# Pedagogical Implications of Computer-Assisted Instruction in Reconfiguring Contents for General and Applied Ecology

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***Abstract:*** *The present research explores the pedagogical implications of Computer-Assisted Instruction (CAI) in reconfiguring educational content for General and Applied Ecology (EGA). The article demonstrates that CAI fundamentally transforms the learning process, moving it from a theoretical, passive approach to a practical and interactive one, essential for future specialists in the field. Through dynamic simulations and massive data analysis, students become active participants, able to explore complex ecological phenomena, such as population dynamics, climate change, and biogeochemical cycles, in a controlled virtual environment. The working methodology, focused on in-depth consultation of the specialized literature as the main method, emphasizes the importance of the theoretical foundation of any practical endeavor. The results reveal that CAI not only consolidates knowledge but also develops a series of essential skills for the modern ecology specialist, including critical thinking, data management, problem solving, and teamwork. Another central component is the ability to integrate information from various fields - biology, geography, and sociology - promoting a holistic and interdisciplinary vision of environmental issues. In conclusion, the CAI is not just an auxiliary tool, but a catalyst for a new educational paradigm that forms adaptable professionals with critical thinking and solid technical expertise, prepared to face the complex and dynamic challenges of the contemporary world.*

***Keywords:*** *Applied ecology, computer-aided instruction, environmental protection, digitalization.*

## 1. Introduction

The present research examines the pedagogical implications of Computer-Assisted Instruction (CAI) and its significant role in reconfiguring and modernizing educational content for the study of General and Applied Ecology (GAE). This methodological approach - striving for the predictive understanding of complex systems [1] - revolutionizes teaching and learning, overcoming the limits of traditional methods. By integrating CAI, ecology is transformed from a predominantly theoretical discipline into an extremely practical and interactive one, that can support biodiversity conservation and food production [2]. Under the above conditions, students are no longer mere recipients of information but become active participants in the instructional and educational process [3-5]. They can simulate complex phenomena, from population dynamics to the global carbon cycle, analyze massive data sets, and visualize the long-term consequences of environmental decisions.
This ability to "experiment" in a virtual environment strengthens the understanding of abstract concepts (such as climate change) [6], and connects theory to ecological reality, providing a relevant context for future specialists to better understand the ecological behavior [7].

The transition from a passive to an active teaching model is perhaps the most significant contribution of CAI and GenAI to ecology [8,9]. Traditional courses, focused on memorizing definitions and classifications, fail to capture the complexity and interdependence of ecological systems. Through CAI, fundamental concepts, such as interspecific competition or ecological succession, come to life in dynamic simulations. A student no longer just reads about the logistic growth model, but can directly manipulate variables (e.g. *environmental carrying capacity*, *reproductive rate*) to observe how they directly influence the evolution of a population. This direct interaction stimulates critical thinking and causal reasoning, essential for making informed predictions and developing viable solutions to environmental problems.
Equally, CAI facilitates an interdisciplinary approach to ecology. Computational models allow the integration of data from various fields - biology, chemistry, geography, and sociology - to provide a holistic view of ecological systems. For example, a species distribution model can include not only climatic and biological variables, but also sociological data on land use by local communities [10], thus highlighting the link between ecology and social factors. Thus, educational contents are reconfigured to prepare specialists capable of approaching environmental problems not only from an ecological perspective, but also from an economic, social, and ethical point of view.
In essence, CAI is not just an auxiliary tool but a catalyst for a new educational paradigm, which forms adaptable professionals with critical thinking, prepared to face the complex and dynamic challenges of the contemporary world. In addition to the cognitive benefits, CAI plays a crucial role in developing technical skills directly applicable in the job market. Data management and technology become core skills, not optional. Students learn to use specialized GIS mapping software to create conservation maps, apply statistical algorithms to analyze large pollution monitoring data sets, and develop simulation models to predict the effectiveness of a forest management plan [11]. These skills transform future ecologists from passive observers into ecosystem engineers, capable of generating data-driven solutions and collaborating effectively in multidisciplinary teams. The CAI thus reflects professional reality, preparing students for a field where technology is a central element of research and practice.

## 2. Working methodology - consultation and interpretation of specialized literature

The working methodology is based on an analytical and synthetic approach, with an emphasis on the systematic consultation of the specialized literature. This fundamental stage provides the theoretical foundation necessary to evaluate the effectiveness of CAI in the pedagogical context of ecology. The research began with a thorough review of scientific articles (theoretical foundation), reports, and case studies published in databases such as Web of Science®, Scopus®, ResearchGate®, and Google Scholar®.
The search targeted keywords such as *Instructional Computing in Ecology*, *Ecological Modeling Education*, *GIS in Environmental Education,* and *Pedagogical Innovations in Applied Ecology*, which allowed the identification of the existing conceptual framework and research gaps.

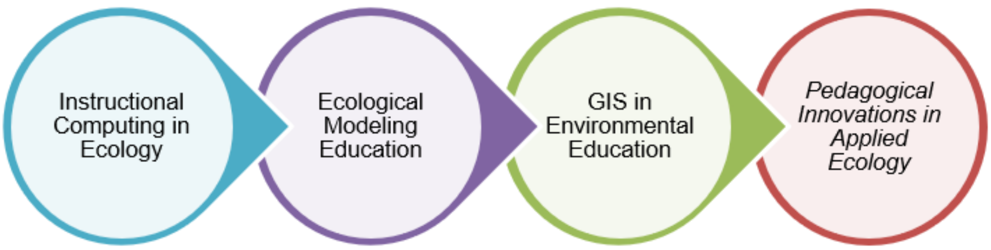


**Fig. 1.** Examples of keywords used in consulting and analyzing specialized literature

The information collected was synthesized to highlight how CAI reconfigures curricular content. A comparative analysis was conducted between traditional and CAI-based pedagogical methods, focusing on five key competencies identified as essential for the modern ecology specialist: critical thinking, modeling and simulation, data management, problem solving, and collaboration. In addition, a correlation matrix was created between the competencies facilitated by CAI and the specific modules of general and applied ecology.

## 3. Results and Discussions regarding the Pedagogical Implications of CAI in Ecology

Computer-assisted instruction (CAI) is proving to be an essential pedagogical tool for training ecologists, providing concrete results and contributing to the development of a wide range of skills. In addition to understanding theoretical concepts, students acquire practical modeling and simulation skills, allowing them to virtually experiment with complex ecological systems and visualize the consequences of human actions.

- **Ecosystem dynamics and structure** show us how life develops and interacts within an ecosystem, from the individual level to that of the entire community, by referring to:
    - ***interspecific relationships*** - basic interactions (predation, competition) define how species coexist;
    - ***population dynamics*** - these interactions directly influence the numerical growth or decline of populations;
    - ***ecological succession*** - populations and their interactions determine how an ecological community evolves and matures over time;
    - ***ecological evolution*** - in the long term, these interactions and environmental changes lead to the adaptation and evolution of species;
    - ***biodiversity*** - the result of these processes of evolution, interaction, and succession is reflected in the richness of species and the genetic variety associated with them;
    - ***aquatic ecosystems***, respectively ***coastal ecosystems*** - are only a small part of specific examples of environments in which all the processes mentioned above take place, one after the other.
- **Ecological flows and cycles** describe the movement of energy and matter, fundamental to the functioning of any ecosystem, by directly relating to:
    - ***primary production*** - the beginning of any energy flow, where plants (producers) convert solar energy into biomass;
    - ***energy flow*** - the energy stored in biomass is transferred along food chains;
    - ***biogeochemical cycles*** - in parallel with the energy flow, matter (elements such as carbon, nitrogen) continuously circulates between organisms and the environment;
    - ***hydrological cycles*** - the water cycle is essential and interconnected with the other cycles, transporting nutrients;
    - ***biomagnification*** - occurs as a result of the energy flow and matter cycles, where pollutants accumulate along the food chain.
- **Anthropogenic impact and pollution** describe how human intervention affects natural processes, from cause to effect, by relating to:
    - ***atmospheric pollution*** - industrial emissions are the primary source of pollutants;
    - ***greenhouse effect*** - occurs as a direct consequence of atmospheric pollution, through the accumulation of greenhouse gases;
    - ***climate change*** - the increase in the greenhouse effect leads to long-term changes in the global climate;
    - ***pesticide effects*** and ***the impact of mining*** - are only a small part of the concrete examples of activities that lead to specific pollution and degradation;
    - ***antibiotic resistance*** - is reflected as a consequence of the use of chemical substances in the environment, affecting biological processes;
    - ***waste management*** - comes as a response to the problem of pollution, representing efforts to minimize the impact.
- **Landscape ecology and resource management** refer to planning and interactions on a larger scale, often related to land use, by referring to:
    - ***landscape ecology*** - the analysis of the structure and composition of the landscape is invariably the starting point;
    - ***habitat fragmentation*** - a consequence of human development that alters the structure of the landscape;

  - ***forest resource management*** and ***the impact of tourism*** - also just a small part of the examples of specific management activities that influence the landscape;
  - ***ecosystem services*** - the functioning of the landscape provides benefits (services) to society, and their management is crucial.
- **Urban ecology and stress response** focuses on the interaction between the urban and natural environment, but also on the capacity of organisms to adapt, by referring to:
  - the relationship between ***urbanization and ecosystems*** - the initial process that inevitably alters the natural environment;
  - ***urban ecology*** - a branch of ecology that studies ecosystems in cities, as a reaction to urbanization;
  - ***urban sprawl*** - a specific problem of the urban environment that naturally and inevitably arises from urbanization;
  - ***stress response of organisms*** - a fundamental biological response to altered environmental conditions (e.g., *pollution*, *drought*, *desertification*);
  - ***host-parasite relationship*** and ***the impact of invasive species*** - are only some of the ecological relationships that can be intensified or modified in the context of urban stress;
  - ***ecological monitoring*** - a method to measure and evaluate all these processes, being a final step in understanding and managing them.

**Table 1:** Pedagogical implications of CAI in relation to the dynamics and structure of ecosystems

| **Indicatorul considerat** | Implications in **General Ecology** | Implications in **Applied Ecology** | **Pedagogical purpose** |
|---|---|---|---|
| ***Interspecific relationships*** (🤝) | Models competition, predation, and symbiosis relationships | Control agricultural pests by simulating their interactions | ***Understanding complex interactions*** It helps students visualize and understand the hidden dynamics behind ecological relationships. |
| ***Population dynamics*** (📈) | Simulates complex growth and interaction models | Plan for the management of threatened species | ***Developing predictive thinking*** It builds the ability to forecast changes in populations and plan interventions. |
| ***Ecological succession*** (🌱) | Simulates the development stages of ecosystems | Restore degraded habitats by designing regeneration scenarios | ***Strengthening the concept of ecosystem evolution*** It allows accelerated observation of slow regeneration processes. |
| ***Ecological evolution*** (🧬) | Models evolutionary processes at the population and species level | Predicts the evolution of pathogens and harmful species | ***Illustrating evolutionary mechanisms*** It provides a platform to see natural selection and adaptation in action. |
| ***Biodiversity*** (🦋) | Analyze species distribution and richness | Identify priority conservation areas | ***Understanding the importance of biodiversity*** It helps visually identify the links between biodiversity and ecosystem stability. |
| ***Aquatic ecosystems*** (🌊) | Simulates water quality and marine life | Monitors and prevents water pollution | ***Study of specific ecosystems*** It allows detailed exploration of difficult-to-access environments (the ocean floor). |
| ***Coastal ecosystems*** (🌴) | Simulate their role in coastal protection | Design restoration projects | ***Applying knowledge in concrete case studies*** Connect theory to real-world conservation issues. |

**Table 2:** Pedagogical implications of CAI in relation to ecological flows and cycles

| **The indicator considered** | Implications in **General Ecology** | Implications in **Applied Ecology** | **Pedagogical purpose** |
|---|---|---|---|
| ***Primary production*** (🌿) | Simulates ecosystem productivity | Optimizes fertilization and irrigation in agriculture | ***Understanding the energetic basis of life*** Visually explain how energy enters ecological systems. |
| ***Energy flow*** (⚡) | Visualize food chains and webs | Optimize agricultural production by modeling energy efficiency | ***Strengthening the concept of energy transfer*** It shows how energy is lost at each trophic level, explaining the structure of the ecosystem. |
| ***Biogeochemical cycles*** (🔄) | Models the circulation of elements (C, N, P) | Assess the impact of pollution on nutrient cycles | ***Integrating the notions of chemistry and ecology*** It helps to visualize the circuit of matter on a global and local scale. |
| ***Hydrological cycles*** (💧) | Models water distribution and quality | Manages drinking water resources | ***Awareness of the importance of water*** It trains students in managing a critical resource for survival. |
| ***Biomagnification*** (🧪) | Models the accumulation of pollutants in the food chain | Develops hazardous waste management plans | ***Demonstration of toxic effects over time*** It illustrates how pollutants accumulate in food chains with a serious impact. |

**Table 3:** Pedagogical implications of CAI in relation to anthropogenic impact and pollution

| **The indicator considered** | Implications in **General Ecology** | Implications in **Applied Ecology** | **Pedagogical purpose** |
|---|---|---|---|
| ***Air pollution*** (🏭) | Model the dispersion of pollutants | Plan the location to minimize impact | ***Visualizing the invisible impact*** It helps to understand how pollutants disperse in the environment. |
| ***The greenhouse effect*** (🌡) | Simulates the impact of greenhouse gases on the climate | Develops strategies to reduce emissions | ***Climate change awareness*** It demonstrates the direct link between human actions and global warming. |
| ***Climate change*** (☁) | Model climate evolution scenarios | Adapt agricultural strategies to new conditions | ***Forming adaptive solutions*** Prepares students to develop strategies for adapting to change. |
| ***Effects of pesticides*** (💀) | Simulates the effects of pesticide residues on organisms | Optimizes pesticide use in agriculture | ***Understanding chemical risks*** It shows how chemicals can affect food chains and human health. |
| ***The impact of mining*** (⛏) | Simulates soil and water pollution | Develops plans for the greening of abandoned mining sites | ***Developing remedial solutions*** It allows planning and simulation of industrial area restoration processes. |
| ***Antibiotic resistance*** (💊) | Simulates the evolution of resistant bacteria in the environment | Preventing the spread of resistance in water treatment systems | ***Connecting ecology with public health*** It shows how ecological processes can directly influence human health. |
| ***Waste management*** (🗑) | Model waste decomposition in landfills | Design efficient composting and recycling systems | ***Promoting the circular economy*** Helps to understand recycling processes and their environmental impact. |

**Table 4:** Pedagogical implications of CAI in relation to landscape ecology and resource management

| **The indicator considered** | Implications in **General Ecology** | Implications in **Applied Ecology** | **Pedagogical purpose** |
|---|---|---|---|
| ***Landscape ecology*** (🏞) | Analyze the structure and function of the landscape | Plan land use at the regional level | ***Developing large-scale thinking*** It helps to understand how landscape elements interact. |
| ***Habitat fragmentation*** (💔) | Analyze the impact of landscape barriers on species | Design ecological corridors to connect habitats | ***Understanding connectivity*** It demonstrates the impact of isolation on species and the importance of ecological corridors. |
| ***Forest resource management*** (🌳) | Model tree growth and harvesting | Optimizes cuts for sustainable exploitation | ***Assimilation of the concept of sustainability*** It forms the ability to manage natural resources in the long term. |
| ***Ecosystem services*** (🎁) | Evaluate the benefits of ecosystems to society | Calculate the economic value of environmental services | ***Valuing nature*** It shows students that nature offers quantifiable benefits, not just aesthetic ones. |
| ***The impact of tourism*** (🚶) | Modeling tourist pressure on protected areas | Develop sustainable ecotourism strategies | ***Understanding human pressure*** It highlights how recreational activities can affect the environment and the need for ecological planning. |

**Table 5:** Pedagogical implications of CAI in relation to urban ecology and stress response

| **The indicator considered** | Implications in **General Ecology** | Implications in **Applied Ecology** | **Pedagogical purpose** |
|---|---|---|---|
| ***Urbanization and ecosystems*** (🏢) | Simulates the impact of urban expansion on the environment | Design green cities and sustainable urban spaces | ***Understanding coexistence*** It shows how the natural and built environments can coexist and influence each other. |
| ***Urban ecology*** (🌿) | Simulates the role of green spaces in air purification | Plan parks and green roofs in cities | ***Developing eco-infrastr. solutions*** It trains practical skills to integrate nature into the urban environment. |
| ***Urban agglomeration*** (🥵) | Analyze the urban heat island effect | Design cooling strategies through urban vegetation | ***Awareness of city problems*** It offers solutions to environmental problems generated by urban density. |
| ***The body's response to stress*** (😰) | Models plant response to drought or salinity | Develop strategies for agriculture in arid environments | ***Study of biological adaptability*** It helps to understand the mechanisms by which organisms adapt to extreme environmental conditions. |
| ***Host-parasite relationship*** (🐛) | Model the dynamics of parasite populations | Controls diseases in natural and agricultural ecosystems | ***Understanding biological control*** It shows how natural processes can be used to manage problems in agriculture. |
| ***Impact of invasive species*** (👾) | Simulates the spread and impact of non-native species | Develop control plans for invasive species | ***Preventing biological risks*** It builds the ability to identify and control threats to local biodiversity. |
| ***Ecological monitoring*** (🔬) | Analyze data to detect changes | Early warning systems for pollution | ***Training in monitoring skills*** Prepares students to use technology in data management. |

The last column in the above tables explains the educational purpose of each implication of CAI, showing how the use of these tools contributes to the formation of theoretical skills and (re)adaptation of practical skills among students, as future specialists in the field.
Moreover, from a pedagogical point of view, in order to highlight the connection between IAC and general and applied ecology, we can also consider the types of skills and competences developed by students. Some of these are reproduced in Table 6, in a natural (chrono)logical chain, which reflects a progressive learning path, where each level builds on the previous one, namely:

- ***Critical Thinking & Analysis*** - this is the foundational level; before students can use digital tools or plan projects, they need to understand the basic concepts. IAC provides models so that students can analyze and interpret cause-and-effect relationships.
- ***Modeling & Simulation*** - once the student understands the theoretical principles, they can move on to applying them in virtual models. This level transforms abstract knowledge into controlled experiments. Simulations are used to test hypotheses and understand how ecological systems work without the need for costly practical effort.
- ***Mapping & Visualization*** - once the student understands the processes, they need to place them in a spatial context. Mapping and visualizing geographic data is crucial for seeing how ecological phenomena are distributed on a map and how they change over time. It is a transition from understanding processes at a local scale to visualizing them at a global scale.
- ***Data Management & Technology*** - this level focuses on concrete tools. IAC is not just about visualizing, but also about working with large data sets. The ability to collect, organize, and use specialized software becomes vital to process information obtained from simulations or from the field.
- ***Communication & Presentation*** - once the data has been analyzed and interpreted, the results must be communicated effectively. This competency refers to transforming complex information into clear (info)graphics and reports, accessible to the general public or decision-makers.
- ***Collaboration & Teamwork*** - environmental projects are rarely carried out by a single person. IAC facilitates collaboration through virtual platforms. This level of competency develops as students learn to work together, share tasks, and combine individual results into a common project.
- ***Problem Solving & Decision Making*** - using analysis, simulation, data, and collaboration, students learn to approach complex environmental problems and formulate concrete solutions. It is the level where theory is transformed into action, making informed decisions to solve an environmental problem.
- ***Project Planning & Management*** - involves organizing and implementing a solution; a student competent in this area can structure a project from A to Z, allocate resources and monitor progress, applying environmental knowledge in a realistic setting.
- ***Ethics & Social Responsibility*** - this level is the highest, integrating all the others; it is the point where the student understands not only how to solve a problem, but also why and for whom. IAC offers complex scenarios to discuss the ethical implications of environmental decisions, developing a sense of professional responsibility.

All the skills mentioned complement each other and culminate in problem-solving and decision-making, where students apply critical thinking and technical knowledge to develop viable solutions to real environmental challenges, all of which contribute to a complete and relevant education for the job market. Furthermore, CAI provides an ideal framework to overcome traditional disciplinary boundaries, promoting a holistic and interdisciplinary view of environmental issues. Using simulations and shared databases, students learn to integrate knowledge from ecology, computer science, chemistry, sociology, and even economics. For example, a specialist can use a CAI model to analyze not only the ecological impact of a project, but also its economic and social consequences. This approach allows future specialists to communicate effectively with experts from various fields, from engineers and urban planners to policymakers.
Therefore, CAI not only improves technical knowledge but also contributes to the training of professionals capable of navigating the complexity of global problems and developing integrated solutions adapted to reality.

**Table 6:** Skills developed among students as a result of IAC's foray into ecology

| **Level of competence** | **Relevance*** (%) | Skills developed (**General Ecology**) | Practical Applications (**Applied Ecology**) |
|---|---|---|---|
| ***Critical thinking & analysis*** (🧠) | 15% | Analysis of ecological data (e.g., growth curves)<br>Identification of causes and effects within ecosystems | Assessing the impact of an industrial project on an ecosystem<br>Analysis of water and air quality monitoring data |
| ***Modeling & simulation*** (💻) | 15% | Understanding complex processes (e.g., *ecological succession*)<br>Experimenting with multiple variables in a virtual environment | Simulating the spread of an invasive species<br>Modeling reforestation scenarios |
| ***Mapping & visualization*** (🗺) | 10% | Interpreting ecological maps and spatial data<br>Large-scale visualization of global ecological phenomena<br>Understanding the spatial distribution of species and habitats | Creating flood risk maps based on vegetation<br>Planning migration corridors for animals<br>Identifying areas with potential for eco-energy development |
| ***Data management & technology*** (📊) | 15% | Collecting, storing, and organizing large data sets<br>Using specialized software<br>Familiarizing with remote sensing and monitoring technologies | Implementing automated environmental monitoring systems<br>Analysis of genetic data for biodiversity conservation<br>Automating environmental impact reports |
| ***Communication & presentation*** (📢) | 5% | Creating clear visual representations of ecological data<br>Developing reports and presentations based on simulations<br>Explaining complex concepts to non-specialist audiences | Creating infographics about local biodiversity<br>Presenting the results of an environmental impact study<br>Developing interactive educational materials for schools |
| ***Collaboration & teamwork*** (🤝) | 15% | Using online platforms to work on joint projects<br>Dividing tasks and integrating individual contributions | Collaboration with experts from various fields for environmental projects<br>Development of a common, widely accessible species database |
| ***Problem solving & decision making*** (💡) | 10% | Systematic approach to complex environmental problems<br>Collaborating in virtual teams to solve practical cases | Developing a management plan for a national park<br>Making informed decisions about resource use |
| ***Project planning & management*** (📅) | 5% | Structuring an ecological study in stages (analysis, reporting)<br>Allocation of resources for a virtual project | Managing a degraded habitat restoration project<br>Planning an invasive species inventory campaign |
| ***Ethics & social responsibility*** (⚖) | 10% | Recognizing the ethical implications of ecological research<br>Assessing the risks and benefits of environmental decisions | Ethical analysis of a natural resource exploitation project<br>Assessing the social impact of pollution on communities |

* relevance for the future ecology specialist

## 4. Perspectives and Proposals in relation to the Integration of IAC in Ecology

Despite the obvious benefits, the implementation of CAI in environmental education faces challenges related to access to technology and teacher training. To maximize the potential of this approach, the following development directions are proposed:

- ***creating integrated educational platforms*** - developing customized software suites that combine simulations, data analysis, and GIS tools in a single platform would facilitate the learning process and reduce technological barriers.
- ***continuous training of teaching staff*** - refresher courses for teachers are essential to familiarize them with new pedagogical tools and methodologies, ensuring an effective integration of IAC into the curriculum.
- ***promoting pedagogical research*** - it is necessary to carry out rigorous impact studies to assess the extent to which CAI improves learning outcomes in the long term, providing concrete data to justify investments in technology.
- ***developing case studies based on real data*** - using current data sets from environmental agencies or active research would increase the relevance and realism of student projects.

CAI represents an indispensable component for the future of ecological education, providing a bridge between theoretical knowledge and practical application. By proactively adopting this approach, educational institutions can train a new generation of specialists, capable of responding effectively and innovatively to the complexity of the ecological challenges of the 21st century.

## 5. Conclusions and Good Practice Recommendations

Based on the analysis of the specialized literature and pedagogical results, it can be concluded that Computer-Assisted Instruction (CAI) is essential for the modernization of ecology education. This approach transforms the learning process, shifting the emphasis from a passive assimilation of information to an active and interactive participation. Through simulations, data analysis, and visualizations, CAI provides a solid bridge between theoretical knowledge in general ecology and practical applications of applied ecology. The formation of skills such as critical thinking, modeling, data management, and collaboration is fundamental to preparing a new generation of specialists capable of successfully addressing complex environmental challenges. To maximize the benefits of CAI in ecological education, the following good practice recommendations are proposed:

- ***holistic curricular integration*** - CAI should not be treated as a separate module, but as an integrated tool in all ecology disciplines, from basic courses to advanced research projects. Educational institutions should reassess and restructure curricula to coherently incorporate digital tools.
- ***universal access to specialized tools*** - ensuring students have access to specialized software, either through university licenses or through the use of open-source tools, is crucial. This will bridge the technology gap and allow all students to develop relevant skills.
- development of personalized teaching materials - teachers are encouraged to create case studies and exercises based on real ecological data, specific to their region or country. This motivates students by connecting theory to local problems.
- ***continuous teacher training*** - organizations and universities should offer regular training sessions for teachers, focused on the latest CAI techniques and platforms. A well-trained teaching workforce is key to a successful implementation of this methodology.
- ***promoting interdisciplinary projects*** - encouraging students to participate in projects that involve collaboration with specialists from other fields will simulate the real work environment and emphasize the importance of a holistic approach in solving environmental dynamic problems.

Finally, adopting this pedagogical approach represents not only an improvement in teaching methods but also a strategic investment in the training of competent professionals capable of responding with innovation and responsibility to the complexity of the ecological challenges of the future.

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