

Integration of intelligent chatbots in mathematics education at the undergraduate level in Morocco: Impact on learning difficulties and academic success

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Abstract

This study investigates the integration of intelligent chatbots in mathematics education at the undergraduate level in Morocco and their impact on students' learning difficulties, motivation, and academic performance. In the context of the Moroccan educational system's digital transformation, accelerated by the COVID-19 pandemic and guided by the Strategic Vision 2015–2030, artificial intelligence tools have become increasingly relevant in higher education.

A quasi-experimental mixed-methods design is adopted, comparing an experimental group using an educational chatbot with a control group receiving traditional instruction. Data are collected through pre-tests, post-tests, academic performance indicators, questionnaires, interviews, and classroom observations. Quantitative and qualitative analyses are used to evaluate the effectiveness of chatbot-based learning support.

The study hypothesizes that chatbot integration improves academic performance, reduces conceptual difficulties, and enhances student motivation. Beyond academic outcomes, the research also addresses pedagogical, technological, and ethical considerations related to AI adoption in higher education. The findings aim to contribute to the development of more adaptive, inclusive, and learner-centered teaching models in Moroccan universities.

Keywords: Intelligent chatbots; Educational artificial intelligence (AI); Mathematics teaching; Higher education in Morocco; Learning difficulties; Academic success; Learning personalization; Digital transformation; Quasi-experimental approach; Student motivation; Immediate feedback; Heterogeneous classes; Adaptive learning

1. Introduction

Over the past ten years, Moroccan education has undergone profound structural transformations and significant developments across pedagogical, technological, and digital dimensions. These changes stem from a major project led by the Higher Council for Education, Training, and Scientific Research (CSEFRS), particularly the Strategic Vision 2015–2030, which is based on three main pillars: **equity and equal opportunity, quality for all, and the promotion of the individual and society**. These consultations involved the various stakeholders of the education system, including learners, administrators, and experts.

In this regard, the Council has proposed a set of reform measures targeting educational stakeholders in their diversity, curricula and training programs, governance of the education system, as well as the improvement of scientific and technical research and innovation.

Furthermore, since the COVID-19 pandemic, the implementation of the strategic vision has undergone a transition in teaching modalities, shifting from traditional face-to-face instruction to distance learning. This shift required both

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teachers and learners to adapt to different educational systems, regardless of the channel used (radio, television, mobile phones, online platforms, etc.). It was during this period that teachers encountered significant challenges in monitoring learners, particularly given large class sizes often exceeding 100 students, as well as the diversity of cognitive development within heterogeneous groups, which require well-structured and carefully planned support, especially in core subjects such as mathematics and languages.

In line with these changes, the Council is working on detailed recommendations addressing major issues related to digital transition and the renewal of pedagogical models, both in primary and secondary education and in higher education.

Within this context, my thesis entitled *“Integration of Intelligent Chatbots in the Teaching of Mathematics at the Undergraduate Level in Morocco: Impact on Learning Difficulties and Academic Achievement”* is situated. It aims to address several key requirements in the field of education by answering the following main research question: What is the impact of intelligent chatbots on the learning of mathematics at the undergraduate level?

2. Research Context

The emergence of conversational artificial intelligence (chatbots) represents a major transformation in the field of education. Chatbots can be integrated into educational platforms or applications, interacting either in written or spoken form. They are characterized by immediacy, providing instant responses that also facilitate communication between students and teachers. Chatbots offer the possibility of personalizing educational content and adjusting the level of difficulty according to each learner's performance. Their permanent availability thus provides an effective response to the challenge of individualized support in heterogeneous classrooms, particularly when teachers have limited resources.

The literature shows that chatbots can strengthen key factors of academic success, particularly learners' interest and motivation. By fostering an interactive and stimulating learning environment, they indirectly contribute to improving performance while reducing teachers' workload. Furthermore, empirical studies confirm their direct impact on learning: the use of chatbots has led to better knowledge acquisition, such as vocabulary learning, as well as significant improvement in results when personalized feedback is provided to learners.

Applied to the teaching of mathematics at the first-year university level, these findings suggest that chatbots can play an important role in supporting students. For example, they can provide explanations adapted to each learner's level, offer progressive exercises, and deliver immediate feedback. This is particularly relevant in a context where students often face conceptual difficulties and where classrooms are heterogeneous. Thus, chatbots appear to be a promising tool for improving the understanding of mathematical concepts, enhancing student engagement, and promoting academic success.

3. Research Problem

Morocco is firmly committed to the era of artificial intelligence, which is considered a lever for its economic and social development. By integrating AI-based solutions into key sectors such as agriculture, health, education, and infrastructure, the Kingdom is laying the foundations for an ambitious digital transformation. However, this vast potential comes with major challenges, including talent training, infrastructure improvement, and the establishment of an appropriate regulatory framework. Through strategic partnerships and a forward-looking vision, Morocco is actively advancing in this field. Indeed, several initiatives and projects demonstrate the country's commitment to AI, such as agricultural yield optimization, medical diagnosis, and smart cities.

In the education sector, the Kingdom aims to develop personalized digital platforms based on machine learning. However, this approach does not always meet the requirements for acquiring the skills and competencies targeted by the school curriculum, especially since it is not formally regulated. Despite the pedagogical efforts made in Moroccan higher education, first-cycle university students still face significant difficulties in mathematics, particularly in terms of conceptual understanding and problem-solving.

With the emergence of intelligent chatbots, a fundamental question arises:

- To what extent can the integration of intelligent chatbots contribute to reducing learning difficulties in mathematics and improving the academic success of university students in Morocco?

To address this question, this research is based on three complementary hypotheses:

- First, Hypothesis 1 assumes that the integration of chatbots significantly improves students' performance in mathematics by providing personalized and continuous support.
- Second, Hypothesis 2 suggests that these tools help reduce conceptual difficulties by offering adapted explanations and immediate feedback.
- Finally, Hypothesis 3 postulates that the use of chatbots enhances students' motivation by making learning more interactive and engaging.

Thus, these hypotheses make it possible to operationalize the research problem by examining the cognitive, pedagogical, and motivational effects of chatbots on mathematics learning.

4. Research Methodology

The integration of artificial intelligence into the Moroccan education system remains limited. To address this issue, we analyzed the main policy and regulatory texts governing education in Morocco, as well as national and international studies. These sources include, in particular, the Strategic Vision 2015–2030, reports from the INE and UNESCO, as well as specialized academic journals. Building on research in generative AI, considered as a learning support tool, a mixed-methods approach was adopted, combining both quantitative and qualitative methods. This choice is justified by the nature of the research topic, which aims simultaneously to measure objective outcomes related to students' academic performance while also exploring their perceptions, attitudes, and behaviors toward the use of artificial intelligence technologies in their learning process.

The research follows a quasi-experimental design with a descriptive and explanatory aim. It is based on a comparison between two groups of students: an experimental group benefiting from the integration of an educational chatbot in their mathematics learning, and a control group following traditional instruction without the use of this tool. This structure makes it possible to evaluate the actual impact of the technological intervention on learning difficulties and academic achievement.

The target population of this study consists of first-year university students enrolled in scientific and economic programs at Moroccan universities, particularly public institutions. The selected sample includes between 60 and 120 students, evenly distributed between the two groups, in order to ensure sufficient statistical validity and better representativeness of the results.

The experimental design relies on the integration of an intelligent chatbot, based either on generative artificial intelligence or a specialized educational system in mathematics. This tool is designed to provide detailed explanations of concepts, offer step-by-step solutions to exercises, deliver immediate feedback, and adapt to each student's level. The chatbot is integrated into various teaching activities, including tutorials, homework assignments, and self-learning phases. The experiment spans a period of six to twelve weeks, allowing significant effects on learning to be observed.

Data collection is carried out using various instruments. Quantitative data include pre-tests and post-tests, exam scores, success rates, and exercise completion times. In parallel, qualitative data are collected through questionnaires assessing student motivation and perceptions, semi-structured interviews, and classroom observations.

The research variables are defined to structure data analysis, which relies on descriptive statistics for quantitative data and coding procedures for qualitative data. The independent variable corresponds to the use of the chatbot, while the dependent variables include mathematics learning difficulties, academic performance, and students' motivation level.

To ensure the scientific rigor of the study, particular attention is paid to the validity and reliability of the instruments used. Internal validity is strengthened through the presence of a control group, while external validity is ensured by the diversity of the sample. The reliability of the questionnaires is assessed using statistical indicators such as Cronbach's alpha coefficient.

Furthermore, ethical considerations are integrated throughout the research process. Participants are informed about the objectives of the study, and their consent is obtained beforehand. Anonymity and data confidentiality are guaranteed, and responsible use of artificial intelligence tools is ensured.

Finally, several potential limitations of the research are identified, including constraints related to access to technology, disparities in students' digital skills, and the risk of excessive dependence on the chatbot. These elements will be taken into account when interpreting the results.

The research process follows a structured timeline, beginning with a literature review, followed by the design of the experimental framework, the experimentation phase, data analysis, and finally the writing of the research report. Particular attention is given to contextualizing the study within the Moroccan setting, especially regarding the languages of instruction (French and English) and the specific difficulties faced by students in mathematics, such as abstraction and formal reasoning.

5. Conclusion

In conclusion, this research is part of a broader dynamic of profound transformation within the Moroccan education system, characterized by the gradual integration of digital technologies and artificial intelligence. Faced with persistent challenges related to learning difficulties in mathematics at the undergraduate level, the introduction of intelligent chatbots appears to be an innovative and promising approach for renewing pedagogical practices.

Through a rigorous methodological approach, combining quantitative and qualitative analysis within a quasi-experimental framework, this study aims to objectively and contextually assess the impact of these tools on students' understanding of concepts, academic performance, and motivation. It highlights the potential of chatbots to provide personalized, continuous, and adaptive support, addressing the specific needs of a heterogeneous student population.

Beyond its empirical contributions, this work also aims to contribute to the reflection on the evolution of pedagogical models in Moroccan higher education, by integrating the opportunities offered by artificial intelligence while taking into account its limitations and ethical challenges. Ultimately, it seeks to explore to what extent these technologies can serve as an effective lever to improve the quality of learning, enhance academic success, and support the transition toward a more innovative, inclusive, and learner-centered education system.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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