Metaverse Basic and Applied Research. 2023; 2:71
doi: 10.56294/mr202371

REVIEW

The Metaverse as an Innovative Tool for Teaching Biology in High School

El metaverso como herramienta innovadora para la enseñanza de la biología en el bachillerato

Andrea Eloisa Monroy Villon[1]

[1]Unidad Educativa Pedro Balda Cucalón, Docente de Biología, Manta, Ecuador.

Cite as: Monroy Villon AE. The Metaverse as an Innovative Tool for Teaching Biology in High School. Metaverse Basic and Applied Research. 2023; 2:71. https://doi.org/10.56294/mr202371

Submitted: 02-07-2023 **Revised:** 16-10-2023 **Accepted:** 26-12-2023 **Published:** 27-12-2023

Editor: Yailen Martínez Jiménez

Corresponding author: Andrea Eloisa Monroy Villon

ABSTRACT

Introduction: this paper exposes the educational potential of the metaverse as an innovative tool for teaching the scientific contents of the biology subject within the high school sub-level, considering the current pedagogical challenges and the possibilities offered by immersive environments to improve the understanding of biological phenomena.
Method: through a theoretical and documentary review of research from the last 5 years, the study was systematized and organized around key categories: conceptualization, applications, challenges and opportunities of the metaverse in the biology teaching process.
Results: relevant educational applications of the metaverse were identified, such as the simulation of cellular processes, three-dimensional anatomical exploration, recreation of ecosystems and the use of virtual laboratories. Similarly, benefits such as increased student motivation, personalization of learning and strengthening of scientific competencies were highlighted.
Conclusions: the metaverse offers significant opportunities to transform high school biology teaching, provided that its implementation is based on sound pedagogical principles, inclusion, and continuous teacher training.

Keywords: Metaverse; Biology Teaching; High School Education; Educational Technology; Immersive Reality.

RESUMEN

Introducción: el presente documento expone el potencial educativo del metaverso como herramienta innovadora para la enseñanza de los contenidos científicos de la asignatura de biología dentro del subnivel de bachillerato, considerando los desafíos pedagógicos actuales y las posibilidades que ofrecen los entornos inmersivos para mejorar la comprensión de fenómenos biológicos.
Método: por medio de una revisión teórica y documental de investigaciones de los últimos 5 años, se sistematizo y organizo en torno a categorías clave: conceptualización, aplicaciones, desafíos y oportunidades del metaverso en el proceso enseñanza de la biología.
Resultados: se identificaron aplicaciones educativas relevantes del metaverso, como la simulación de procesos celulares, la exploración anatómica tridimensional, la recreación de ecosistemas y el uso de laboratorios virtuales. De igual manera, se destacaron beneficios como el aumento en la motivación estudiantil, la personalización del aprendizaje y el fortalecimiento de competencias científicas.
Conclusiones: el metaverso ofrece oportunidades significativas para transformar la enseñanza de la biología en el bachillerato, siempre que su implementación se base en principios pedagógicos sólidos, inclusión y formación docente continua.

Palabras clave: Metaverso; Enseñanza de la Biología; Educación En Bachillerato; Tecnología Educativa; Realidad Inmersiva.

INTRODUCTION

We live in a time when digital technology is advancing unchecked and is increasingly present in everything. And amid this advance, the metaverse emerges as a resource that could radically change how we teach. These are virtual spaces with 3D graphics, interactive environments, and an "inside" feeling that changes the experience. This new world offers different, unusual ways for students to see, experience, and understand complex biological phenomena. It is no longer just about reading or looking at a flat image: now they can immerse themselves, move around, and touch (well, almost) these contents.

Biology in high school has the challenge of connecting with today's teenagers. It is not enough to teach facts or theories. A bridge is needed between this scientific knowledge and what they experience or feel. And yes, the metaverse could be that bridge. Because it is not just a flashy novelty, it is a tool with the potential to generate learning that leaves a mark. Especially considering that the Ecuadorian curriculum seeks to promote scientific thinking, value the environment, and apply scientific methods as an essential part of training in natural sciences.

Within this framework, the virtual becomes useful. Very useful. It allows us to observe processes that cannot be seen with the naked eye or that would be costly or dangerous in real life. It also breaks down barriers: the lack of resources, laboratories, or even the physical limitations of the classroom can be left behind if this technology is used well. The sensory, the visual, the interactive... all this awakens interest. And not only that, it also encourages participation, which is key to real learning.

Many studies agree that immersive environments positively affect how science students learn. Makransky and Mayer (2022) reviewed research showing improvements in understanding and knowledge retention thanks to these technologies.[1,2,3] Why? Because they allow us to see concepts that were previously just words or drawings. And that gives classes a different rhythm, a different depth. Something more meaningful.

This article starts from that premise: that the metaverse is not just technology but a new way of teaching biology. The advantages and limitations will be analyzed. It is not about idealizing it. We will have to think about the ethical, the pedagogical, and, above all, the role of the teacher in this new scenario. Because if it is not used with intention and meaning, it could remain just a fad. The idea is to go further: to integrate these tools into the curriculum in a critical, conscious way adapted to our reality.

BIOLOGY, METAVERSO AND EDUCATION IN THE BACCALAUREATE

Biology is a subject that focuses on teaching how the living world works. From the most minor thing, a cell, to massive systems like an entire ecosystem. In high school, this subject seeks something more than just memorization: it is about students observing, thinking, comparing, and questioning. About developing that scientific, but also ethical, view of life. Because knowing how we live also helps us to take better care of who we are and what surrounds us.[4]

In parallel, this concept of the metaverse appears. An idea that at first sounds like science fiction but is already part of many areas. Lee et al. (2021) emphasize that it is a digital space where several technologies intersect: augmented and virtual reality, social networks, all of that together.[5] A place where you don't just look but where you enter, move, and act. It is as if you were inside a video game but for educational purposes. A space where you can learn by touching, exploring, and experimenting.

When you combine biology and the metaverse, an interesting door to teaching opens up. Biology provides the content, the essentials: what there is to learn. The metaverse offers another way of experiencing it—a more immersive, more visual way. This is ideal for students who are just at that stage when abstract thinking begins to take hold. So yes, these tools can help them understand processes that remain distant concepts.

To give an example: it is not the same to see a drawing of a cell as it is to be able to walk inside one in giant size. It is essential to know how the organelles move, how DNA replicates, and how everything is connected. That generates another kind of impact. You can also simulate entire ecosystems and see how species relate to each other and how climate or pollution influences them. All of that, which often seems so theoretical, becomes tangible where skills such as observing, analyzing, hypothesizing, and discussing with others are developed.[6] And that is the kind of learning that sticks. Therefore, 21st-century education cannot ignore these technologies as long as they are used judiciously and with a solid pedagogical approach.

UNESCO (2021) has insisted that digital literacy should include much more than knowing how to use a computer. It is about understanding how these digital environments work, how to participate in them critically, and how to use technology to build knowledge rather than just consume it.[7] From there, the metaverse can be a learning space where one investigates, collaborates, and reflects, not just a place to look at things.

https://doi.org/10.56294/mr202371

Of course, it must be said that not everything is so easy. Using the metaverse in class does not just mean turning on an application. You have to plan. Be clear about what it is used for, how you will work with the students, and what tools are needed. And don't forget that it is not a substitute for real life. It is an extension, a complement. Because not everything can be learned in the virtual world, nor should it be. So, the challenge is there. For biology teachers, above all. To find ways of integrating these technologies without losing sight of what is essential: the learning objectives, the reality of the classroom, and the needs of the students. Because yes, the metaverse can transform the way we teach biology, but only if it is done with purpose, with meaning, and, above all, with humanity.

Applications of the Metaverse in the Teaching of Biology at Secondary School Level

Biology, a science that relies heavily on observation, experiment, and analysis, requires students to do things, not just listen or read. However, that becomes complicated in many schools, especially at the sub-baccalaureate level. There is a lack of laboratories, time, and materials. Sometimes, there is not even adequate space. That is why the metaverse can be a way out. A different option that, if used well, expands what is possible in the classroom. It allows for simulation, creation, and exploration. Things that could not be done in the physical classroom.

One of the most potent ideas is to see cellular and molecular processes in 3D. Mitosis, meiosis, how DNA is transcribed, and all those processes commonly seen in a diagram or a video can be experienced here. Where the student can enter, move around inside, and observe from different angles. That changes the way things are understood. Because when you see something move and interact, you remember it better. According to recent studies, this immersive experience helps to fix the contents more because it activates visual, spatial, and sensory memory.[8,9,10]

Another practical application is the exploration of the human body. Platforms such as BioDigital Human allow you to explore the body as if it were a building and each system and organ as if it were a different room. You can remove layers, rotate, and zoom in. See muscles, bones, and tissues. You can even do clinical simulations. Diagnoses, treatments, physiological analyses. This can be a powerful way for high school students to learn anatomy, clinical reasoning, and logical thinking.[11,12] Thus, they escape the traditionalism that goes beyond just looking at drawings.

However, the possibility of entering ecosystems: jungles, oceans, moors, etc. No longer just reading about the Amazon or coral reefs. Now, students can explore them and see the species, the cycles, and the food chains. They can see how pollution affects them and what happens with climate change. These experiences generate an ecological awareness that grows with each immersion. They also allow for integrating various subjects: biology, geography, and even environmental education.[13,14,15]

Then, there are virtual laboratories. With simulators like Labster, you can perform experiments that would be costly or dangerous in real life. Cell cultures, microscopy, DNA analysis—all of this can be done online, safely, at any time, and repeated as many times as necessary. De Jong et al. (2021) point out that these virtual laboratories complement face-to-face teaching well. They give students more autonomy and allow them to learn at their own pace.[16]

The metaverse is a tool that adapts. Not all students learn in the same way or at the same pace. Some need more time, while others prefer the visual. This type of technology allows for personalization, adjusting the difficulty, giving feedback in real-time, and adapting tasks according to needs.[17] These principles are very much in line with the formative assessment promoted by the Ecuadorian curriculum. It is worth mentioning that, in these environments, students are not alone. They can work in teams, talk to others through their avatars, and solve problems together. This strengthens other skills: empathy, communication, argumentation, and creativity. These are necessary skills for the 21st century, where it is no longer enough to know; you have to learn how to do and live together.[18]

Although it is still not very common in Ecuador to see metaverse in the classroom, there are some pilot experiences. Some schools have started to use virtual reality in biology practices. Simulators have been tested in specific technical baccalaureate programs to train students in health and science. And yes, the results are promising. What is needed is more investment, training for teachers, and giving them the tools to implement these innovations in their planning.

However, for all this to work, it has to be planned with intention. It's not about just using technology for its own sake. Teachers must be clear about what they want to achieve, how it will be assessed, and what activities will be proposed. Technology alone does not work miracles. It is the pedagogical use that makes the difference. A significant obstacle is that many teachers have not been trained or are hostile to technology. They are unfamiliar with immersive technologies, nor do they know how to design digital experiences. So, offering continuous training, workshops, and support is essential. It is not enough to hand over equipment. You also have to train people in the how and the why. Only in this way can effective, ethical, and context-appropriate use be guaranteed.[19,20]

This initiative must be accompanied by structural reform and investment in institutions, as in many schools, there are no computers, or the internet fails. And that limits. But mixed solutions could be sought: collaborations with universities, companies, and the state. Models that allow resources to be shared and reach more places. Democratizing access to the educational metaverse so that it is not only available in private schools.

Finally, there is the motivation factor. The metaverse has something specific that hooks you. Students become more interested, pay attention, and get involved. Especially teenagers, who tend to disconnect from the more traditional approach. When they feel that they are inside the knowledge, that they are living it, that they can experience it, their attitude changes. And that shows in their performance, learning, and the way they see science. The metaverse can be a powerful tool for transforming how biology is taught in secondary education. But it requires planning, training, and support. It is not a magic wand but an opportunity to make science come alive in the classroom.

Challenges and Opportunities of Integrating the Metaverse into Biology Education

When thinking about the metaverse in the classroom, especially in high school biology classes, it is inevitable to see both the challenges and the possibilities. This technology brings with it an apparent duality: on the one hand, it offers enormous potential; on the other, it presents barriers, many of them structural. Understanding this tension, what can be done, and what is still preventing it is key if we want to build a strategy that works and is realistic and useful for the Ecuadorian educational context.

One of the biggest obstacles is inequality of access—the famous digital divide. Although significant technological progress has been made in some urban regions of the country, this does not translate to all contexts. There are institutions, especially in the public system, where there is no adequate equipment and there is not even constant connectivity. It is tough to talk about implementing metaverse or immersive realities. Rural or remote schools, for example, face much more serious limitations that are not resolved with good intentions.[21,22,23] In addition, the costs are high; we are not just talking about buying virtual reality glasses or platform licenses. Infrastructure, maintenance, and technical support are also required. And that, in most of the country's educational centers, is still unfeasible.

Another problem has to do with the teachers themselves. Many biology teachers working in secondary education have not been trained in using immersive technologies. They have not been trained in active methodologies that combine science and technology. What is observed in several Latin American countries, and Ecuador is not the exception, is that the lack of technical knowledge and the resistance to change become barriers that are difficult to break.[24,25] For this reason, it is becoming urgent that there be clear policies for professional updating. Training programs that not only teach digital tools but also incorporate pedagogical reflection, instructional design, and critical thinking. Technology without accompaniment falls short. It is wasted.

There are also issues to do with inclusion. Because not all students have the same conditions for interacting with virtual environments. Some have sensory, motor, or cognitive limitations. For this reason, the platforms and resources used in the educational metaverse must include adaptations for everyone, without exceptions. Otherwise, there is a risk of creating new forms of exclusion. In addition, we must be careful with the side effects. Excessive use of digital environments without clear guidance or a balance with face-to-face learning can lead to problems such as eyestrain, isolation, or even a certain degree of technological dependence.[26,27] All this must be considered from the outset, with planning that puts the student's well-being first.

From an ethical perspective, there are also issues to be resolved. Data management, for example. When students use avatars or interact on digital platforms, they leave traces of data that can be sensitive. If not adequately protected, without a clear privacy policy, that information could be used for non-educational purposes. That is why any implementation must include security standards. Protocols that ensure informed consent, especially when working with minors. It is about using technology and doing so responsibly and with care.[28,29]

Even with all these challenges, the opportunities brought by the metaverse are enormous. One of the most powerful is the possibility of providing access to quality educational experiences, regardless of location or resources. Students who have never entered a laboratory could simulate one, observe biological structures, analyze processes, and interact with complex systems—all without the need for expensive materials or physical infrastructure. This not only improves learning but also reduces inequalities.

Furthermore, the metaverse allows us to go beyond memorization. Here, students do not repeat; they do. They ask questions, experiment, compare results, and conclude. In this way, they develop the foundations of the scientific method—but not as a theory. But as experience. It also encourages collaborative work, effective communication, and problem-solving—skills that are not exclusive to science but fundamental to any field in the 21st century.[30,31]

Motivation is another key factor. It has been shown that immersive environments capture students' attention more, especially teenagers, who often feel disconnected and bored with content they perceive as distant. Their attitude changes when they are allowed to learn in a dynamic, participatory way, in a space that more closely resembles the world in which they already live digitally. Not only that, but their willingness to learn,

their retention of content, and their overall performance also change.[32]

And there is one last point that should not be overlooked: interdisciplinarity. What is taught in the metaverse does not have to be limited to biology alone. Other subjects such as chemistry, physics, mathematics, environmental sciences, philosophy, and ethics can be integrated. Because when life is simulated and artificial worlds are created to understand the natural world, questions arise about what is real, the limits of science, and what it means to intervene in life (19). And those questions deserve space, where the Ecuadorian curriculum already proposes that perspective with its integrated approach. The metaverse can be another way of putting this into practice. Therefore, integrating the metaverse into high school biology education is not easy, but it is a unique opportunity to change how young people relate to science. If decisions are made based on ethics, pedagogy, and context, the benefits can far outweigh the problems.

CONCLUSIONS

The metaverse is undoubtedly emerging as one of the most profound transformations in how natural sciences are taught today, especially in biology. Its capacity to generate immersive spaces where the student observes and interacts makes it a tool with the potential to overcome many barriers that limit teaching in secondary education. We are talking about real barriers: the shortage of laboratories, the lack of materials, and the limited time available for scientific practices that contribute to learning. In contrast, three-dimensional simulations and the visualization of processes in digital environments offer a new possibility: learning in-depth, actively, from experience.

Throughout this text, we have shown that the metaverse opens new possibilities in terms of content and teaching resources and allows for developing skills that cut across all areas. Skills such as critical thinking, collaboration, problem-solving, and autonomy. All the things needed so that students not only learn science but also become citizens with criteria when faced with the challenges of health, the environment, sustainability, or technology we face as a society. And it is not a minor detail: it has also been seen how the virtual environment achieves something often lost in traditional classes. To motivate. To engage. To get students interested in science again. To make them want to know more.

Of course, it's not all enthusiasm. Serious obstacles were also identified that cannot be ignored if there is to be a real integration of the metaverse in the classroom. Obstacles include digital inequality, the lack of technical and pedagogical preparation of teachers, technical requirements, ethical implications related to the use of personal data, or the risk of generating new exclusions instead of reducing them. Solving these problems requires a global perspective. It is not something that a single teacher or a single institution can do alone. Educational authorities need to lead the process. Clear public policies need to be created, continuous training processes need to be promoted, and there needs to be investment in infrastructure. Alliances must be built between the education system, universities, and the technology sector. In other words, a comprehensive and long-term commitment is required.

In this sense, the metaverse should not be considered a goal but an end in itself. That would be a mistake. It has to be seen as a means. It is another tool that, if used well, can transform how we experience biology education. But for that to happen, its implementation must be guided by sound pedagogical criteria. It has the student at the center. It thinks about inclusion, context, and the meaning of what is being taught. Above all, it always maintains a critical perspective because it is not about using technology for novelty's sake but for relevance.

From now on, the ideal would be to promote research that evaluates with concrete data how this tool is impacting learning. What works, and what doesn't? What barriers are still present? And, above all, what strategies can be replicated in different contexts throughout the country? Although Ecuador is one country, the educational reality is diverse. For the metaverse to have a real effect on the teaching of biology, it must be adapted to these differences.

Right now, we have the opportunity. It is an opportunity to leave certain traditional classroom boundaries behind and open the door to a new way of teaching and learning. A way that not only uses technology but inhabits it. That turns it into a bridge, a space, a living experience. A more active, more immersive, and, at heart, more human education.

REFERENCES

1. Makransky G, Mayer RE. Benefits of immersive virtual reality in learning science: A systematic review. Applied Cognitive Psychology. 2022;36(3):471–85. https://doi.org/10.1002/acp.3903

2. Alvarado MAG. IA´ Tools for the development of investigative skills. LatIA 2023;1:17–17. https://doi.org/10.62486/latia202317.

3. Bair E, Stenerson M, Skolnik A. Using BioDigital Human in biology instruction: engaging students in im-

mersive anatomical exploration. Journal of Science Education and Technology. 2022;31(3):373–83. https://doi.org/10.1007/s10956-021-09942-y

4. Boutahir MK, Hessane A, Lasri I, Benchikh S, Farhaoui Y, Azrour M. Dynamic Threshold Fine-Tuning in Anomaly Severity Classification for Enhanced Solar Power Optimization. Data and Metadata 2023;2:94–94. https://doi.org/10.56294/dm202394.

5. Bowman ND, Jones ML, McMahan T, et al. Virtual nature as an educational tool: exploring environmental science concepts in immersive settings. Environmental Education Research. 2023;29(2):289–304. https://doi.org/10.1080/13504622.2022.2049782

6. Cabero J, Llorente MC. Formación docente y tecnologías emergentes: retos para la enseñanza en contextos digitales. Comunicar. 2020;28(65):25–34. https://doi.org/10.3916/C65-2020-02

7. Cano CAG, Castillo VS. Systematic review on Augmented Reality in health education. Gamification and Augmented Reality 2023;1:28–28. https://doi.org/10.56294/gr202328.

8. Castillo JIR. Augmented reality in surgery: improving precision and reducing risk. Gamification and Augmented Reality 2023;1:15–15. https://doi.org/10.56294/gr202315.

9. Cobo C. La brecha digital en América Latina: nuevos desafíos para la equidad educativa. Revista Iberoamericana de Educación. 2021;87(2):61–77. https://doi.org/10.35362/rie8724689

10. De Jong T, Linn MC, Zacharia ZC. Physical and virtual laboratories in science and engineering education. Science. 2021;371(6524):eaba7294. https://doi.org/10.1126/science.aba7294

11. Dengel A, Essel M, Chouhan J. Teacher readiness for immersive learning: A review of challenges and support systems. Education and Information Technologies. 2022;27:12075–95. https://doi.org/10.1007/s10639-022-11090-5

12. Fowler C. Virtual reality and learning: where is the pedagogy? British Journal of Educational Technology. 2015;46(2):412–22. https://doi.org/10.1111/bjet.12135

13. Gonzalez-Argote D, Gonzalez-Argote J, Machuca-Contreras F. Blockchain in the health sector: a systematic literature review of success cases. Gamification and Augmented Reality 2023;1:6–6. https://doi.org/10.56294/gr20236.

14. Lee L-H, Braud T, Zhou P, Wang L, Xu D, Lin Z, et al. All one needs to know about Metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. Journal of Latex Class Files. 2021;18(1):1–52. https://doi.org/10.48550/arXiv.2110.05352

15. Líbano JM, Campusano NG, Castillo JP, Oyanedel JC, Cabrera MMY. Psychometric Properties of the Social Media Addiction Scale (SMAS) on Chilean University Students. Data and Metadata 2023;2:91–91. https://doi.org/10.56294/dm202391.

16. Makransky G, Terkildsen TS, Mayer RE. Adding immersive virtual reality to a science lab simulation causes more presence but less learning. Learning and Instruction. 2019;60:225–36. https://doi.org/10.1016/j.learninstruc.2017.12.007

17. Merchant Z, Goetz ET, Cifuentes L, Keeney-Kennicutt W, Davis TJ. Effectiveness of virtual reality-based instruction on students' learning outcomes in K–12 and higher education: A meta-analysis. Computers & Education. 2014;70:29–40. https://doi.org/10.1016/j.compedu.2013.07.033

18. Ministerio de Educación del Ecuador. Currículo de Bachillerato General Unificado. Quito: MINEDUC; 2016.

19. Ministerio de Educación del Ecuador. Lineamientos para el desarrollo del currículo integrado. Quito: MINEDUC; 2022.

20. Neves VR, Djament L. Benefits of the use of telemedicine in patients with obesity: A systematic review.

Gamification and Augmented Reality 2023;1:4-4. https://doi.org/10.56294/gr20234.

21. Passig D, Eden S. Enhancing the induction of empathy through virtual reality. Technology, Instruction, Cognition and Learning. 2020;13(1):1-16.

22. Quispe JFP, Huamantumba CFG, Huamantumba EG, Huamantumba AG, Serquen EEP, Carbajal LVR, et al. Quantitative Evaluation of the Impact of Artificial Intelligence on the Automation of Processes. Data and Metadata 2023;2:101-101. https://doi.org/10.56294/dm2023101.

23. Radianti J, Majchrzak TA, Fromm J, Wohlgenannt I. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education. 2020;147:103778. https://doi.org/10.1016/j.compedu.2019.103778

24. Ramírez LÁ. Artificial Intelligence in Psychological Diagnosis and Intervention. LatIA 2023;1:26-26. https://doi.org/10.62486/latia202326.

25. Riva G, Wiederhold BK. Virtual reality in the treatment of mental disorders: A review of current evidence. Cyberpsychol Behav Soc Netw. 2019;22(3):182-91. https://doi.org/10.1089/cyber.2019.0001

26. Rodríguez-Pérez JA. Augmented reality as an accessory technology in surgery. Gamification and Augmented Reality 2023;1:27-27. https://doi.org/10.56294/gr202327.

27. Sinisterra DV, Barrientos KJ, Villota MAL. Benefits and challenges of artificial intelligence in the Colombian health system. LatIA 2023;1:25-25. https://doi.org/10.62486/latia202325.

28. Slater M, Sanchez-Vives MV. Enhancing our lives with immersive virtual reality. Frontiers in Robotics and AI. 2016;3:74. https://doi.org/10.3389/frobt.2016.00074

29. Suárez YS, Alawi AM, Ricardo SEL. Hospital processes optimization based on artificial intelligence. LatIA 2023;1:19-19. https://doi.org/10.62486/latia202319.

30. Tapia JVM, Gallo VHP, Morales NEM, Chavarrea TLP. Comparison between CAD-CAM and conventional techniques in the manufacture of fixed zirconia prostheses. Data and Metadata 2023;2:90-90. https://doi.org/10.56294/dm202390.

31. Torres ER, Rodríguez RC, Briñez ET. Use of AI to improve the teaching-learning process in children with special abilities. LatIA 2023;1:21-21. https://doi.org/10.62486/latia202321.

32. Triantafyllou SA. A detailed study on implementing new approaches in the Game of Life. Data and Metadata 2023;2:95-95. https://doi.org/10.56294/dm202395.

33. UNESCO. Marco de competencias de los docentes en materia de TIC. París: Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura; 2021.

34. Villarroel J, Briones G. Didáctica de las Ciencias Naturales para la educación media. Quito: Ediciones Universitarias; 2019.

FUNDING

None.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTION

Conceptualization: Andrea Eloisa Monroy Villon.
Data curation: Andrea Eloisa Monroy Villon.
Research: Andrea Eloisa Monroy Villon.
Supervision: Andrea Eloisa Monroy Villon.
Validation: Andrea Eloisa Monroy Villon.

Writing - original draft: Andrea Eloisa Monroy Villon.
Writing - revising and editing: Andrea Eloisa Monroy Villon.

https://doi.org/10.56294/mr202371