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Artificial intelligence at the service of educational inclusion: AI-assisted pedagogical remediation (AAPR), a tool to reduce disparities in education.

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Abstract

Technological advancements offer significant advantages in terms of accessibility and efficiency in contemporary education. However, their integration raises pedagogical and technical challenges that must be addressed to ensure inclusive teaching tailored to the individualized needs of learners. Artificial intelligence (AI) is emerging as a promising solution for educational remediation, aiming to reduce disparities and promote the development of learners' skills.

This study analyzes the remote pedagogical remediation practices of secondary school teachers and proposes an AI-assisted pedagogical remediation solution (AAPR), including the preparation of digital diagnostic tests and the organization of personalized support sessions. A quantitative survey conducted among 80 teachers from the Rabat-Salé-Kénitra regional academy allowed for data collection via an online questionnaire, distributed on teachers' professional communication platforms (Google Forms, WhatsApp, Facebook). The results highlight a lack of suitable

tools to accurately diagnose learning gaps at a distance, as well as an underutilization of ICT in personalized remediation. Faced with these observations, the study proposes the development of an AI-based web application designed to identify the individual needs of learners and facilitate the implementation of targeted remote support sessions.

This research highlights the importance of integrating AI into educational remediation to improve accessibility and teaching effectiveness, thereby contributing to educational inclusion and reducing disparities in the educational field, while addressing the diverse and specific needs of teachers and learners.

Keywords: Artificial intelligence (AI), learning gaps, ICT, AI-assisted pedagogical remediation (AAPR).

1. Introduction

In the modern educational system, a dual challenge arises: providing effective educational services to learners while optimizing the use of available resources and improving administrative management. Technological advancements play a key role in addressing these challenges.

Indeed, the integration of information and communication technologies (ICT) in education offers numerous advantages, particularly in terms of accessibility and efficiency, and can make a real contribution to the individualization of teaching provided they are used wisely and appropriately. Poyet, F., & Drechsler, M. (2009). However, it also raises significant challenges. The incorporation of technology into the educational system raises various challenges, whether pedagogical or technical, aimed at ensuring inclusive, effective, and tailored education to meet the individual needs of learners.

Online learning represents a promising avenue for addressing these challenges. The implementation of a learning management module allows for a detailed analysis of learner-related data. This allows for the identification of their learning gaps, which manifest as discrepancies or deficiencies in the knowledge, skills, or know-how expected at a given stage of their educational journey. These gaps often result from difficulties in assimilation or inappropriate teaching. The module can then offer personalized pedagogical strategies to effectively address them. Such a solution offers a comprehensive and continuous view of learners' progress, thereby promoting individualized monitoring tailored to their specific needs.

Thanks to these tracking tools, teachers and institutions could better evaluate learners' outcomes, identify their specific needs, and adjust their learning paths accordingly. This approach would contribute to improving the efficiency of the educational system while optimizing the use of available resources.

In this context, the integration of AI in educational remediation can reduce disparities in teaching and promote the development of learners' skills. UNESCO's recommendations emphasize the need to define a systemic vision for artificial intelligence (AI) policies in education, ensuring an inclusive and equitable use of AI. They encourage the optimization of AI to enrich education, the development of essential skills in the face of AI, as well as education on its

functioning and implications. Moreover, they advocate for transparent management of educational data and a focus on the learner to improve learning and assessment. UNESCO. (2021).

Educational remediation, whether conducted in person or remotely, aims to identify and address learners' learning gaps to ensure their academic progress. However, in a remote teaching context, this approach faces challenges amplified by the diversity of profiles and the heterogeneity of learners. These factors complicate the diagnosis of individual difficulties, making differentiated support and the use of adapted tools necessary to meet the specific needs of each learner. In this context, educational accessibility and inclusion emerge as major priorities. They aim to ensure access to quality educational resources and to personalize equitable learning paths thru adaptive technologies and targeted support systems. Thus, the objective is twofold: to reduce inequalities and integrate solutions tailored to learners with specific needs, contributing to the construction of an inclusive educational system where everyone can succeed, regardless of their particularities or the constraints of their learning environment.

Artificial intelligence (AI) plays a key role in this transformation by redefining educational practices thru personalized learning, targeted remediation, and task automation. This technological revolution raises a central question: how to reconcile pedagogical innovation with educational equity? More precisely, to what extent does AI succeed in adapting teaching to individual needs, effectively addressing learners' gaps, and optimizing teachers' work, while also meeting the challenges related to preserving the human dimension, accessibility of tools, and training of educational stakeholders? The challenge is to transform the disruptive potential of AI into a sustainable lever for education that is both inclusive, effective, and attentive to contemporary social issues.

In this perspective, the objective of this study is to examine the remote pedagogical remediation practices of secondary school teachers and to propose an artificial intelligence-assisted solution (AAPR). This approach seeks to increase the effectiveness of online learning by developing digital diagnostic tests, detecting potential learning gaps, and organizing tailored educational support sessions. By combining needs analysis and intelligent technologies, this solution aims to optimize remediation while adhering to a framework of equity and educational inclusion.

2. Theoretical framework

2.1. ICT: Tools for Educational Inclusion and Reducing Disparities in Education.

2.1. 1. Definitions

The concept of information and communication technology (ICT) is characterized by a plurality of definitions. Some are focused on the tools used, while others concentrate on the activities that these tools facilitate, or encompass both aspects. Moreover, some definitions even include the users of these technologies. According to UNESCO (2009), ICTs are defined as "a set of tools and technological resources that allow for the transmission, recording, creation, sharing, or exchange of information," encompassing various devices such as computers, the internet (including websites, blogs, and emails), as well as broadcast technologies (radio, television, live and delayed streaming) and telephony (landline,

mobile, satellite, videoconferencing, etc.) (UNESCO, 2009). For its part, the Grand terminological dictionary of the Office québécois de la langue française (OQLF) describes ICT as "a set of technologies resulting from the convergence of computer science and advanced multimedia and telecommunications techniques," highlighting their role in the emergence of more efficient means of communication, by improving the processing, storage, dissemination, and exchange of information (OQLF, 2008).

2.1.2. ICT at the Service of Education

Information and Communication Technologies for Education (ICTE) represent a set of tools and digital means integrated into the educational process, aiming to add value to the quality of teaching (Pedagogical Guide for the Integration of ICTE, 2014). These technologies include computers, tablets, educational software, mobile applications, communication networks, videoconferencing devices, and online learning platforms. ICTs are used in various educational activities, such as research, collaboration, distance learning, online training, educational content creation, assessment, and teaching management. They exert a notable influence on pedagogical practices and are considered essential tools for addressing the challenges of digital education.

The integration of ICT in education is based on several references. The National Charter for Education and Training emphasizes the importance of generalizing technological multimedia to ensure equal opportunities in accessing information and networks, thereby helping to solve the schooling problems of targeted populations in remote areas thru distance learning (The National Charter for Education and Training, 1999). The "GENIE" project (Generation of Information and Communication Technology in Schools) was launched with the aim of preparing for the mastery of recent technologies and meeting the challenge of human capital training (The National Charter for Education and Training, 1999). Moreover, the Strategic Vision 2015-2030, thru Project 21, aims to integrate ICT into schools in order to actively participate in the knowledge economy and the new knowledge society (The Strategic Vision 2015-2030). Specific objectives include the complete equipping of schools with ICT, their integration at all levels of management, the strengthening of their use to improve the quality of learning, the development of distance education, and raising awareness of their role in educational reform (The Strategic Vision 2015-2030).

2.1.3. ICT and the reduction of educational inequalities

The relationship between information and communication technologies (ICT) and educational inequalities is complex. An important observation reveals that simply distributing computer equipment is not enough to address these inequalities. According to UNESCO (2023), ICT for education (ICTE) offers significant potential to overcome physical barriers to learning and improve academic outcomes. However, their effectiveness largely depends on the modalities of their deployment and the conditions of their implementation. Although ICTs can optimize learning, the most disadvantaged learners benefit less from them due to insufficient access or inadequate support. Thus, UNESCO

advocates ensuring universal access to educational technologies and adapting content to local needs, with particular priority given to marginalized learners.

ICTs facilitate access to education for disadvantaged populations, particularly thru online learning programs. Vrasidas, Zembylas, and Glass (2009) emphasize that these technologies allow reaching individuals and communities often excluded from traditional educational institutions. Furthermore, they help raise awareness about development issues and the importance of education thru tools such as blogs, wikis, and social networks. ICT can also create innovative learning environments, such as 3D virtual worlds, where learners and teachers can actively engage in social justice initiatives. However, Selwyn (2015) cautions against excessive optimism regarding the impact of ICT. He argues that in the absence of a critical analysis of access conditions, such as infrastructure and digital skills, ICTs risk exacerbating inequalities rather than reducing them. Inclusion is not automatically guarantyd by the implementation of educational technologies, and it is crucial to pay particular attention to marginalized groups in discussions about digital education. In parallel, it is essential to recognize that ICT can play a significant role in the individualization of teaching. Poyet and Drechsler (2009) assert that these technologies, when used relevantly, offer positive potential for both teachers and parents. The impact is particularly notable for students with good academic performance, but ICT also constitutes a valuable resource for those in difficulty, thus promoting a personalized approach to learning.

Finally, Zheng et al. (2016) emphasize that programs integrating tailored technical and pedagogical support, specifically designed to meet the needs of disadvantaged learners, are more likely to reduce learning gaps. These initiatives, when well-targeted, often lead to significant improvements in academic outcomes and strengthen the bonds between teachers, learners, and families.
In summary, to reduce educational inequalities thru ICT, it is imperative to adopt an integrated and critical approach that takes into account not only access to technologies but also the necessary pedagogical support to ensure that all students can fully benefit from them.

2.2. Educational AI: Personalization and Ethical Foundations

Artificial intelligence (AI) is beginning to exemplify new teaching and learning methods, showing potential for personalizing learning thru intelligent, personalized, and conversational educational systems that provide grades, evaluations, feedback, and hints, or that adapt users for collaborative learning, with the aim of supporting stakeholders and putting them in control of the learning process (Khosravi et al., 2022). AI plays an important and growing role in education, with personalized teaching systems already well established and increasing evidence of their effectiveness in improving learning (Khosravi et al., 2022). However, ethics form the indispensable foundation for the integration of AI in education, guided by principles of equity, transparency, and respect for human rights, in accordance with the Sustainable Development Goals (SDGs) that remind us of the imperative of inclusive education and require increased vigilance against algorithmic biases and inequalities in access (UNESCO, 2021; Holmes et al., 2019). An ethical AI

involves a participatory design that integrates the perspectives of marginalized communities to avoid reproducing structural discrimination (Salas-Pilco et al., 2022).

2.2.1. AI in the service of equity and educational inclusion

Artificial intelligence is positioned as a catalyst for equity in education thanks to its ability to personalize learning and optimize resources. Intelligent tutoring systems (ITS), such as CENTURY Tech, illustrate this dynamic: drawing on pedagogical and neuroscientific models, they adjust content and provide individualized feedback, reducing achievement gaps between privileged and disadvantaged students (Luckin & Cukurova, 2019). At the same time, educational management information systems (EMIS) target the needs of marginalized areas, identifying students at risk of dropping out for a more equitable allocation of resources (UNESCO, 2021). These technologies, combined with interdisciplinary partnerships (EDUCATE program), enhance access to quality education, notably thru MOOCs and open educational resources (OER) adapted to local contexts thanks to translation algorithms or the integration of minority languages (Bulathwela et al., 2024; Salas-Pilco et al., 2022). Initiatives like DebateMate amplify this impact by automating the selection of tutors thru psychometric data analysis, thereby expanding access to key skills in disadvantaged schools (Luckin & Cukurova, 2019).

However, AI comes with inherent risks. Algorithmic biases, fueled by data reflecting structural inequalities, perpetuate gender or socioeconomic stereotypes, as evidenced by voice recognition tools ill-suited to local dialects (UNESCO, 2021). Moreover, technologies designed in privileged contexts, such as high-end ITS, exacerbate the digital divide in regions lacking infrastructure, while the dominance of tech giants threatens the diversity of educational solutions (Bulathwela et al., 2024; Luckin & Cukurova, 2019).

Despite these challenges, AI remains a powerful tool for reducing disparities. By automating administrative tasks (e.g., automated grading), it frees up teachers' time for targeted support of vulnerable students, while predictive tools identify early risks of dropout (UNESCO, 2021; Salas-Pilco et al., 2022). Projects like Wikipedia, used as universal taxonomies, illustrate how AI can unify knowledge while integrating local perspectives, thereby mitigating educational asymmetries (Bulathwela et al., 2024). Thus, while AI requires increased vigilance against its excesses, its potential lies in a balanced articulation between technological innovation, social justice, and ethical regulation.

2.2.2. Pillars for an inclusive and humanizing AI

To develop truly inclusive and humanizing artificial intelligence (AI), four pillars are essential: open educational resources (OER), multilingual and adaptable, allow developing countries to bridge educational gaps (Bulathwela et al. 2024). Balanced collaborations between educators, researchers, and developers ensure that AI is grounded in pedagogical realities (Luckin & Cukurova, 2019); algorithmic transparency, with explainable and auditable models,

avoids biases and enhances trust (UNESCO, 2021); and ethical governance, with policies framing equitable access and promoting AI as a public good (Salas-Pilco et al., 2022). Moreover, an inclusive AI integrates principles of social justice, involving the culturally sensitive personalization of intelligent tutoring systems (ITS) to the linguistic and historical contexts of learners (Salas-Pilco et al., 2022), the integration of education on AI issues into curricula to empower future citizens (UNESCO, 2021), and the development of low-tech solutions that work offline for poorly connected areas (Bulathwela et al., 2024). These pillars, combined with a culturally sensitive and inclusive approach, outline the contours of a humanizing AI, capable of reconciling technical innovation and social equity.
Artificial intelligence (AI) presents unprecedented opportunities to promote educational inclusion. However, its success depends on a holistic approach that combines technical innovation with social justice. The challenges posed by AI, such as unequal access, algorithmic biases, and technological dependence, require bold political responses and global collaborations. Only an AI designed ethically, with and for marginalized communities, will be able to fulfilll its promise of equitable education, tailored to the richness of human diversity. Such AI must be transparent, accountable, and mindful of human rights in order to overcome challenges and fulfilll its commitments to inclusion and equity in education.

2.3. Artificial intelligence: a tool to improve educational remediation

2.3.1. Personalization of learning and identification of gaps

Artificial intelligence (AI) is revolutionizing educational remediation by analyzing massive amounts of data to identify learning gaps and adapt educational pathways. Intelligent tutoring systems (ITS), as illustrated by CENTURY Tech, use learner models to adjust educational content in real-time, particularly in structured subjects (mathematics, sciences) (Luckin & Cukurova, 2019). These systems combine predictive analytics, such as the Open University's (OU Analysis) project, which detects students at risk of failure and allows for proactive interventions (Chen et al. 2020).
Adaptive learning, supported by intelligent virtual environments, reinforces this approach by dynamically adjusting educational activities according to individual needs. Open learner models (OLMs) promote metacognition by making skills and gaps visible, allowing students to self-regulate their strategies (Khosravi et al. 2022). Furthermore, neural networks and natural language processing (NLP) optimize the detection of learning styles and affective states, although their full potential still requires a stronger integration of pedagogical theories (Chen et al. 2020).

2.3.2. Support for teachers and management of systemic educational challenges

AI reduces the administrative burden on teachers by automating routine tasks (assessments, reports) and generating precise diagnoses of classroom needs. Systems like "FUMA" identify ineffective learning behaviors in MOOCs and offer contextualized advice, thereby reducing achievement gaps (Khosravi et al. 2022). Explainable AI (XAI) plays a key role by providing actionable diagnostic feedback, such as resource recommendations or personalized explanations of students' errors, facilitating targeted remediation (Khosravi et al. 2022).

However, systemic challenges persist, notably the widening gaps between high-achieving students and those struggling. As Davis (2020) points out, unresolved gaps gradually worsen, compromising educational equity. A systemic approach, integrating ICT and relying on scrutinizable models, is essential for guiding educational objectives and evaluating the effectiveness of interventions (OUAGAGUE & EL FECH, 2024). The work of Luckin and Cukurova (2019) emphasizes the importance of grounding these technologies in learning sciences to maximize their impact.

AI offers promising solutions for educational remediation thanks to its ability to personalize learning, support teachers, and address structural challenges. However, its effectiveness depends on a harmonious integration between technological innovations, educational theories, and pedagogical practices. Future research will need to fill theoretical gaps, particularly in the application of NLP, and enhance the transparency of models to ensure an inclusive and equitable education.

3. Empirical Framework

3.1. Research Methodology

The methodology of this research revolves around three complementary stages: a literature review, a quantitative survey by questionnaire, and the design of a computer solution, aimed at exploring and optimizing pedagogical remediation practices in the context of e-learning.

The literature review forms the theoretical and practical basis of the study. By synthesizing and critically evaluating previous works, it systematizes the conceptual foundations, clarifies the formulation of objectives, and identifies key notions related to e-learning. She highlights contemporary issues, such as the digital transformation of education, the role of artificial intelligence (AI) in personalizing learning and educational inclusion, while emphasizing the goal of reducing disparities in education. Thus, it justifies the relevance of the research, guides the choice of methods – whether proven or innovative – and positions the study as a contribution to the advancement of knowledge and the resolution of societal challenges.

The quantitative survey is based on a structured questionnaire administered to a sample of 80 secondary school teachers of life and earth sciences (SVT) from the Regional Academy of Rabat-Salé-Kénitra. Disseminated via Google Forms in closed groups on WhatsApp and Facebook, this tool aims to analyze pedagogical practices related to diagnosing learning gaps and remote remediation integrating information and communication technologies for education (ICTE). The collected data focuses on three main areas: the strategies used to identify learners' difficulties during remote support sessions, the obstacles encountered in their implementation, and the use of specific digital tools. Exported in Excel format for analysis, these responses provide empirical insight into the interaction between digital skills, remediation methods, and operational challenges, in an educational context marked by the transition to hybrid

modalities.

Finally, based on the results of this exploratory study, a computer solution was developed to meet the identified needs in terms of pedagogical remediation in e-learning. This system aims to optimize the management and analysis of learning processes by focusing on four functional areas : centralization of educational activities to standardize operations, improved learner tracking thru precise indicators, automation of educational resource planning for efficient allocation, and standardized assessment of achievements using objective criteria. Integrating statistics and visual reports, this solution supports administrators' decisions while offering an intuitive interface for an optimized user experience. By combining technological innovation and methodological rigor, it aims to reconcile operational efficiency, personalized learning paths, and adaptability to contextual constraints, thereby contributing to the continuous improvement of digital pedagogical practices.

This methodology thus combines a theoretical, empirical, and applied approach to address the challenges of remote educational remediation, while maintaining a perspective of efficiency and educational inclusion.

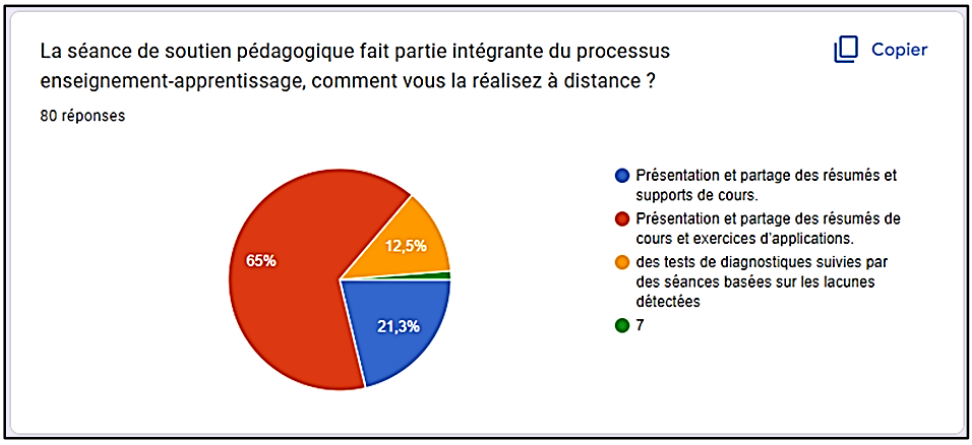
3.2. Analysis and discussion of the results

The sample for this study, primarily qualitative in nature, consists of 80 teachers of life and earth sciences (SVT), representing the provincial directorates of Salé, Kénitra, and Sidi Slimane. The gender distribution is relatively balanced, with 47.5% women and 52.5% men.

- Modalities for conducting remote educational support sessions

Figure 1: Modalities for conducting remote educational support sessions

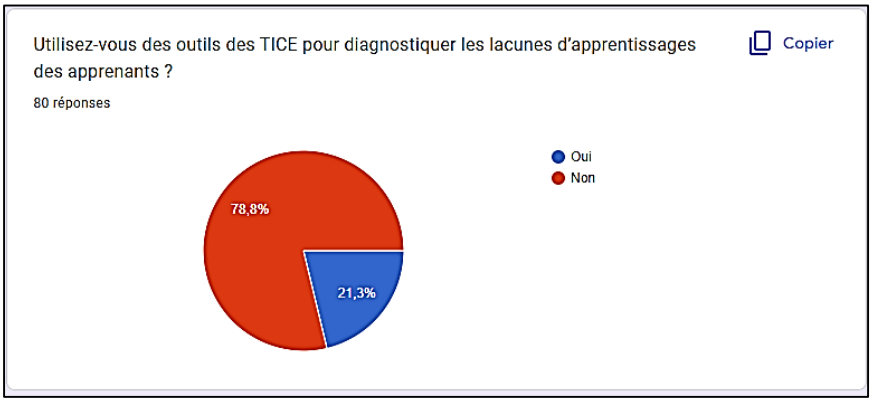
Source 1: Authors



The study identifies three distinct strategies for remote educational support: a dominant transmissive approach (65%, focused on course materials), an integrative method (21.3%, combining theory and practice), and a minority but more efficient diagnostic approach (12.5%, based on personalization). The persistence of alternative practices (7 cases) and the predominance of traditional methods highlight both the necessity and the potential for the development of differentiated approaches, particularly thru adapted digital tools and targeted training.

- Use of ICT for diagnosing learning gaps

Figure 2: Use of ICT for the diagnosis of learning gaps

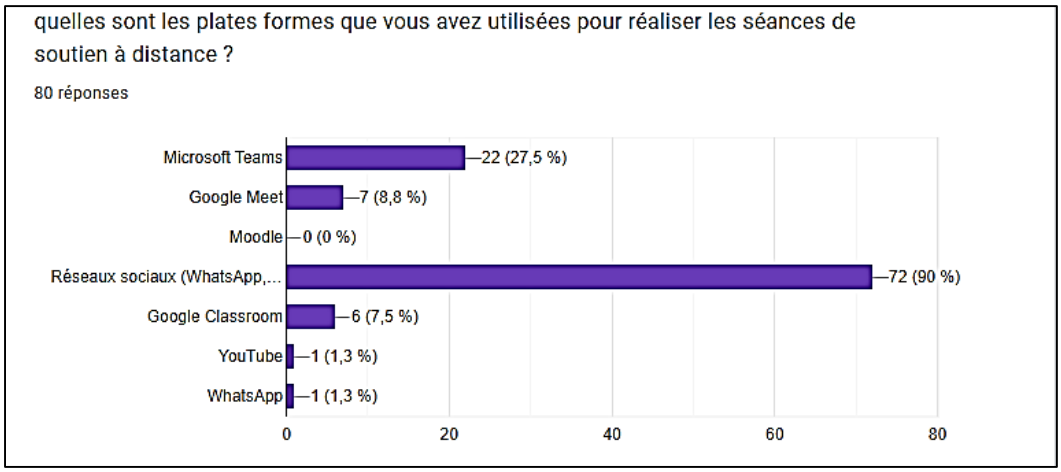


Source 2: Authors

An overwhelming majority of 78.8% of participants declare not using ICT for this purpose, while only 21.3% use them. This low adoption suggests the existence of significant obstacles to the integration of these technologies into diagnostic evaluation practices.

- Platforms used for remote academic support

Figure 3: Platforms used for remote academic support



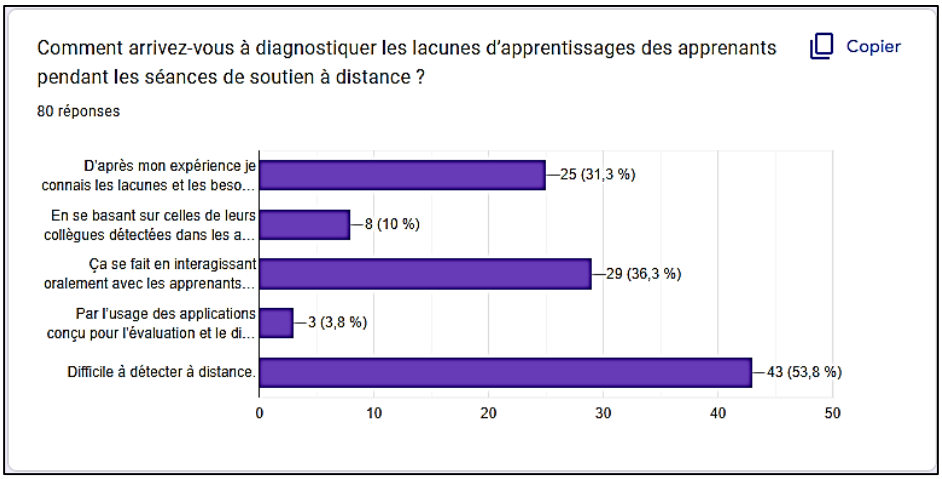
Source 3: Authors

The survey reveals a marked fragmentation in the use of digital educational tools, with a predominance of institutional ecosystems (Microsoft Teams: 27.5%; Google Meet: 8.8%) and a marginalization of specialized platforms (Moodle

absent, YouTube/WhatsApp: 1.3%). This polarization between concentration on a few major solutions and diversification of practices (90% of alternatives) underscores the need for an integrated framework better suited to the demands of distance learning.

- Diagnosis of remote learning gaps

Figure 4: Diagnosis of learning gaps at a distance

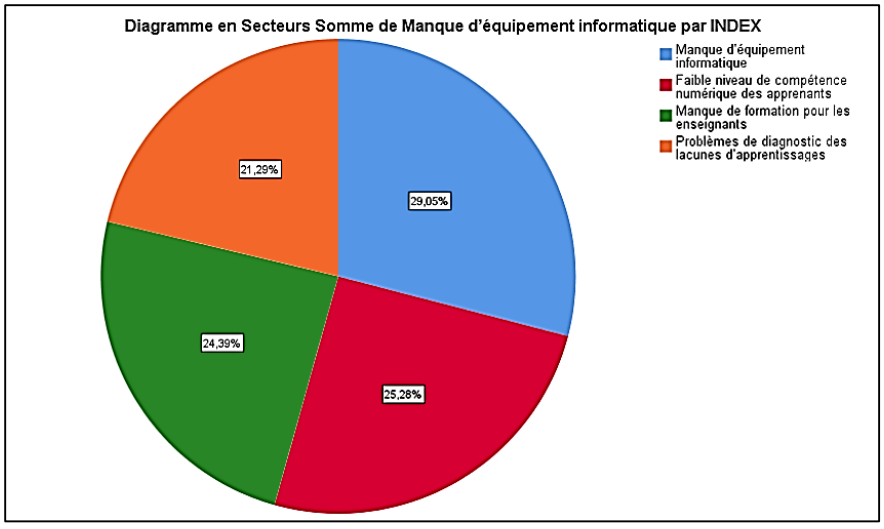


Source 4: Authors

The study reveals a predominance of informal methods for diagnosing learning gaps in a remote context, with 36.3% of teachers resorting to oral interaction and 31.3% relying on their personal experience. Conversely, collaborative (10%) and digital tools (3.8%) remain marginal. The difficulty perceived by 53.8% of respondents in identifying gaps remotely underscores the urgency of integrating specialized technological tools and developing structured collaborative practices, combining traditional approaches with pedagogical innovations.

Obstacles to digital teaching

Figure 5: Obstacles to digital teaching

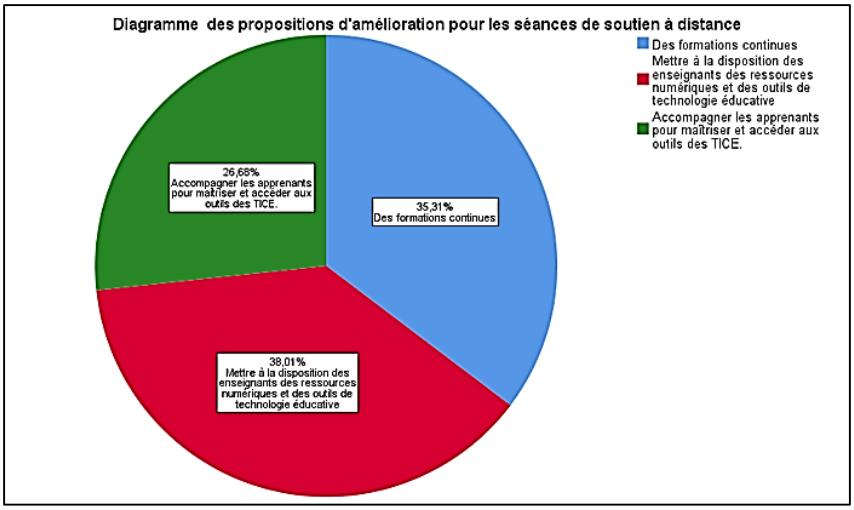


Source 5: Authors

The analysis reveals four major and balanced challenges (21.23%-29.05%) in digital education : limited learner skills (29.05%), diagnostic difficulties (25.62%), insufficient teacher training (24.63%), and inadequate equipment (21.23%). This homogeneous distribution (maximum difference of 7.82 points) underscores the systemic nature of the obstacles, requiring an integrated approach combining digital skills development, pedagogical innovation, infrastructure strengthening, and improvement of assessment tools. The study highlights that educational digital transformation requires a synchronized, multidimensional intervention, going beyond the mere technological dimension to encompass the entire pedagogical ecosystem.

- Perspectives for improving remote support sessions

Figure 6 : Perspectives for improving remote support sessions



Source 6 : Authors

The study identifies three complementary priorities to improve remote support: access to digital resources (38.01%), continuous teacher training (35.31%), and learner support (26.68%). These results highlight the need for a systemic approach that simultaneously integrates technological tools, professional development, and student empowerment. The balanced distribution of expectations (maximum difference of 11.33 points) suggests that only a multidimensional intervention, tailored to specific contexts, will enable an effective transformation of remote support practices.

3.3. The Odoo platform for diagnosing learning gaps

3.3.1. Introduction to Odoo

Odoo is an open-source ERP information system that allows companies to manage various aspects of their business. It operates on a modular platform, with each functionality divided into modules that can be activated or deactivated according to the company's needs. These modules can be configured to adapt to the specific processes of the company and allow for better process automation. Moreover, Odoo is customizable, which means that businesses or other users can add additional features based on their needs. Finally, Odoo offers a simple and intuitive user interface, making it easy for users to navigate the system.

3.3.2. The Odoo E-Learning Application

The Odoo e-learning application is an integrated application that allows businesses and educational institutions to create and manage online courses. Users can create courses and lessons, share content with their learners and colleagues, and learners can take online courses while evaluating their progress thru tests and exams.
This application can be used in various ways to support learning:
- The creation of online educational resources (presentations, documents, videos, quizzes, etc.) to complement learning.
- The dissemination of online courses that learners can follow at their own pace - Monitoring learners' progress (results, assignments, projects) and providing personalized feedback.
- Communication between teachers and learners to strengthen their relationship and create a more interactive learning environment.
Odoo's e-learning application is a versatile tool that can be used in various ways to support learning and enhance the learning experience for students.

3.3.3. Functional structure and technical architecture of Odoo

Odoo relies on a modular architecture that facilitates the addition or removal of features thru distinct modules. Each module is presented in the form of an organized directory, integrating Python code as well as XML files that define the data structure, forms, menus, reports, and management interfaces.
On the technical side, the platform primarily relies on three essential components:
- The PostgreSQL database server, which ensures data management thru an ORM (Object-Relational Mapping) layer allowing for the persistence of business objects.
- The application server, which hosts the business logic, the workflow management engine, as well as the report generation tools.
- The presentation server, offering an interface accessible to users thru any modern web browser (such as Google Chrome or Firefox), thus ensuring flexible and multi-platform use.
This modular and technical architecture gives Odoo great adaptability and facilitates its integration into various professional environments.

3.3.4. Configuration of an Odoo module

An Odoo module integrates several essential components such as objects, views, reports, wizards, and workflows. A module can notably include:
Objects: These correspond to Python classes defining business data, whose management and persistence are ensured by Odoo's ORM system.

Views: They allow users to visualize and interact with objects, by configuring the display of data in various forms, including form, kanban, list (tree), graph, and calendar views.

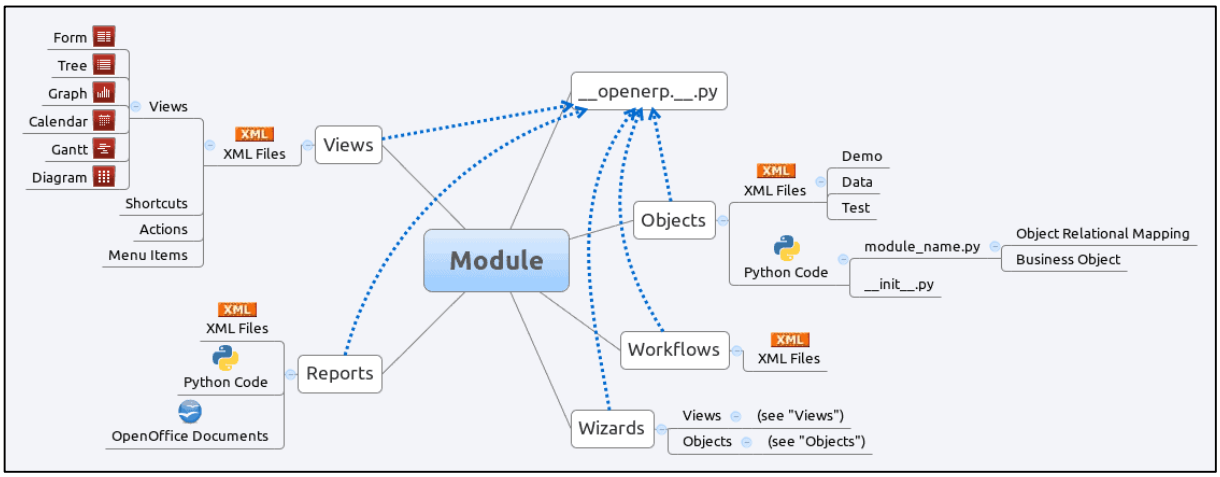
XML files: These files contain the configuration parameters and metadata necessary to initialize or update the database during module installation or update.

Reports: Generated in PDF or HTML formats, the reports leverage QWeb, Odoo's templating engine, which offers dynamic customization of their presentation.

Thus, Odoo's modular structure is based on an organized combination of these elements, allowing for flexible

- Adaptation to business needs.

Figure 7: Structure of an Odoo module



Source 2 : Shivam Sahu, 2019

3.3.5. Integrating artificial intelligence into Odoo

The integration of artificial intelligence (AI) in Odoo revolutionizes processes by combining automation, advanced analysis, and optimized decision-making. Based on technologies such as machine learning, natural language processing (NLP), and predictive analytics, AI allows for the automation of repetitive tasks, more efficient data utilization, and the facilitation of more natural interactions with users. This adaptive intelligence adjusts the platform in real time, detects hidden trends, and aids in faster and more informed decisions.

In the field of education, AI integrated into learning management systems (LMS) improves pedagogical and administrative efficiency while reducing errors. It automates grading, report generation, and planning, allowing teachers to focus on pedagogy. The algorithms personalize learning paths according to students' needs, while NLP helps to better understand their interactions and emotions to maintain their engagement. Finally, AI detects learners' difficulties early, facilitating a quick and tailored intervention.

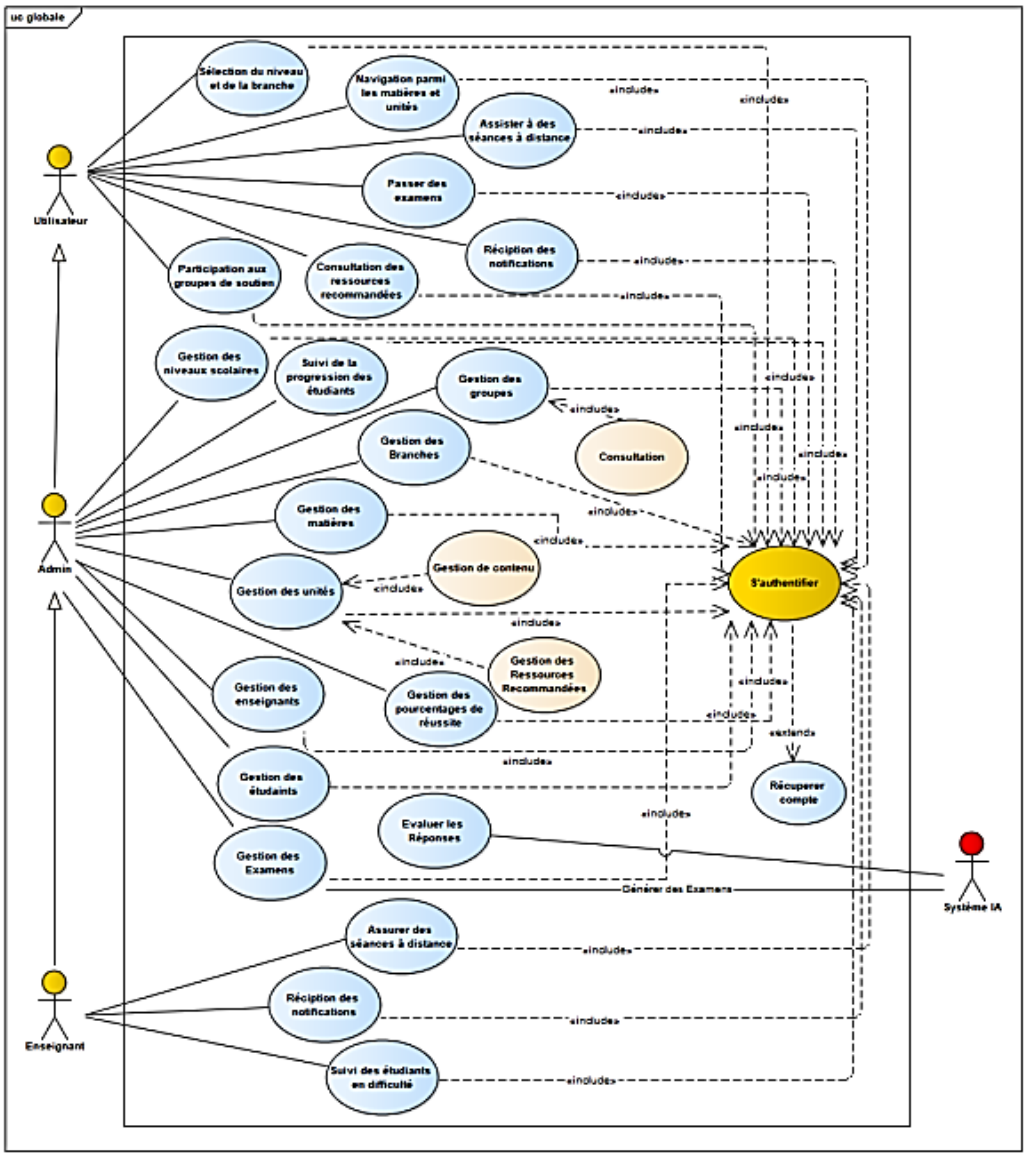
Thus, AI in LMS opens new perspectives for personalizing learning, optimizing educational practices, and supporting student success.

3.4. Design and modeling

In the context of modeling our project, three types of diagrams were used: the class diagram, which illustrates the system's architecture, the use case diagram, which defines the functionalities, and the sequence diagram, which details the interactions between the components.

3.4.1. Global Use Case Modeling

Figure 8: Use case diagram



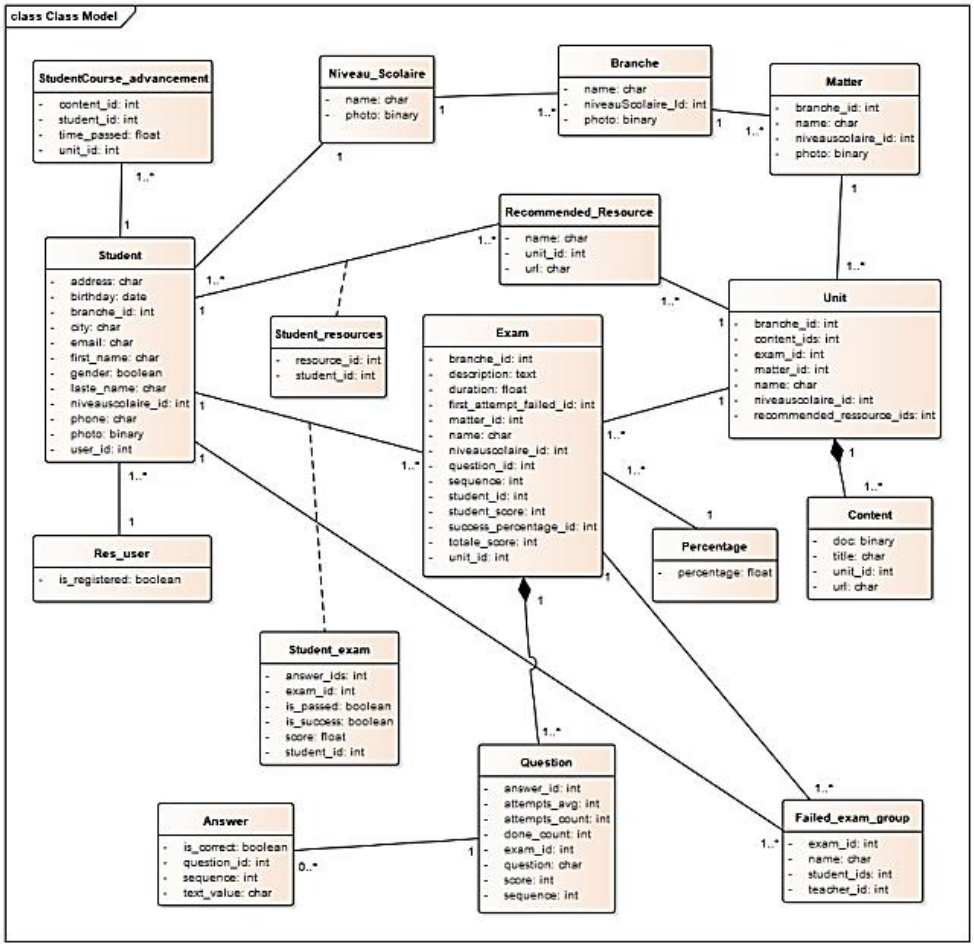
Source 3 : Authors

This comprehensive use case diagram offers a graphical and synthetic representation of the system's main functionalities. It highlights the different roles and permissions of the actors, as well as the essential interactions between these actors and the system within our module.

3.4.2. Class Diagram

The class diagram graphically represents the classes and interfaces of a system, as well as their relationships. A class, a model of a group of objects, defines their responsibilities, behaviors, and attributes, grouping semantically related functions and data. Classes allow for the breakdown of a complex program into simpler sub-tasks and can be connected thru inheritance (hierarchical relationships) or other types of relationships. The classes are then instantiated to create objects, each object having its own values for the characteristics defined by its class.

Figure 9 : Class Diagram



Source 4 : Authors

3.4.3. Sequence Diagrams

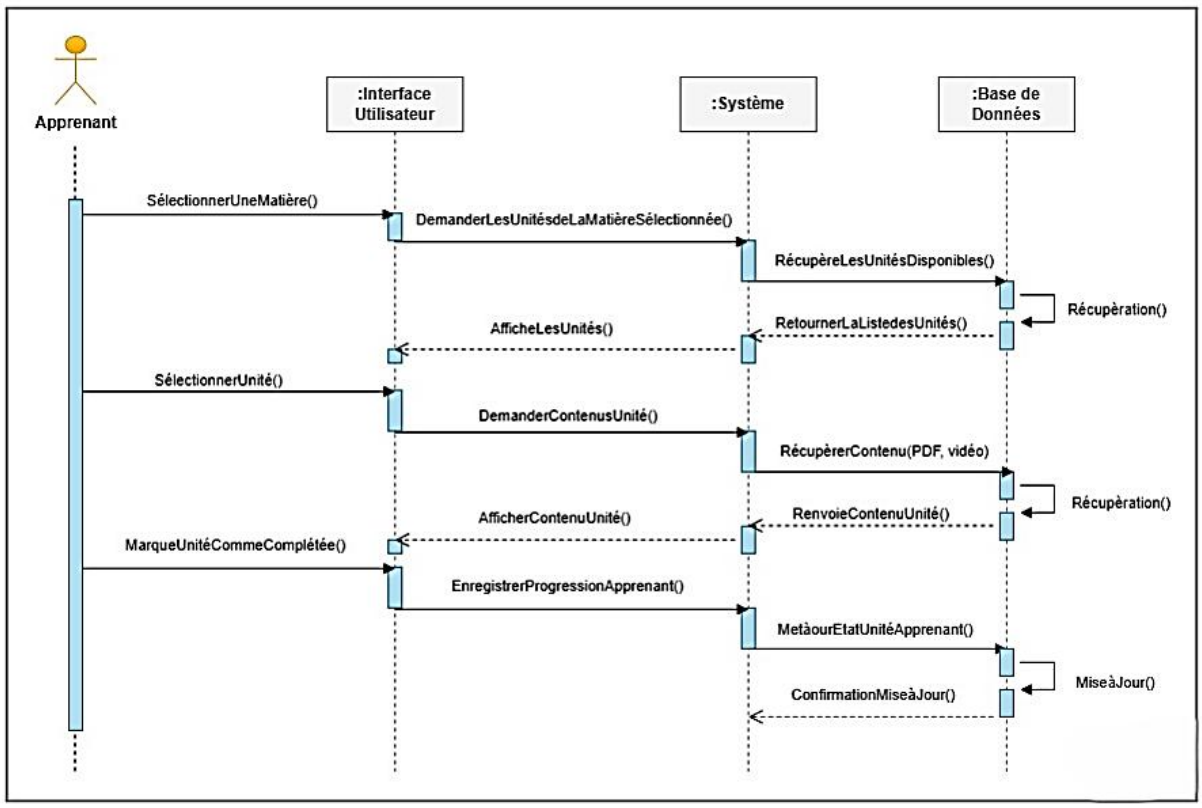
Sequence diagrams are a commonly used graphical tool to chronologically represent the interactions between objects and actors in a system. They offer a dynamic view of these message exchanges, with the vertical axis representing time and the horizontal axis representing the entities involved. This intuitive representation facilitates the understanding of

interactions between subsystems or classes, thereby assisting the architect or designer in the progressive development of their solution.

- Sequence diagram of the tracking of a unit/sub-unit/pedagogical grain of a program by the learner

The sequence diagram below illustrates the process by which the learner selects and accesses a unit. At each step, he interacts with the interface to access the content, while the system updates his progress, thus confirming the tracking of the unit.

Figure 10: Sequence diagram of unit tracking

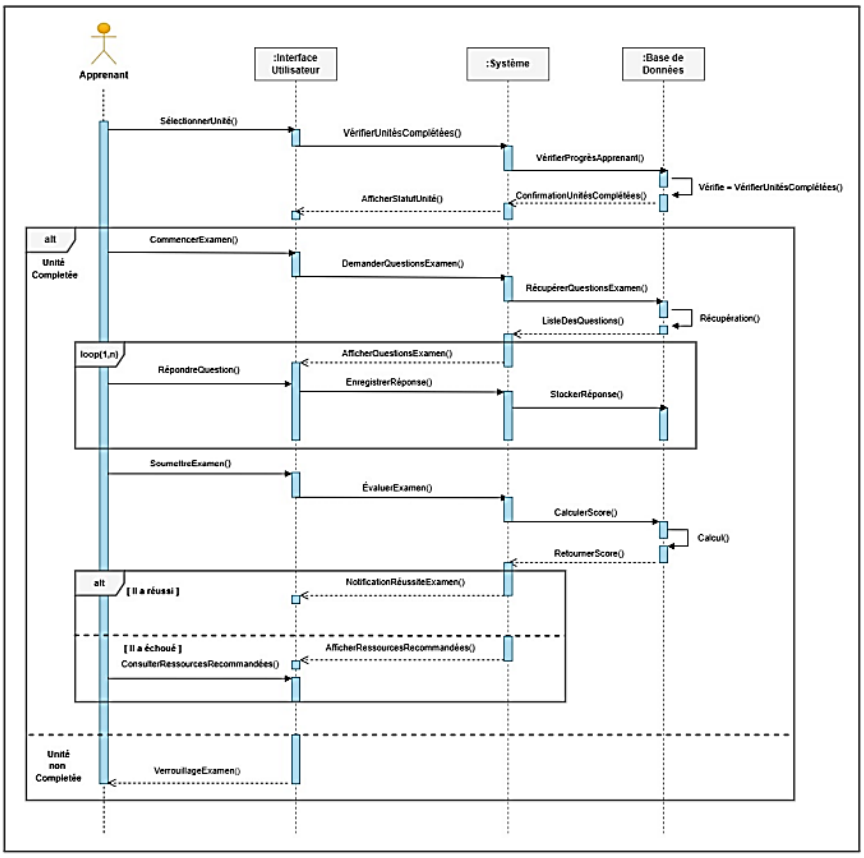


Source 10: Authors

- Sequence diagram of passing the first normal self-assessment test

The sequence diagram illustrates the process of the first self-assessment test: the learner selects a unit, checks its status, and begins the exam. He answers the questions, the system records his answers, evaluates the score, and informs the learner of his success or failure. In case of failure, revision resources are offered before allowing another attempt.

Figure 11: Sequence diagram of passing the first self-assessment test

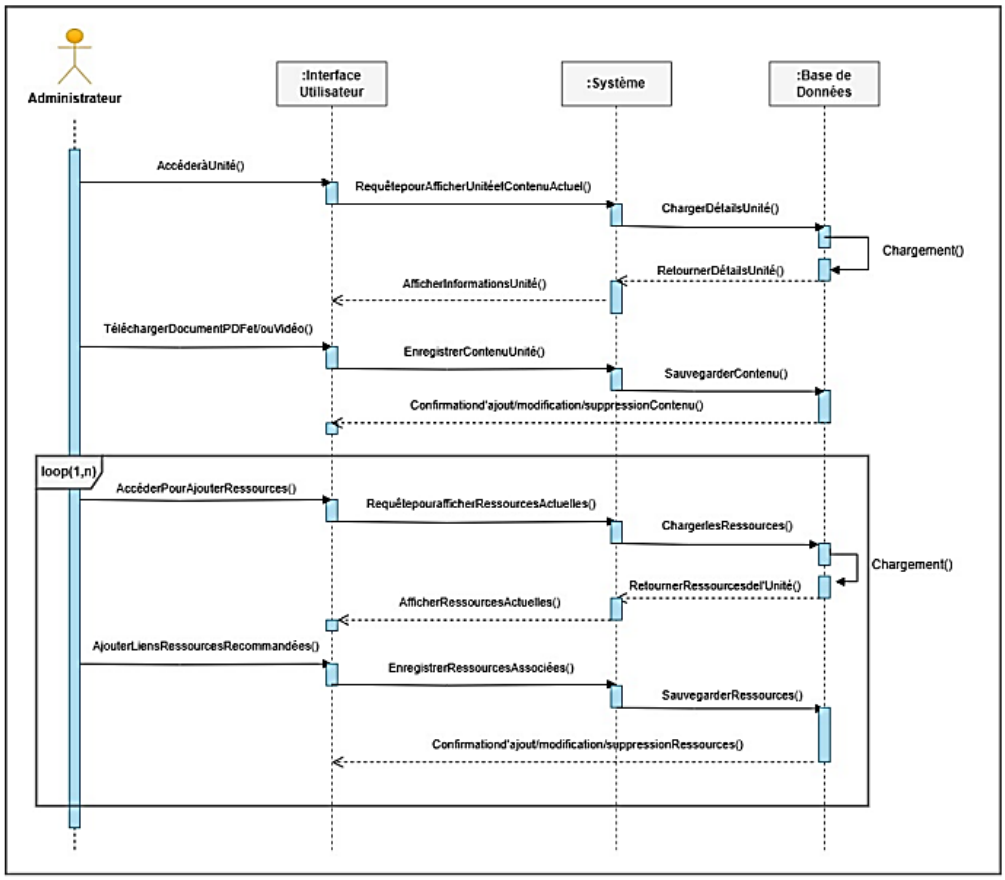


Source 5 : Authors

- Sequence diagram for adding content and recommended resources intended for self-support.

The sequence diagram below illustrates the process of adding content (documents, videos) and resources recommended by the administrator for a unit, intended for self-training of learners. The administrator accesses the unit, then the system records and stores the content or resources in the database, with confirmations sent back to the user interface for each action performed.

Figure 12: Sequence diagram for adding content and recommended resources for self-support

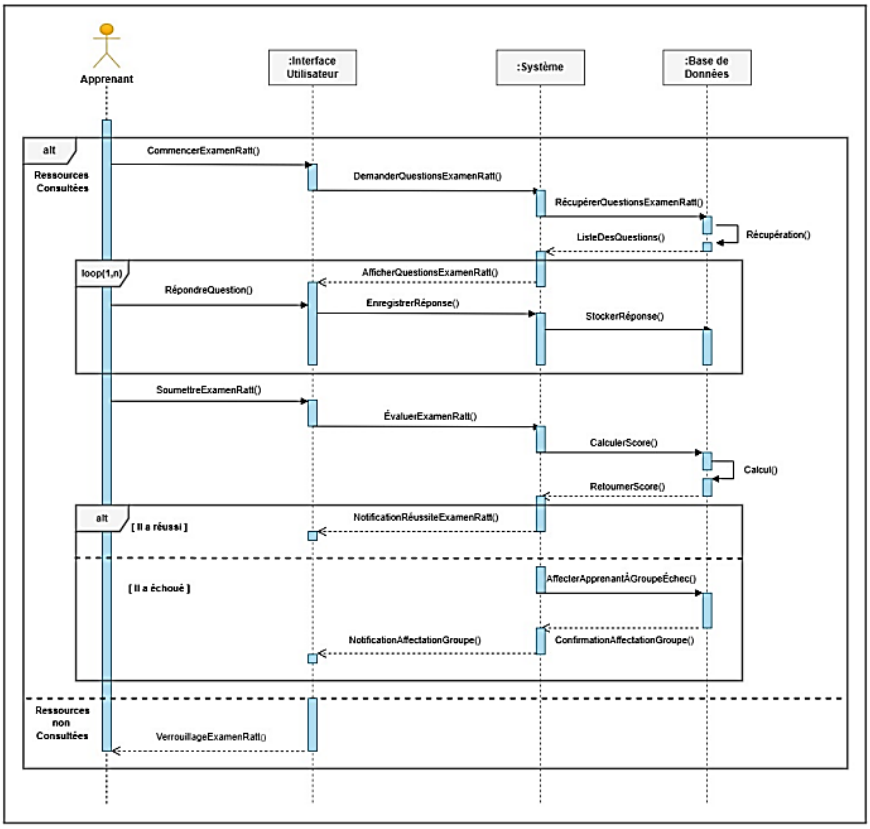


Source 6: Authors

- Sequence diagram of taking the second self-assessment test (make-up exam)

The sequence diagram of the retake exam describes the process followed by the learner after an initial failure. The learner answers the exam questions, their responses are recorded in the database, then the system evaluates the score and determines success according to the established threshold. In case of success, a notification is sent to the learner; in case of failure, the learner is integrated into a group for additional monitoring.

Figure 13: Sequence diagram of passing the second self-assessment test

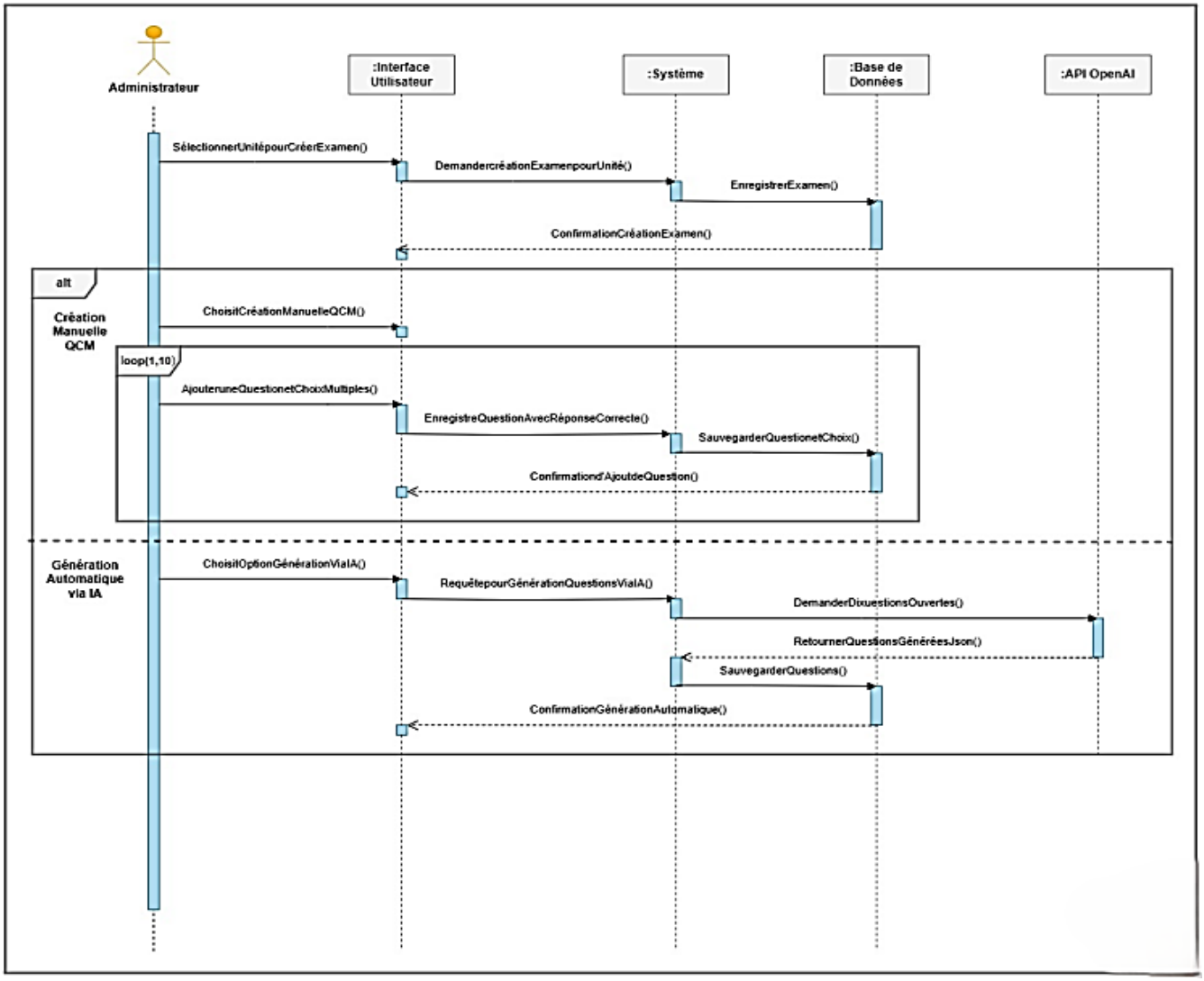


Source 7: Authors

- Sequence diagram of AI-based test creation

The sequence diagram highlights the creation of exams by the administrator, who can design an exam manually or leverage AI to automatically generate questions. The exams and questions are then stored in the database, with confirmations sent to the user interface at each step.

Figure 14: Sequence diagram of AI-driven test creation

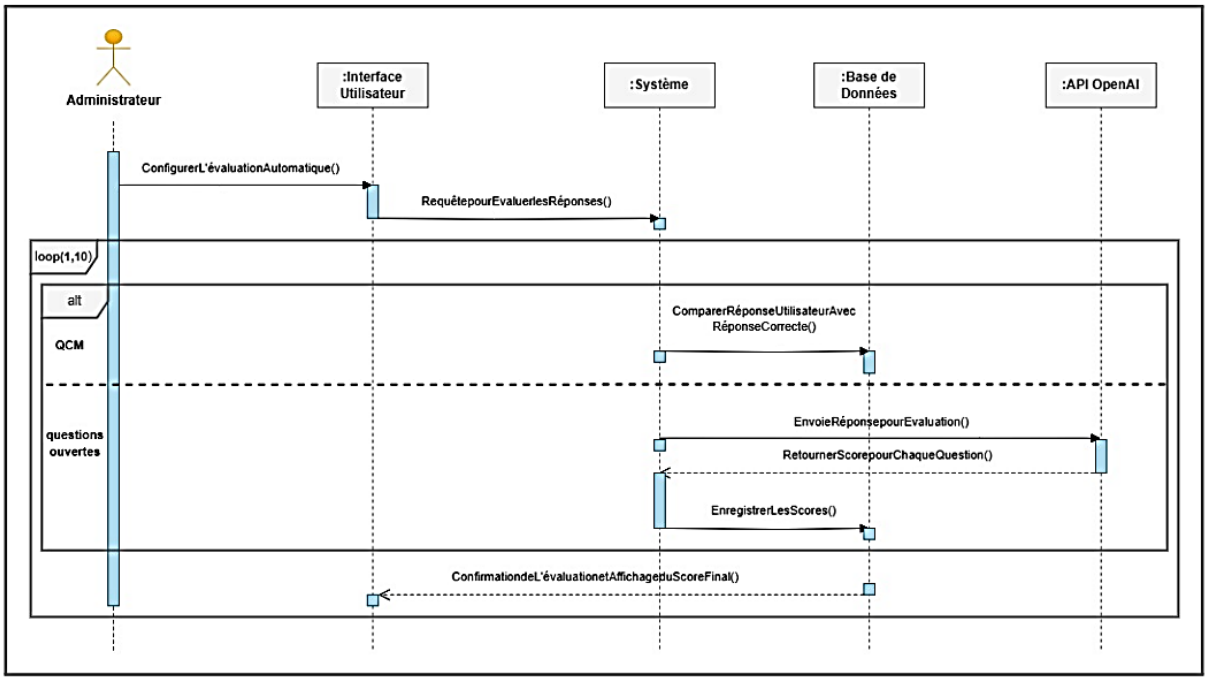


Source 8: Authors

- Sequence diagram for AI-automated evaluation

This sequence diagram illustrates the process of the automatic evaluation of an exam. The administrator starts by configuring the evaluation, then the system launches a request to analyze the answers provided by the user. For each question, depending on whether it is a multiple-choice question or an open-ended question, the system compares the answer to the correct solution or uses the Open AI API to proceed with the evaluation. The results obtained for each question are then stored in the database. Finally, the system validates the end of the evaluation and displays the total score.

Figure 1: Diagramme de séquence pour l'évaluation automatisée par IA

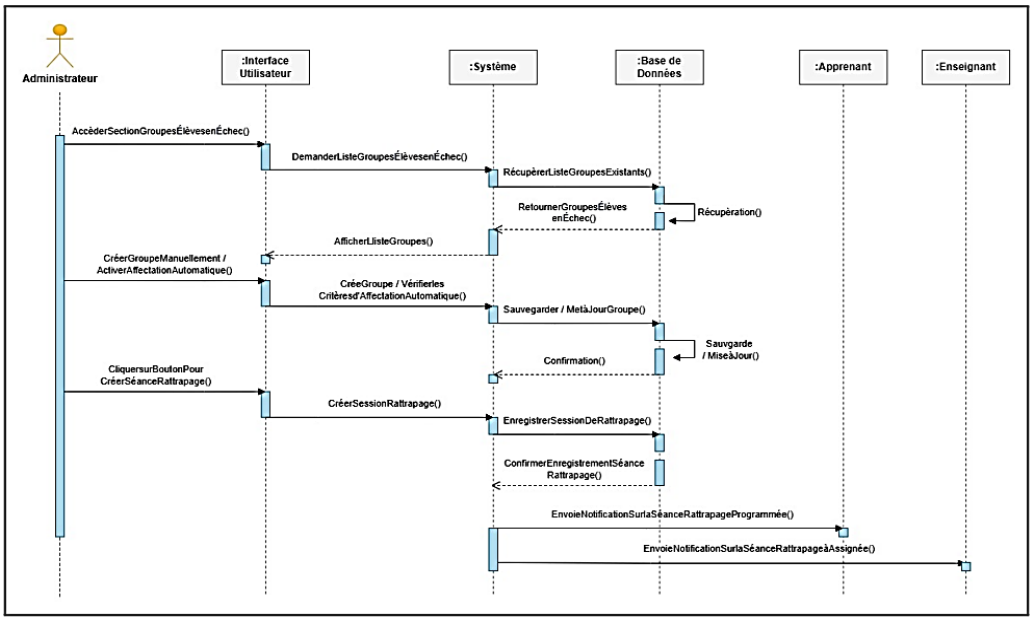


Source 9: Authors

- Sequence diagram for monitoring groups of students with learning difficulties

This sequence diagram illustrates how an administrator manages groups of students in difficulty and plans remedial sessions. The administrator can view or create groups, then schedule a catch-up session. Subsequently, email notifications are sent to the students and the concerned teacher to inform them about the support session.

Figure 16: Sequence diagram for monitoring groups of students with learning difficulties



Source 10: Authors

The modeling and design phase involves analyzing functional and technical needs, relying on UML diagrams to identify the main actors and their interactions with the system. This step establishes a solid foundation for the development of the module, ensuring a consistent implementation aligned with user expectations. The implementation phase, which follows from this work, specifies the programming languages, tools, and software used, as well as the structure of the module's interfaces and dashboards.

1.1. Implementation and Validation of Module Functionalities

The following section presents some interfaces, illustrating the realization of theoretical concepts thru the development of the essential functionalities of the module. These interfaces demonstrate the feasibility of the proposed solution, while highlighting the potential for evolution and improvement. This implementation phase constitutes a decisive step in validating the technical and architectural choices adopted for the project.

1.1.1. Development platform

Windows is used as the primary environment to run Odoo, PostgreSQL, and development tools, ensuring compatibility and ease of local testing.

- Frameworks and libraries

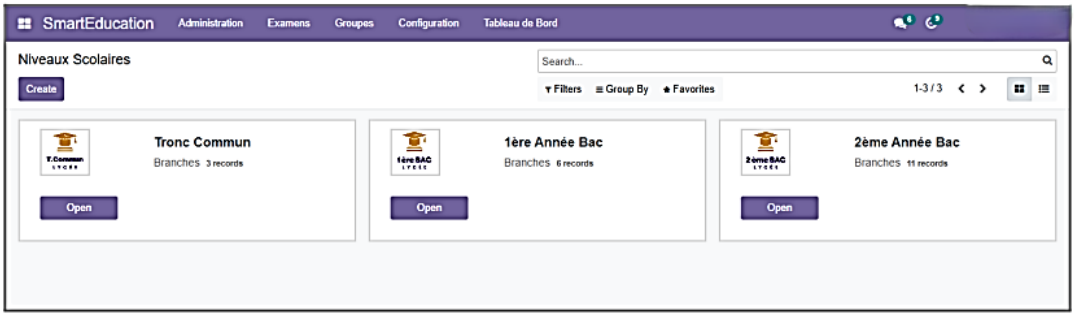
Odoo 15: Open-source enterprise management software, with a three-layer architecture (PostgreSQL for data, application server in Python, web server with XML interface). It offers improved performance, security, and features.

Odoo ORM: Facilitates data management by manipulating the PostgreSQL database as an object-oriented database, without manual SQL queries.
Qweb: XML engine to generate HTML pages in Odoo.
OWL: Lightweight JavaScript framework (<20 KB) for dynamic interfaces, based on components linked to Qweb, optimizing interactivity and performance.
OpenAI (GPT-3): Integrated API for artificial intelligence features, enhancing the user experience.
JSON: Lightweight format for data exchange between server, client, and external services like the OpenAI API.
Google Meet API: Allows for the planning and management of videoconference sessions for student remediation

1.1.2. The typical interfaces of the developed module - School Level Management Interface

It allows the administrator to oversee the different academic levels of the module, with a presentation in Kanban or list mode. The addition, modification, and deletion of school levels are carried out according to institutional requirement

Figure 17: School Level Management Interface

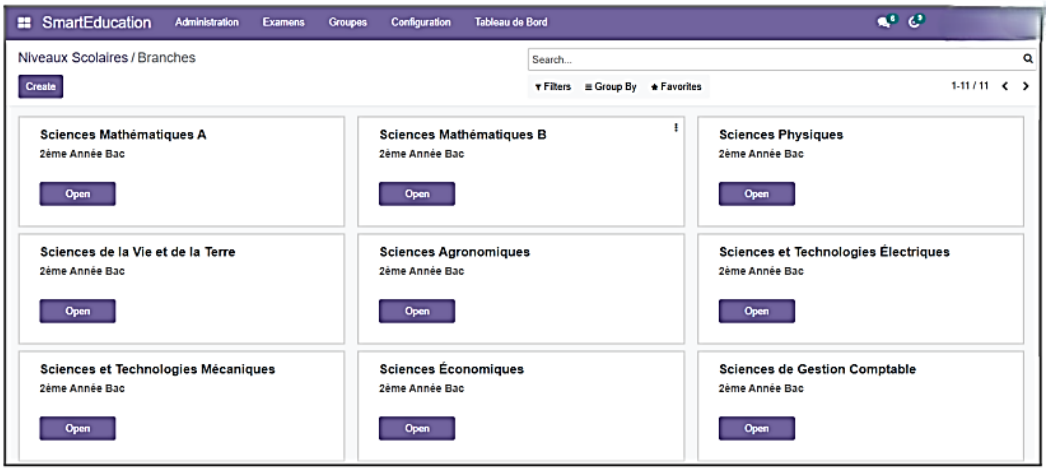


Source 11 : Authors

- Branch management interface

This interface offers the administrator the possibility to manage the different tracks or specializations offered. He can create, modify, or delete programs according to the needs of the educational curricula.

Figure 18: Branch Management Interface

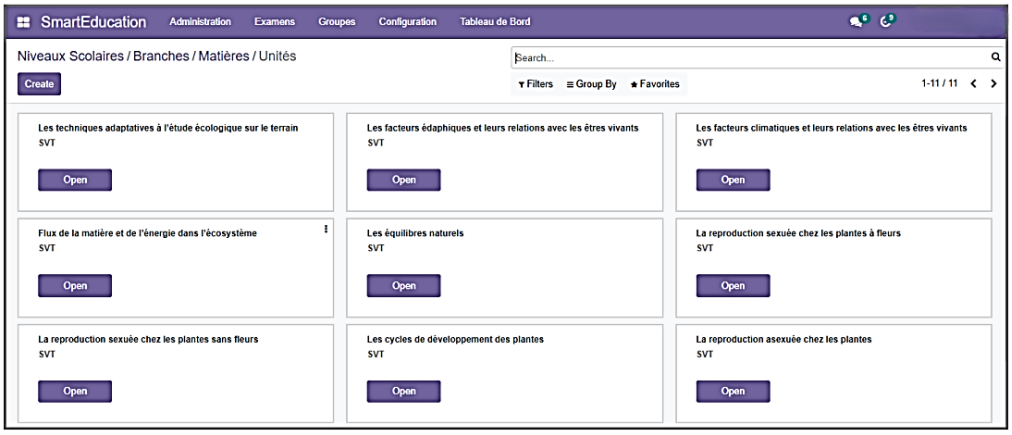


Source 12: Authors

- Interface for managing educational units

This interface allows the person in charge of academic support to manage the different teaching units within each subject.

Figure 19: Interface for managing educational units

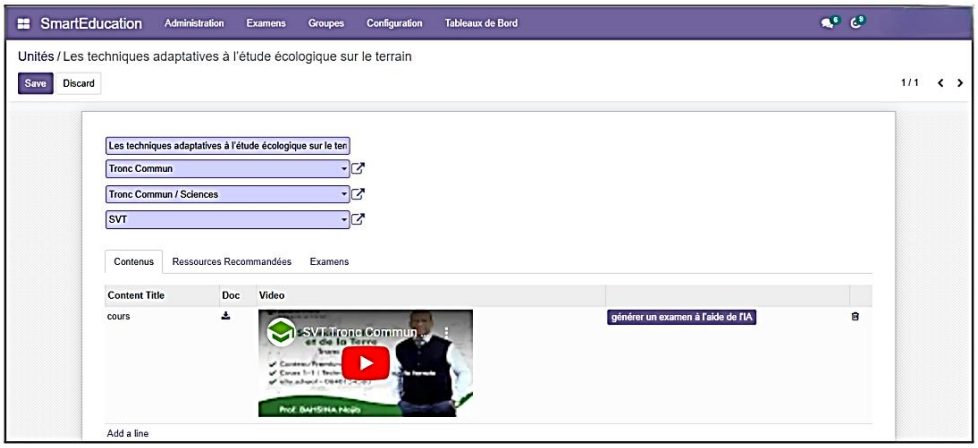


Source 13: Authors

- Automatic Exam Generation Interface by Artificial Intelligence

This interface allows for the automatic generation of exams for a given teaching unit, using the capabilities of artificial intelligence. When a unit is selected, the AI system analyzes the available educational content and creates a suitable exam.

Figure 20: Interface for Automatic Exam Generation by AI

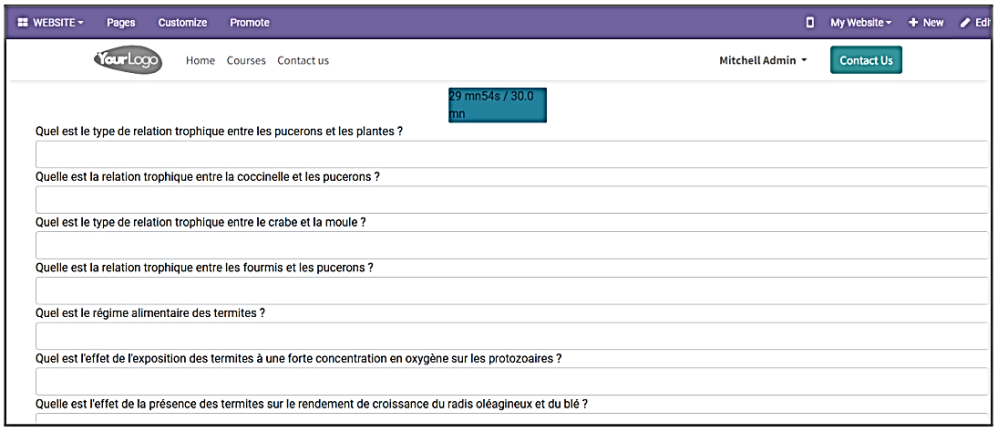


Source 14 : Authors

- **Interface of the first self-assessment test of the normal session**

This interface offers a standard session review in which the user answers a set of questions, mainly multiple-choice or short-answer. Accessible at the end of a learning session or a unit.

Figure 21: Interface of the first self-assessment test of the normal session

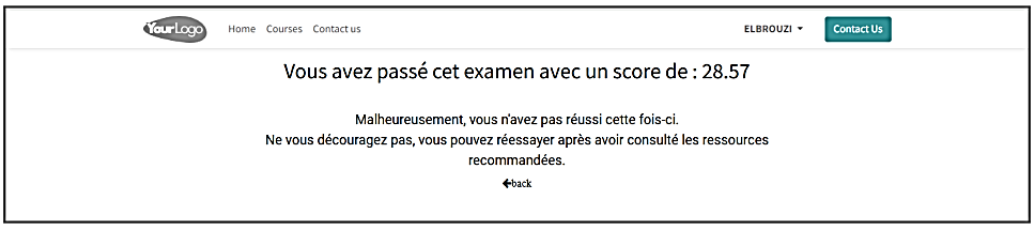


Source 15: Authors

-Interfaces for the results of the first self-assessment test and recommended resources

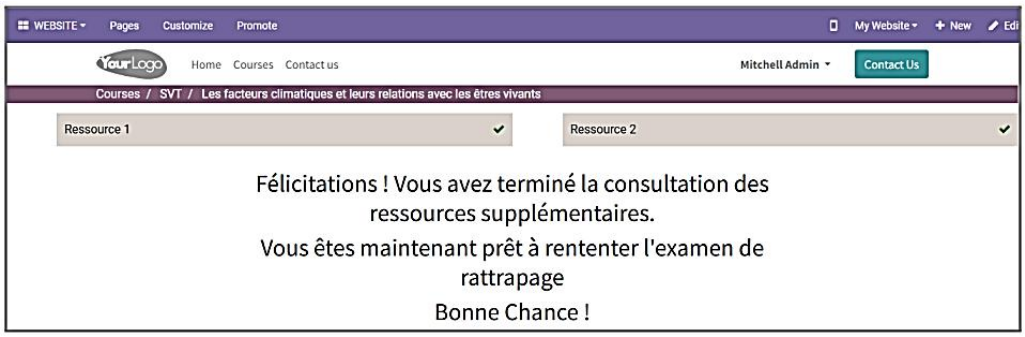
Immediately after submitting the first self-assessment test, the learner receives personalized feedback. The results interface displays the score obtained, accompanied by a congratulatory message in case of success, thereby encouraging motivation. In case of failure, the learner is directed to a Recommended Resources interface, providing them with direct access to educational materials focused on the key concepts of the unit, thereby promoting effective remediation before attempting a retake exam.

Figure 22: Result interface of the first self-assessment test



Source 16: Authors

Figure 23: Interface of recommended resources

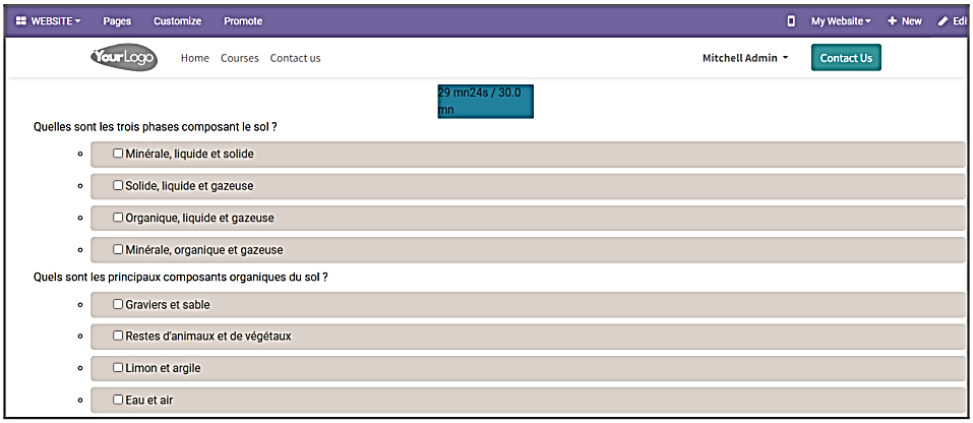


Source 17: Authors

- Interface of the Retake Exam: 2nd self-assessment test

The "Catch-Up Exam" interface offers the user a second opportunity to self-assess. It is accessible only after failing the initial self-assessment test.

Figure 24: Interface of the second self-assessment test

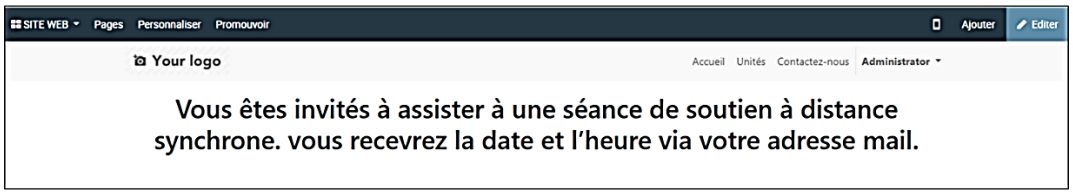


Source 18: Authors

- Interfaces for Remedial Results and Management of Struggling Learners

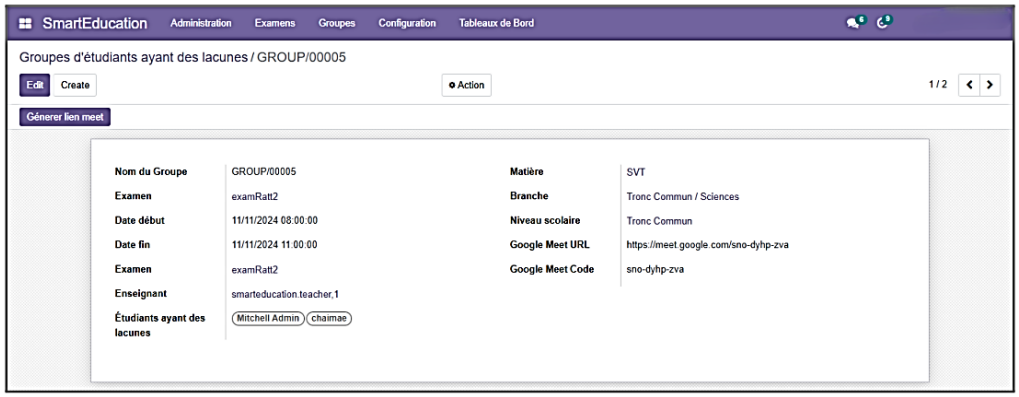
To help struggling learners after a second unsuccessful self-assessment test, the system automatically integrates them into a targeted group based on their educational gaps. This segmentation allows for tailored interventions. An email invites the learner to remote synchronous sessions for personalized and interactive support**.**

Figure 25: Interface of Catch-Up Results



Source 19: Authors

Figure 26: Interface for Managing Learners in Difficulty



Source 26: Authors

Conclusion

Artificial intelligence (AI) represents a paradigmatic shift in educational systems, offering unprecedented perspectives to improve teaching and learning (UNESCO, 2021). Its potential lies in its ability to combine technological innovation and equity, allowing for fine customization of educational paths. Thanks to adaptive algorithms, AI dynamically adjusts content, pace, and resources according to individual needs, skills, and preferences, while providing immediate feedback to optimize performance (Académie de Paris).

This dynamic of personalization is part of an inclusion logic, helping to reduce educational inequalities (UNESCO, 2021). By offering assistance tools and targeted activities, AI particularly supports struggling learners, ensuring equitable access to quality education, regardless of socio-economic backgrounds. However, UNESCO (2021) emphasizes the need to frame this deployment with rigorous public policies, so that AI meets the fundamental principles of inclusion and equity. Thus, if AI redefines education as a vector of success and accessibility, its integration must be accompanied by ethical governance to maximize its benefits.

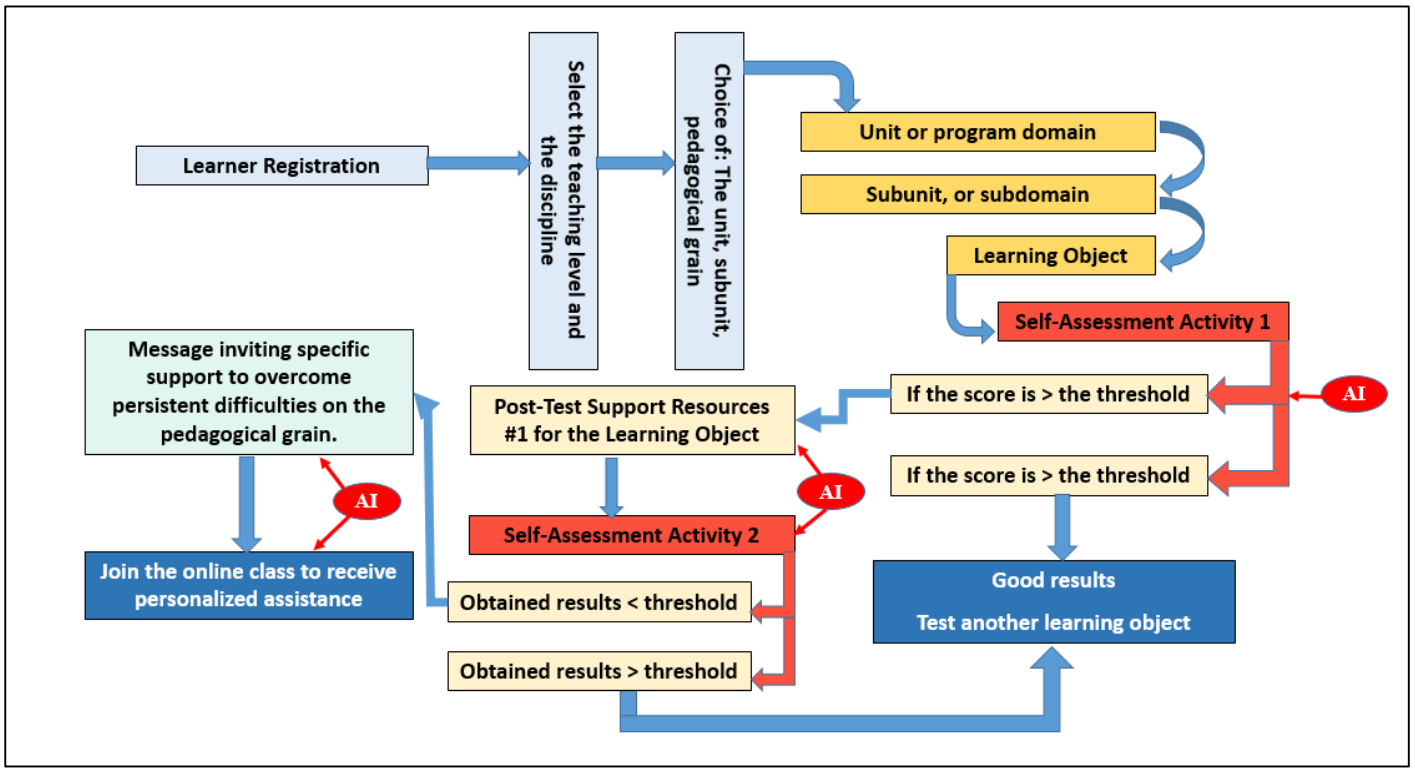
The integration of AI-assisted adaptive learning tools effectively addresses the specific needs of struggling learners, while also opening up new perspectives for improving pedagogical practices. These advanced educational

technologies, combined with adapted teaching methods, offer targeted support to students facing particular learning challenges. Their main advantage lies in their ability to dynamically adjust the educational content and learning pace according to individual performance, thereby promoting true pedagogical differentiation. This mechanism significantly contributes to the reduction of educational inequalities by ensuring that all students, regardless of their personal circumstances, have equitable access to quality educational resources. The ultimate goal of this approach is to establish a more inclusive educational environment where each learner can benefit from personalized support and learning materials tailored to their level and specific needs.

This study examines the contribution of Information and Communication Technologies for Education (ICTE) in identifying learning gaps and difficulties encountered by students in Life and Earth Sciences at the qualifying level, particularly within the framework of remote support sessions, with the aim of developing relevant remediation strategies.

The research led to the design and development of a generic decision-making support module integrated into the Odoo ERP system, assisted by artificial intelligence (AI), specifically tailored for the e-learning domain. This innovative and modular solution, developed using an approach centered on the specific needs identified, allows for both the centralization of learning management and the automation of certain critical tasks. The integration of advanced analysis tools to support pedagogical decision-making represents a major contribution of this work, fully meeting the initial objectives of the project. This systemic approach thus combines a precise diagnosis of learning difficulties with the implementation of adapted technological solutions for effective remediation.
The pedagogical conceptual model, presented in the diagram below, describes an innovative architecture for a pedagogical remediation module made intelligent with the assistance of artificial intelligence.

Figure 27: Conceptual pedagogical model of the AI-assisted Module



Source 20 : Authors

The model presents a structured architecture based on a systemic logic with three clear components. The process begins with a targeted registration phase where the learner, identified as having persistent difficulties with a specific pedagogical grain, joins a virtual class after selecting their level and discipline. The system then relies on a two-stage adaptive assessment mechanism: an initial self-assessment activity positions the learner in relation to a predefined competency threshold, triggering either immediate remediation resources (score < threshold) or validation of acquisition (score > threshold). The second evaluation loop consolidates this differentiated learning. The originality of the model lies in its top-down curricular organization (unit → sub-unit → pedagogical grain) coupled with an algorithmic logic that allows for intelligent looping back to other grains when mastery is demonstrated. This dual approach, combining didactic rigor and technological flexibility, perfectly illustrates how AI can optimize remediation pathways while maintaining fundamental pedagogical coherence. The operationalization of these mechanisms within a pedagogical module represents a significant advancement for the development of truly adaptive and personalized teaching. This innovation aims to establish educational equity by reducing learning disparities and providing tailored support to students with specific needs. To achieve this, the system is based on two complementary pillars : on the one hand, the provision of high-quality educational resources, and on the other hand, the integration of intelligent technological assistance tools. This dual approach allows for the reconciliation of academic excellence and educational inclusion, while adapting to the individual profiles of the learners.

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