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CONECTA#ADOTE: COMBINING ACTIVE METHODOLOGIES AND ARTIFICIAL INTELLIGENCE TO ENHANCE MICROBIOLOGY TEACHING AND ACADEMIC CONTENT MANAGEMENT

CONECTA#ADOTE: COMBINAÇÃO DE METODOLOGIAS ATIVAS E INTELIGÊNCIA ARTIFICIAL PARA POTENCIALIZAR O ENSINO DE MICROBIOLOGIA E A GESTÃO DE CONTEÚDOS ACADÊMICOS

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ABSTRACT: Here, we aimed to develop and validate the Conecta#Adote platform, which integrates artificial intelligence (AI) into the #Adote project to centralize, organize, and analyze content produced by students on social media. The platform, designed with a modular architecture, incorporates AI tools and function as a repository and environment for automated analyses. For validation, we used as a pilot the posts from the Neisseria group of the "Adopt a Bacterium" activity in the Bacteriology course (Biomedical Sciences program – USP). The posts were imported into the platform, which performed content analyses including term counting, identification of biological vocabulary, and word cloud generation. The results demonstrated the technical feasibility of integrating AI and active methodology, as well as the potential of Conecta#Adote to enhance the efficiency of educational data management. We conclude that Conecta#Adote modernize microbiology teaching by combining AI and active learning methodologies, establishing itself as an innovative tool for hybrid education.

KEYWORDS: #Adote Project. Artificial intelligence. Microbiology. Education.

RESUMO: *Neste estudo, objetivou-se desenvolver e validar a plataforma Conecta#Adote, que integra inteligência artificial (IA) ao projeto #Adote para centralizar, organizar e analisar conteúdos produzidos por estudantes em redes sociais. A plataforma, em arquitetura modular, incorpora ferramentas de IA funcionando como repositório e ambiente de análises automáticas. Para a validação, utilizamos como piloto postagens do grupo Neisseria da atividade "Adote uma Bactéria" da disciplina de Bacteriologia (curso de Ciências Biomédicas – USP). As postagens foram importadas para a plataforma, que executou análises de conteúdo, incluindo contagem de termos, identificação de vocabulário biológico e geração de nuvem de palavras. Os resultados evidenciaram a viabilidade técnica da integração entre IA e metodologia ativa, bem como o potencial do Conecta#Adote para ampliar a eficiência da gestão de dados educacionais. Conclui-se que o Conecta#Adote contribui para modernizar o ensino de microbiologia ao unir IA e metodologias ativas, configurando-se como ferramenta inovadora para o ensino híbrido.*

PALAVRAS-CHAVE: *Projeto #Adote. Inteligência artificial. Microbiologia. Educação.*

RESUMEN: *En este estudio se buscó desarrollar y validar la plataforma Conecta#Adote, que integra inteligencia artificial (IA) al proyecto #Adote para centralizar, organizar y analizar contenidos producidos por estudiantes en redes sociales. La plataforma, de arquitectura modular, incorpora herramientas de IA y funciona como repositorio y entorno de análisis automáticos. Para la validación, utilizamos como piloto publicaciones del grupo Neisseria de la actividad "Adopta una Bacteria" de la asignatura de Bacteriología (curso de Ciencias Biomédicas – USP). Las publicaciones fueron importadas a la plataforma, que ejecutó análisis de contenido, conteo de términos, identificación de vocabulario biológico y generación de nubes de palabras. Los resultados evidenciaron la viabilidad técnica de la integración entre IA y metodología activa, y el potencial de Conecta#Adote para mejorar la gestión de datos educativos. Se concluye que Conecta#Adote moderniza la enseñanza de microbiología al combinar IA y metodologías activas, constituyéndose en una herramienta innovadora para la enseñanza híbrida.*

PALABRAS CLAVE: *Proyecto #Adote. Inteligencia artificial. Microbiología. Educación.*

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INTRODUCTION

Digital transformation has reshaped the production, sharing, and dissemination of knowledge. In this scenario, Digital Information and Communication Technologies (DICTs) have directly impacted teaching and learning processes, establishing themselves as high-value didactic-pedagogical resources, particularly for Generations Z and Alpha (Lima et al., 2021; Coutinho et al., 2024). When associated with active learning methodologies, DICTs promote greater engagement, autonomy, and inclusion, favoring dynamic and meaningful learning in which the student occupies a central position in the construction of knowledge (Yannier et al., 2021).

In the field of microbiology, a well-established example is the active methodology "*Adote uma Bactéria*" (Adopt a Bacterium), an educational branch of the #Adote Project (Piantola et al., 2018; Taschner et al., 2020; Armellini et al., 2021; Corrêa et al., 2023; Santos et al., 2024; Baroni et al., 2024; Gozzi et al., 2025; Picinin et al., 2025). In this proposal, undergraduate students collaboratively produce thematic posts about microorganisms in an interactive environment, fostering exchanges between students, mediators, and professors on social media (Facebook® and Instagram®). This experience has demonstrated efficacy in both promoting scientific learning and strengthening students' academic language, in addition to expanding the reach of pedagogical practices through collaboration in digital environments.

The integration of microbiology with Artificial Intelligence (AI) has been consolidating as a strategic approach for scientific and educational advancement (Gordon et al., 2024; Mohseni & Ghorbani, 2024; Rajan et al., 2024). The use of Machine Learning (ML) and Deep Learning (DL) algorithms has enabled the analysis of large volumes of microbiological data with greater precision and speed, contributing to pathogen identification, antimicrobial resistance prediction (Mahmood et al., 2024), and taxonomic classification in metagenomic studies (Kouchaki et al., 2023).

In the educational context, the incorporation of AI-based tools has the potential to promote personalized learning, offer adaptive feedback, and favor the development of analytical and critical skills (Popenici & Kerr, 2017; Bernardino et al., 2024; Khalid et al., 2024; Toma et al., 2024). However, its use requires well-structured ethical and pedagogical approaches (Park et al., 2024; Marcotte et al., 2024; Akhter et al., 2025), ensuring transparency, reliability, and appropriate interpretation of results.

Based on this potential, the present study introduces Conecta#Adote, a digital platform that integrates the "Adote uma Bactéria" active methodology with AI resources, configuring a virtual environment focused on the centralization, preservation, and automated analysis of content produced by students and professors. This integration enhances accessibility, efficiency, and innovation in the teaching-learning process while consolidating a structured repository of scientific and pedagogical information. The system was designed to be multifunctio-

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nal, combining a database, automated report generation, and analytical tools.

Therefore, the general objective of this study was to develop and validate the Conecta#Adote platform, integrating AI resources into the 'Adote uma Bactéria' active methodology to support microbiology teaching and academic content management. Specifically, we sought to: (i) describe the design process and the technical-pedagogical architecture of the platform; (ii) test the functionalities for organization and automated content analysis using posts from a group in the "Adote uma Bactéria" activity; and (iii) discuss the potential of integrating AI, active methodologies, and learning analytics in the context of higher education in microbiology.

METHODS

Development of the Conecta#Adote Platform

The development of the Conecta#Adote platform was conducted in successive stages, involving conceptual planning, technical structuring (*frontend and backend*), and the integration of AI tools. Initially, the planning and architecture of the platform were manually outlined in a schematic format (Table 1) to define the primary sections and functionalities. This stage corresponded to the frontend (visual interface), which comprises the design of screens, menus, and tabs that organize the platform's various functions (Figure 1). Following this, the backend (computational data processing) was planned for the digital structure of the platform, responsible for communication routes and integration with AI tools. For each planned function, the most suitable AI models were determined (Table 2). This structure enabled automated analysis processing and seamless communication between user interfaces and the database.

The development and programming environment was Replit, which allows for cloud-based code editing and execution. Part of the programming was performed via Vibe Coding, a Replit feature that utilizes fragmented command prompts, thereby minimizing compilation errors. Manually programmed modules were also implemented: HTML for the frontend, Python for the backend, and database configuration scripts in PostgreSQL. For the implementation of automated analysis tools, an OCR (*Optical Character Recognition*) algorithm was integrated to extract text from images. The extracted information was processed and visualized using Chart.js, which is responsible for generating word clouds that identify the most frequent and relevant terms. The general architecture of Conecta#Adote is illustrated in Figure 1.

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Table 1
Organizational structure of the frontend and tab functionalities of the platform.

Structure	Function
Start Screen (Login)	Initial interface where users enter their credentials (name, e-mail, class, and role – professor/mediator or student). Authentication defines the access level and automatically directs the user to the home page.
Home page	Main dashboard that centralizes all platform functionalities, organized into interactive tabs. In this area, users access the Lessons, Exercises, Science Around the World, #Adote, and Analysis modules, with dynamic navigation between them.
Lessons	Space dedicated to providing theoretical content, videos, practical guides, and complementary materials, organized by the instructor or mediator.
Exercises	Area designed for practice and learning consolidation. It gathers interactive activities that assess comprehension of the topics covered and monitor each student's performance.
Science Around the World	Section dedicated to sharing recent scientific news and discoveries in microbiology and related fields, encouraging critical reading and keeping students up to date.
#Adote	Interactive module housing posts from the #Adote project, including science communication content, visual materials, and student-produced narratives. It allows interaction between students, mediators, and professors through comments and feedback.
Analysis	Module focused on quantitative and qualitative assessment of posts. It enables content filtering by title and the automated generation of graphical representations, such as word clouds, frequency charts, and engagement graphs based on interactions (likes and comments).

Note. Elaborated by the authors (2026).

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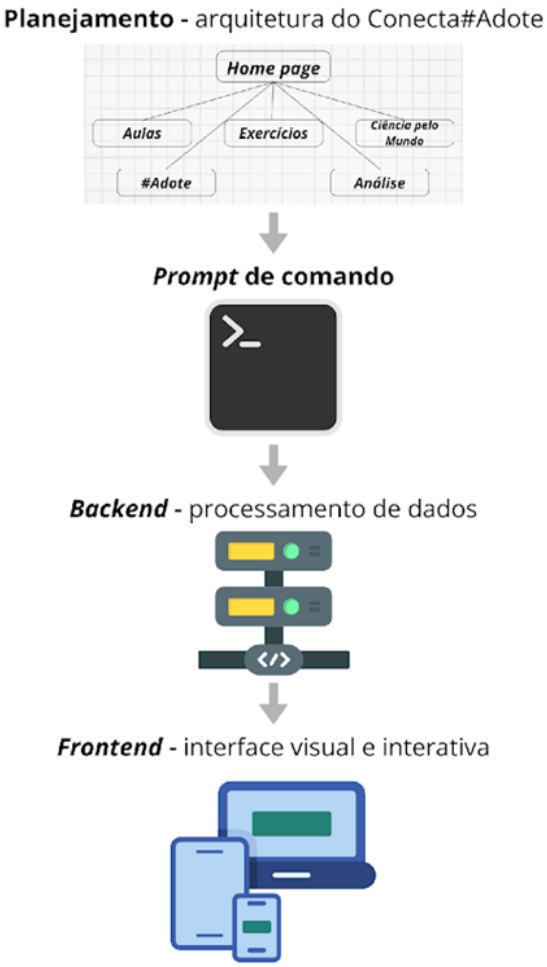
Figure 1
General architecture and workflow of the Conecta#Adote platform.



Note. Prepared by the authors (2026). The image represents the modular planning and structure of the system, comprising different sections accessed from the Home Page (Lessons, Exercises, Science Around the World, #Adote, and Analysis). The operational process is divided into three main layers: the command prompt, which triggers user requests; the backend, responsible for data processing and integration with artificial intelligence resources; and the frontend, which presents the visual and interactive interface used by students and instructors.

Table 2
Backend structure and AI tool integration of the Conecta#Adote platform

Artificial Intelligence / Tool	Function
Replit	Cloud-based development and execution environment.
ChatGPT	Programming via Vibe Coding.
OCR	Extracting text from images.
PostgreSQL	Platform database.
Chart.js	Generating charts and data visualizations.

Note. Prepared by the authors (2026).

"Adote uma Bacteria" for Platform Validation

In this study, posts produced in 2024 during the "Adote uma Bactéria" activity were utilized. This activity was approved by the Human Research Ethics Committee (CEPSH ICB--USP—protocol CAAE 51764021.0.0000.5467) and conducted during the Bacteriology course of the Biomedical Sciences program at the University of São Paulo. For the validation of the Conecta#Adote platform, posts from the *Neisseria* group (comprised of nine undergraduate students) were selected from among the five participating groups.

Posts were manually collected from the activity's official Instagram® profile (Figure 2) using institutional access. Each publication was saved individually as an image and subsequently transferred to the platform environment, simulating the original posting process. This approach aimed to faithfully reproduce the system's usage dynamics, ensuring real-world conditions for interaction and analysis. The resulting dataset served as a basis for testing functionalities related to organization, storage, and automated academic data analysis, thereby validating the platform's performance and applicability in an educational context.

Figure 2
Examples of posts from the 2024 "Adote uma Bactéria" activity, Neisseria group.

Note. Prepared by the authors (2026).

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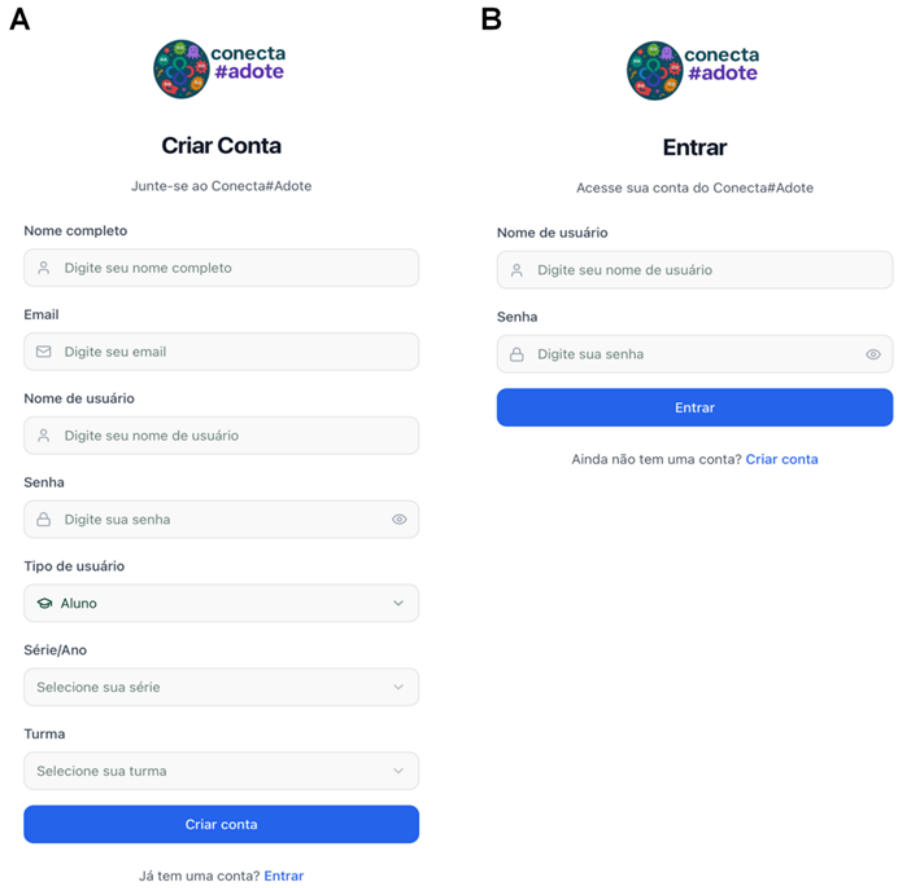
RESULTS AND DISCUSSION

Visual and Interactive Interfaces of Conecta#Adote

The platform currently under development features a functional structure that allows the integration of AI resources into the "Adote uma Bactéria" methodology. Upon accessing the platform, the user's first visual interface is the registration page, where name, e-mail, password, and identification as either student or professor (which also serves for mediator registration) must be provided (Figure 3A). This identification is essential for the subsequent refinement of analytics. After this procedure, users can log in to enter the system (Figure 3B).

Figure 3
Registration and login screens of the platform, with user identification as student or professor.

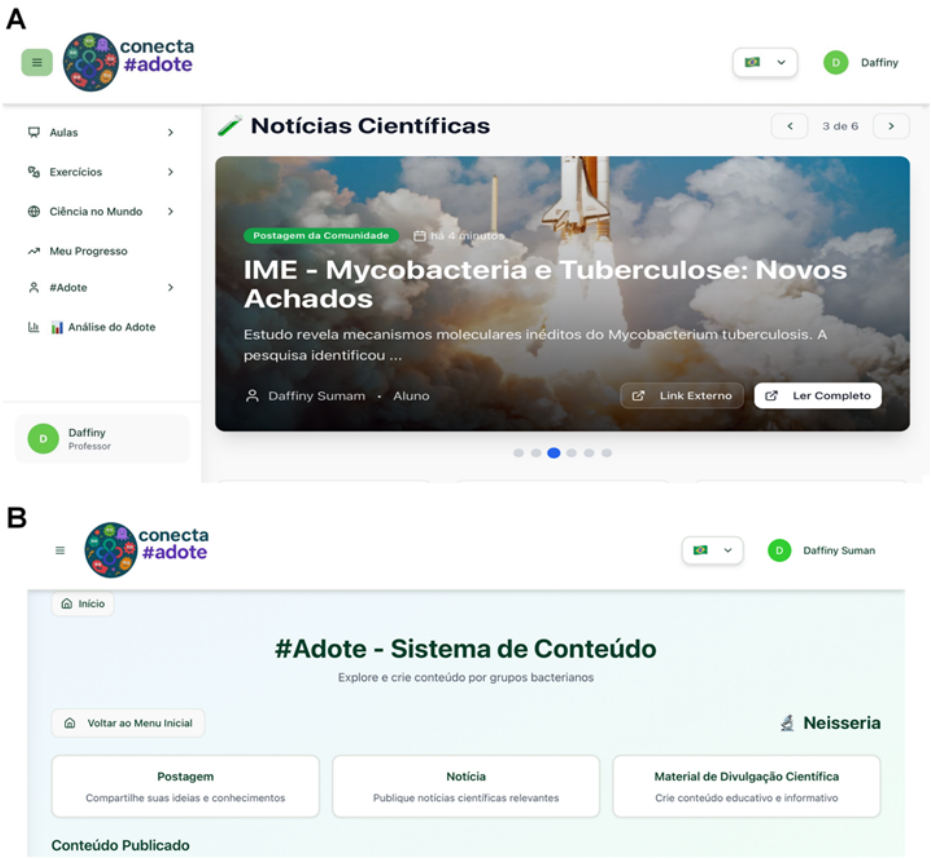


Note. Prepared by the authors (2026). [A] Visual user interface for registration. [B] Visual user interface for login.

Upon logging into Conecta#Adote, the user is greeted by an intuitive interface. The main menu on the left sidebar consists of the following sections: Lessons, Exercises, Science Around the World, My Progress, #Adote, and Adote Analysis (Figure 4A). This organization facilitates navigation and provides an immersive, personalized learning experience. The home

screen highlights the "Science Around the World" module, presented in a dynamic carousel format, displaying updated scientific news produced or selected by the students themselves. This functionality encourages engagement and the development of scientific literacy by connecting students with real discoveries and contemporary scientific vocabulary. The #Adote tab is the core of the activity within the platform, where students can access their adopted bacterial groups and create posts, a task previously performed on Instagram® (Figure 4B).

Figure 4
Interfaces of the Conecta#Adote platform



Note. Prepared by the authors (2026). [A] Main screen of the platform, highlighting the carousel of scientific news in the center and the side menu with the available modules: Lessons, Exercises, Science Around the World, My Progress, #Adote, and Analysis. [B] Interface of the #Adote tab, which organizes the content system by bacterial groups. In this section, students can create posts related to the "Adote uma Bactéria" activity, insert scientific news and publish outreach materials.

Validation of Automated Analysis Tools

To perform an analysis, the user—specifically through a professor login—selects the content type (post, news, or science communication material) and provides the title used in

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the publications for precise selection (Figure 5A). For validation, a content analysis was conducted on the Neisseria group's posts, selected using the title "*keepingupwiththeneisseria#Adote2024*".

The system automatically processed three posts, resulting in a total of 525 words, of which 458 were unique and 164 were identified as biological terms (Figure 5B). These data demonstrate the tool's ability to recognize and classify scientific terminology and quantify lexical diversity in student productions. The generated word cloud highlights the most recurrent concepts, such as "system," "adapt," "bacteria," "capsule," and "nutrients," reflecting the microbiological focus of the posts.

Figure 5
Interface of the analysis area of the Conecta#Adote platform.

Note. Prepared by the authors (2026). [A] Content Analysis Module, in which the user selects the type of post, the adopted bacterial group, and the desired title to start automatic processing. [B] Example of analysis applied to posts from the "Adote uma Bactéria" activity on the platform. Three publications from the *Neisseria group were evaluated*, resulting in a total of 525 words, of which 458 were unique and 164 were identified biological terms. The word cloud highlights the most recurrent concepts present in the posts.

DISCUSSION

The creation of the Conecta#Adote platform emerges as an initiative that combines active teaching methodologies and artificial intelligence (AI) tools in response to current demands for innovation and modernization in microbiology teaching (Tiwade et al., 2024). The proposal arises as an expansion of the #Adote project, where the "Adote uma Bactéria" (Adopt a Bacterium) branch has established itself as an active and collaborative learning strategy, promoting student engagement and scientific communication through social media (Piantola et al., 2018; Taschner et al., 2020; Armellini et al., 2021; Corrêa et al., 2023; Santos et al., 2024; Baroni et al., 2024; Gozzi et al., 2025; Picinin et al., 2025). In this context, Conecta#Adote expands the reach and sustainability of the project by incorporating its own digital repository,

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which centralizes, organizes, and preserves the content produced by students, mediators, and professors. In addition to acting as an academic memory bank, the repository ensures continuity, traceability, and comparability between different editions of the activity, allowing for longitudinal analyses and the valorization of student production as a source of educational data. This configuration reflects contemporary trends in hybrid learning (Armellini et al., 2021) and student-centered teaching, promoting autonomy, collaboration, and educational innovation aligned with the demands of the digital age (Weller et al., 2024; Tiwade et al., 2025).

The incorporation of AI into health education has been growing and already shows utility in personalizing learning (Bernardino et al., 2024), automated feedback, and assessment support (Kim, 2023; Nagi et al., 2023; Gordon et al., 2024; Khalid et al., 2024). In applied studies, AI and Large Language Models (LLMs) have improved formative outcomes in controlled settings (Çiçek et al., 2025), and ChatGPT-assisted PBL approaches have reported gains in knowledge and clinical skills (Hui et al., 2024). Recently, a meta-analysis suggested a global advantage for AI-supported methodologies over traditional teaching strategies (Li et al., 2025)—although literature reviews emphasize that methodological quality remains heterogeneous and requires greater rigor in measuring results (Feigerlova et al., 2025).

In parallel, the pedagogical use of social networks favors student engagement and content dissemination but brings challenges in curation, standardization of student-generated data evaluation, and traceability (Katz et al., 2021), highlighting the need for platforms more appropriate for the pedagogical field. Medical education literature points in this direction (Chan et al., 2019) but also warns of gaps in data standardization, ethics, and privacy that dedicated platforms must offer (Marcotte et al., 2024; Park et al., 2024).

It is precisely this gap that Conecta#Adote seeks to fill by integrating a repository, AI, and data analysis in a single environment. From an innovative standpoint, the expansion of the "Adote uma Bactéria" activity to the Conecta#Adote platform significantly broadens the application possibilities of this active methodology. The platform centralizes interactions between students, mediators, and faculty in a unique environment, in addition to constituting a permanent repository of academic and science communication content. This structure contributes to the preservation of institutional memory and the recording of the project's longitudinal evolution, overcoming the transitory nature of social networks.

Considering the contemporary scenario of microbiology in the era of AI (Mohseni & Ghorbani, 2024; Rajan et al., 2024), Conecta#Adote demonstrates how AI can be used to empower already consolidated active methodologies, transforming the way of teaching and learning by promoting an active, adaptive, and data-driven education. Furthermore, Conecta#Adote can be considered both a predictive AI, by standardizing and analyzing data generated by stu-

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dents, and a generative one, as it has the potential to create reports that streamline information interpretation. In this way, Conecta#Adote modernizes microbiology teaching and presents itself as an innovative technological solution that maintains collaborative learning, as proposed by the #Adote project.

From a conceptual point of view, Conecta#Adote is situated at the intersection of active methodologies, educational artificial intelligence, and learning analytics. Previous experiences with the #Adote project have already shown that strategies such as "Adote uma Bactéria" favor student protagonism and the retention of microbiology concepts (Piantola et al., 2018; Armellini et al., 2021). These findings are aligned with STEM literature, which indicates that active approaches reduce failure rates and improve performance compared to traditional expository teaching (Freeman et al., 2014). By incorporating AI, Conecta#Adote follows current trends in health and medical education, where AI serves both as a curricular resource and a teaching support technology, personalizing training paths and expanding the faculty's ability to monitor student engagement (Masters, 2019; Lee et al., 2021).

In this context, the analytical functionalities of Conecta#Adote approach the field of learning analytics, which refers to the systematic collection and analysis of educational data to optimize learning. By generating indicators such as post frequency, term count, and vocabulary identification, the platform aligns with evidence that the use of digital resources can be associated with academic performance and support targeted pedagogical interventions (Chan et al., 2019; Scott et al., 2026). Studies indicate that hybrid collaboration formats—online and in-person—offer learning benefits, highlighting the importance of understanding interaction patterns in technology-mediated environments (Ran et al., 2025). Furthermore, reviews in STEM show that AI tools can support metacognition and learning monitoring, allowing students to plan and evaluate their own actions (Tsakeni et al., 2025).

In conclusion, Conecta#Adote exemplifies how the combination of active methodologies and AI can enhance microbiology teaching and improve academic content management. By integrating consolidated pedagogical practices from the "Adote uma Bactéria" activity into a dedicated digital environment, the platform centralizes and preserves scientific and educational production, reducing the typical dispersion of social networks. This structure favors automated analysis and learning personalization, allowing for the monitoring of student progress and transforming educational data into meaningful information for teaching practice. Thus, Conecta#Adote establishes itself as an innovative, collaborative, and scalable teaching-learning model, contributing to a more integrated, data-driven, and innovation-led scientific education.

It is important to highlight that, as a pilot study, this work presents limitations that

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must be considered. The platform's validation was performed with a restricted number of posts—originating from a single group in the "Adote uma Bactéria" activity in a specific subject and institution—which limits the generalization of the findings. Furthermore, the results presented relate primarily to the technical and functional feasibility of Conecta#Adote, not including, at this stage, direct measures of impact on student learning or objective academic performance indicators. Added to this is the fact that the platform is still under continuous development, with additional modules and functionalities in the refinement phase.

In future studies, we intend to expand the number of groups, classes, editions, and courses involved, as well as include different educational institutions, to test the tool's robustness in varied contexts and perform broader external validation. We also plan to integrate learning metrics—such as grades, performance in specific assessments, and engagement indicators—into the analyses generated by the platform, enabling a more direct evaluation of Conecta#Adote's impact on student training. Finally, the incorporation of new learning analytics dashboards and qualitative analyses could strengthen the use of the platform as a support for pedagogical decision-making, consolidating it as a scalable tool for AI-mediated microbiology teaching.

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Conflicts of interest: We declare that there are no conflicts of interest related to the conduct of this research.

Ethical approval: The study was approved by the Research Ethics Committee for Human Subjects (CEPSH ICB-USP) under protocol number CAAE 51764021.0.0000.5467. All participants were informed about the objectives and procedures of the research, and their anonymity and confidentiality were preserved throughout the study.

Data and material availability: The data and materials used in this study are available upon formal request. The developed digital platform is still in the finalization phase, with public availability expected from January 2026 onward.

Authors' contributions: DSO: study conception and design; technical development and implementation of the digital platform; structural organization of the project and manuscript writing. FBPO: technical development and technological support, with emphasis on artificial intelligence resources applied to the platform. BRC: provision of scientific-pedagogical material from the Adopt a Bacterium project and manuscript writing. RCCF: scientific guidance, overall supervision of the research, and scientific review. ACRM: scientific guidance, overall supervision of the research, methodological systematization, scientific review, and manuscript writing.

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