on interaction with large language models (LLMs) for generating automated feedback, and recent research on the ethical implications of using AI in education. Institutional documents such as academic regulations, study programs, curricular guides, and course materials were also analyzed and used in developing implementation scenarios for the proposed chatbot.

In addition to the theoretical-analytical component, the research also included the conceptual development of a functional model of an educational chatbot, based on processing real educational documents and integrating a large language model (GPT-3.5).

The technological architecture was described and evaluated in the applied section of the paper. This practical component supports testing the hypothesis that the chatbot can serve as a scalable tool for cognitive support and information mediation, contributing to reducing educational stress and increasing information accessibility, especially in rigid educational contexts (e.g., military training).

Thus, the methodology coherently combines CLA's symbolic and institutional analysis of education with a conceptual design approach for a conversational chatbot developed around specific curricular content. The integration of theoretical analysis and practical components was deemed essential to ensure a perspective that is both comprehensive and grounded in real-world applicability. In this way, the findings become more readily transferable to contemporary educational practice, while our research approach maintains a high degree of internal coherence.

## 3. Theoretical Foundations: Conversational Technologies and the Transformation of the Educational Paradigm

In the last two decades, artificial intelligence has begun to play an increasingly significant role in education, especially through EdTech technologies that promise personalization, scalability, and efficiency [6]. One of the most recent and relevant innovations is the emergence of educational chatbots – conversational agents capable of simulating human dialogue, offering real-time assistance, individualized support, and access to complex content in a accessible and interactive manner [7]. Chatbots are based on modern Natural Language Processing (NLP) techniques, machine learning, and Large Language Models (LLMs), such as those developed by OpenAI.

Unlike traditional online learning systems, which involve static and synchronous interactions, chatbots offer temporal flexibility, contextual interactivity, and adaptability to the students' cognitive style.

Specialized literature indicates a wide range of educational applications for chatbots: assistance in the learning process, administrative support [8], automated feedback [9], virtual tutoring [10], testing, and review [11]. More than a simple automated response tool, the chatbot can become a pedagogical agent [12], a training medium for critical thinking [13], and a dialogue partner in exploring curricular content [14].

In parallel, the educational paradigm itself is undergoing a structural transformation: the emphasis is shifting from information transmission to facilitating autonomous learning [15], from the central authority of the teacher to the co-creation of knowledge. This transition, described in the pedagogical literature through concepts such as constructivism, personalized learning, or adaptive learning [16], offers fertile ground for the integration of conversational technologies, which can support these trends through digital mediation, continuous feedback, and the development of metacognition [17].

Therefore, chatbots are emerging as a coherent and necessary technological response to the challenges of an education system in continuous adaptation. They do not replace the teacher but extend their capabilities – offering time, clarification, and support where human resources are limited or insufficient [18]. This positioning is all the more relevant in a BANI environment, where the ability to manage fragility, anxiety, and complexity becomes essential for the success of educational training [19].

## 4. Development of a Content-Specific Educational Chatbot

To highlight the real potential of chatbots in education, this section presents a functional model of a conversational chatbot capable of retrieving, interpreting, and utilizing the content of an educational document (e.g., course, regulation, textbook) to support the learning process through natural interaction.

### 4.1. Technological Architecture

To illustrate the theoretical and methodological applicability presented earlier, this section proposes a functional model of a conversational chatbot built around the idea of contextualized cognitive assistance. The aim is to highlight how such a system can contribute to adapting the educational process within a framework marked by complexity and instability, by exploiting existing educational content (curricular documents, textbooks, regulations etc.) and transforming it into an interactive, scalable, and permanently accessible interface.

The proposed model (Figure 1) aims to develop a retrieval-augmented generation (RAG) conversational chatbot [20], which combines the capacity for contextualized information retrieval with natural response generation, based on a static but relevant educational corpus.

The technological architecture of the conversational chatbot, Figure 1, implements an advanced RAG model. To fulfil its functions, it is articulated around two distinct but complementary operational flows: the first flow is dedicated to document processing and the rigorous constitution of the knowledge base, and the second flow manages the dynamic interaction with the user, from receiving the question to formulating a contextualized answer.

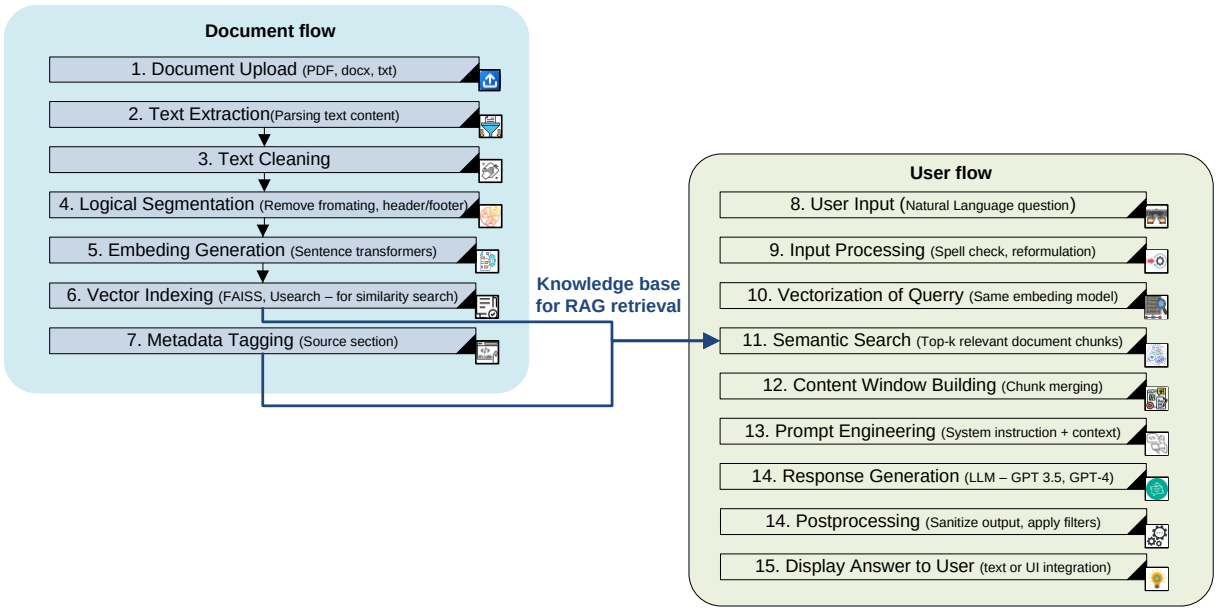


*Figure 1: Operational flow of a document-based conversational chatbot with a Retrieval-Augmented Generation (RAG) architecture. Source: author*

Next, Table 1 provides a detailed description of each stage and component (the specific terms of the RAG architecture) within these two essential flows.

*Table 1: Description of the operational flow. Source: author*

| Document Processing Flow (Knowledge Base Preparation) | User Interaction Flow (Conversational Response) |
|---|---|
| **Document Upload** – accepted files: PDF, DOCX, TXT. The user or administrator uploads one or more relevant educational documents (courses, regulations, textbooks). These represent the fixed source of knowledge on which the chatbot will operate.<br><br>**Text Extraction –** automatic extraction of textual content from source files is performed. Libraries such as pdfplumber, PyMuPDF, docx, textract, etc., are used to robustly extract raw text.<br><br>**Text Cleaning** – the extracted text is cleaned of uninformative elements such as headers, footers, page numbers, special characters, formatting codes, etc.<br>This step increases the semantic quality of the segments to be processed.<br>**Logical Segmentation** – the cleaned content is divided into coherent semantic units: paragraphs, sentences, thematic sections. This stage ensures optimal | **User Input** – the user formulates a question in natural language, addressed to the chatbot, regarding content from the uploaded document.<br><br>**Input Preprocessing** – the question is processed for grammatical correction, ambiguity elimination, and reformulation if necessary.<br>(e.g., using NLP modules like spaCy or language_tool)<br><br>**Query Vectorization** – the question is transformed into a semantic vector, using the same embedding model as in step 5, to ensure search compatibility.<br><br>**Semantic Search** – a semantic search is performed in the vector database, identifying a predefined number (k) of the closest text fragments (the most semantically relevant) from the initial document. Cosine similarity algorithms are applied between the query vector and the |

| Document Processing Flow (Knowledge Base Preparation) | User Interaction Flow (Conversational Response) |
|---|---|
| granularity for efficient search and precise answers.<br><br>**Embedding Generation** – each textual segment is transformed into a multidimensional numerical vector (embedding) using pre-trained sentence-transformer models (e.g., all-MiniLM-L6-v2). These embeddings numerically encode the meaning (semantic significance) of the text, thus being essential for allowing the system to compare the degree of semantic similarity between different text fragments and between text and user questions.<br><br>**Vector Indexing** – the embeddings of each segment are saved in a vector database, optimized to quickly retrieve the most semantically similar text segments (using 'approximate nearest neighbor search' algorithms, which efficiently identify the closest vectors in a multidimensional space Several software libraries, frameworks, or dedicated systems, which implement efficient vector search algorithms, can be used for this purpose. Examples include:<br>FAISS (Facebook AI Similarity Search) – performant and extensible, suitable for large datasets;<br>Usearch – an ultra-efficient vector search engine, with cross-platform support (C++/Python/WebAssembly), designed for low latency and reduced memory, ideal for embedded or serverless implementations.<br><br>**Metadata Tagging** – metadata (source, document title, page, chapter, etc.) is associated with each segment, useful for contextualized display of the answer or for subsequent auditing. | indexed vectors.<br><br>**Context Window Building** – relevant fragments (retrieved contexts) are extracted, concatenated, and arranged into a context window that will be transmitted to the language model. Coherence and relevance are prioritized.<br><br>**Prompt Engineering** – a custom prompt is built, which includes systemic instructions ("Answer only using the information from the context below...") + retrieved fragments + user question.<br><br>**Response Generation** – the prompt is sent to a large language model (e.g., GPT-3.5, GPT-4), which generates a natural language response, strictly based on the provided context, reducing the risk of "hallucination" (model inventions).<br><br>**Postprocessing** – the generated response is checked and processed for clarity, ambiguity elimination, or verification of potentially inappropriate language. Additional formatting or filtering rules can be applied.<br><br>**Display Answer to User** – the final answer is displayed to the user in a conversational interface (chat UI), possibly with reference to the exact source of the information, for transparency and active learning. |

The proposed architecture was designed with practical implementation in mind, making it accessible and flexible enough to accommodate various institutional and curricular needs. Another important consideration was to facilitate integration with widely used educational platforms, such as Moodle or Microsoft Teams, thereby enabling educators to deploy the chatbot in diverse real-world settings with minimal barriers.

### 4.2 Educational Use Scenarios

To demonstrate the practical relevance of the system, several pedagogical scenarios were analyzed in which the chatbot can be integrated as an educational support tool:

- Assisted Review: students can ask questions about content discussed in lectures, and the chatbot responds contextually, allowing for the consolidation of notions through active interaction.
- Learning Simulations: for example, in military or vocational environments, the chatbot can support conversational simulations based on standardized content (e.g., regulations, operational protocols), contributing to the internalization of procedures.
- Interactive Self-Assessment: users can formulate questions to test their level of understanding, and the chatbot can generate counter-questions or requests for further exploration based on the same sources.
- Non-stop Access to Curricular Information: students can consult the chatbot at any time for clarifications regarding course structure, academic regulations, or seminar content, reducing requests addressed to academic staff.

### 4.3 Benefits and Advantages

Integrating such a chatbot into the educational environment brings a series of demonstrable benefits, both for students and educational institutions:

- Extended Accessibility: the chatbot is available 24/7, allowing continuous access to information, without time or space constraints.
- Personalization of Learning: interaction is adapted to the individual needs of the user, based on the questions formulated and the pace of exploration.
- Reduction of Academic Staff Burden: automating responses to frequent or administrative questions allows teachers to focus on complex learning activities and mentoring.
- Stimulation of Critical Thinking and Reflection on One's Own Learning: through active interaction and formulating questions, students develop the capacity for reflection on content, conceptual integration, and cognitive self-regulation.

## 5. Context Analysis: Combined BANI and CLA Approach

In the field of education, BANI offers an adequate analytical framework to understand the systemic, emotional, and cognitive challenges faced by institutions, academic staff, and students in the face of accelerated transformations generated by digitalization, global crises, and new technologies.

In an educational context, CLA provides a valuable framework for understanding not only the functionality of conversational technologies like chatbots but also the cultural, symbolic, and institutional meanings they generate or reflect.

To deeply understand the necessity and added value of an educational chatbot in a modern training environment, a dual analysis is useful: the BANI model and CLA.

### 5.1 The BANI Model and Education

*Table 2: BANI Model: Educational Manifestations and Chatbot Responses*

| BANI Component | Manifestation in Education | Response Offered by Chatbot |
|---|---|---|
| Brittle | Educational programs exposed to shocks (pandemics, conflicts, lack of personnel) | The chatbot maintains access to content regardless of context. |
| Anxious | Students are overwhelmed by the volume of information and lack of | Offers clear, non-judgmental answers, and reduces informational stress. |

| BANI Component | Manifestation in Education | Response Offered by Chatbot |
|---|---|---|
| | clarity | |
| Non-linear | Effort and results no longer have a direct relationship; motivation decreases | Allows adaptation of learning pace and immediate feedback. |
| Incomprehensible | Technologies appear that are difficult for academic staff or students to understand | The chatbot acts as a pedagogical "translator" of complexity. |

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In such a context (table 2), the chatbot becomes not just a tool, but a mechanism for institutional adaptation – a bridge between external instability and the internal need for continuity and support.

### 5.2 CLA of the Educational Chatbot

*Table 3: Application of Causal Layered Analysis (CLA) to the Educational Chatbot*

| CLA Layer | Description | Example Applied to Chatbot |
|---|---|---|
| Litany (superficial level) | What is observed or stated in public discourse | "Students use AI to do their homework faster." |
| Systemic Causes | Institutional or social structures and mechanisms | "Lack of academic staff, pressure for digitalization, need for asynchronous support." |
| Dominant Discourses | Visions about education, cultural norms, strategies | "Student-centred education, personalized learning, autonomy in the cognitive process." |
| Metaphors and Myths | Deep beliefs, archetypal images, symbols | "The invisible teacher", "the permanent guide", "technology as mentor". |

CLA analysis (table 3) shows that an educational chatbot acts as a symbol of a paradigm shift: from authority to collaboration, from transmission to exploration, from rigidity to adaptability.

It embodies the idea of an omnipresent, accessible, empathetic, and personalized digital mentor.

## 6. Conclusions and Future Directions

In an educational world in constant transformation, characterized by uncertainty, external pressures, and technological complexity, educational chatbots appear as an innovative, adaptive, and necessary solution. Combining the BANI model with CLA analysis demonstrates that these systems are not only functional but also symbolically significant – becoming essential links in the transition towards a more flexible and humanized education.

Looking ahead, it would be valuable to pilot the integration of educational chatbots in authentic educational settings, with an emphasis on gradual implementation and careful monitoring of their effects on teaching and learning processes. Equally important is ensuring that educators receive targeted training – not only on the technical operation of such systems, but also on how to harness their pedagogical potential. Any such initiative must also address the ethical challenges raised by AI in education, from algorithmic transparency to data protection and equitable access.

Special emphasis will be placed on the

professional development of academic staff, who must be trained not only in the technical use of chatbots, but also in understanding their pedagogical potential, as well as their limitations in the context of students' cognitive and socio-emotional development.

In parallel, it is essential to establish a rigorous framework for the ethical and critical evaluation of the application of artificial intelligence in education, which considers aspects such as algorithmic transparency, equity in access, data protection, and the risk of excessive delegation of educational authority to automated systems.

At a later stage, the development of proprietary conversational platforms is envisaged, built on authentic institutional content (textbooks, regulations, course outlines), adapted to the specifics of each educational institution, to ensure a coherent, relevant, and contextualized educational experience. It should be emphasized that the technological architecture presented in this paper is deliberately theoretical and conceptual, proposed as a reference model for validating a symbolic and functional perspective on the use of chatbots in education.

To validate the architecture presented here, the logical next step would be to implement it within actual educational institutions. Through a combination of qualitative and quantitative methods, we could then assess its effectiveness, adaptability, and genuine impact on both learning processes and the broader organizational culture.

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