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ORIGINAL

Edublog for applications of linear differential equations, in Biology

Edublog para las aplicaciones de las ecuaciones diferenciales lineales, en Biología

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ABSTRACT

Considering the need for accessible and focused educational material in the ecological-biological area, the development of an edublog is presented to assist in the understanding and application of first-order linear differential equations (LDEs) in the mathematical modeling of ecological processes. It provides detailed explanations of concepts such as exponential growth and decay, logistic growth, Newton's law of cooling, and the mixing model, with step-by-step solutions to examples focused on biology, both typed and handwritten. The edublog is now available to students and is presented to a group of Mathematics II students from the Biology program at FES Zaragoza, who provide feedback after exploring each option on the menu. Subsequently, these students have used screenshots from the blog's examples in some of their presentations, indicating that the resource is proving useful. This blog is complemented by another one on integration techniques, with the same focus on showing step-by-step solutions to exercises, aiming to create a virtual learning environment on integral calculus and the applications.

Keywords: Virtual Learning Environment; Application of Linear Differential Equations; Mathematical Modeling; Ecological Processes; Biology; Edublog Prototype.

RESUMEN

Considerando la necesidad de contar con material didáctico accesible y enfocado al área ecológica- biológica, se presenta el desarrollo de un edublog para ayudar en la comprensión y aplicación de ecuaciones diferenciales lineales (EDL) de primer orden en la modelación matemática de procesos ecológicos. En él, se presentan explicaciones detalladas de conceptos como el crecimiento y decaimiento exponencial, crecimiento logístico, la ley de enfriamiento de Newton y el modelo de mezclas, desarrollando soluciones paso a paso de ejemplos enfocados a la Biología, mecanografiados y *a mano*. El edublog ya está a disposición de los alumnos y se les presentó a un grupo de estudiantes de Matemáticas II de la carrera de Biología de la Facultad de Estudios Superiores Zaragoza (FES Zaragoza), quienes ofrecieron retroalimentación tras explorar cada opción del menú. Posteriormente, estos alumnos han utilizado capturas de pantalla de los ejemplos del blog en algunas de sus presentaciones, lo que indica que el recurso está siendo de utilidad. Este blog se complementa con otro sobre técnicas de integración, con el mismo enfoque de mostrar la solución de ejercicios paso a paso, para conformar un entorno virtual de aprendizaje sobre cálculo integral y sus aplicaciones.

Palabras clave: Entorno Virtual de Aprendizaje; Aplicación de Ecuaciones Diferenciales Lineales; Modelización Matemática; Procesos Ecológicos; Biología; Prototipo Edublog.

INTRODUCTION

In recent years, technological advances have been adapted to better support education, promoting the creation of new learning spaces. Studies such as that of Vargas-Murillo (2021) explain that integrating pedagogical strategies and ICT is essential to create interactive scenarios that foster learning; these strategies include multimedia resources.[1] At the university level, using technological tools such as word processors, presentation software, and videoconferencing platforms has proven to be essential in teaching-learning. Students use institutional tools and look for applications better suited to their academic needs.[2] Virtual Learning Environments (VLEs) are examples of learning spaces that implement such technologies.

VLEs have improved communication between teachers and students through information and communication technologies by optimizing the teaching-learning processes and technological aspects of the virtual environment through the design and management of these environments and the development of digital content.[3]

Therefore, a "virtual learning environment" refers to a space, medium, or environment on the web where communication and interaction between the student and the teacher is possible.[4]

One resource that has gained popularity in these environments is the educational blog or edublog. This allows for integrating multiple multimedia resources and facilitates interaction between teachers, students, and other users.[5]

These resources have been introduced into classes on complicated subjects such as mathematics, developing skills such as visualization, analysis, and the establishment of conjectures. In the context of Biology, students often question the applicability of mathematics in biological contexts.[6] Despite the evidence provided by authors such as Beteta (2015), who suggest that the use of VLE in the teaching of mathematics is effective, there is still a need for resources that address the specific applications of these concepts in biology, as material related to topics such as Differential Equations (DE) is mainly focused on other areas such as engineering. This creates a gap between mathematical theory and its application in ecological and environmental processes, generating a breach in the teaching-learning process that must be addressed.

Learning Differential Equations is essential because they help formulate mathematical models of processes such as population growth, the dispersion of pollutants, or the dynamics of biological interactions. However, studies such as the one carried out by Chilongo M, Lezcano Rodríguez L, and Gibert Benítez E. (2023) reveal various challenges in the teaching-learning process of EDO, mentioning disciplinary disconnection as the lack of contextualization in the tasks and problems to the student's specialty, making it challenging to transfer mathematical knowledge to areas that require specific professional skills; one proposal to address this problem is the incorporation of ICT use and contextualizing EDO in students' fields of study.[7]

METHOD

A compilation of theoretical information related to the basic concepts necessary to understand differential equations and their application in modeling ecological processes was carried out. The topics of differential calculus, integral calculus, and differential equations themselves were covered, reviewing articles, books, and freely available online resources. Artificial intelligence tools were explored to synthesize and organize part of the theoretical information. However, their use complemented the manual work in creating the didactic content.

Based on this theoretical foundation, we wrote short texts explaining key concepts such as exponential growth and decay and logistic growth, among others applied to Ecology, while in Chemistry, Newton's law of cooling and mixing models were of interest. In addition, step-by-step guides were developed describing how to apply first-order differential equations in biology-focused examples obtained from authors Fogiel M, Arterburn DR, Research and Education Association; Saff EB, Snider; and Filio López E.[8,9,10] These guides included typed and hand-drawn exercises in the Pages application, which allowed for a greater variety of presentation formats to improve the visual experience of the users.

With the support material ready, we developed the edublog prototype using the WordPress tool. The material produced was added, and the content was organized into thematic sections within the WordPress platform menu to facilitate user navigation. The solutions to the previously prepared exercises were added in their respective sections, both typed and in their digital handwritten version, to enable understanding and generate a visual appeal that motivates their review.

The blog is available at the link (https://blogceta.zaragoza.unam.mx/vbioedo/)

available to second-year mathematics students in the biology degree course at the FES Zaragoza. These students explored the content and offered feedback on the functionality and clarity of the material.

RESULTS

Although there is abundant material and information related to differential and integral calculus, open information specifically oriented to biology is limited in the case of mathematical modeling. Most resources focused on areas such as engineering or chemistry, reinforcing the need to adapt the examples to a biological approach.

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Based on the information obtained, short texts were developed to explain concepts such as exponential growth and decay, logistic growth, Newton's law of cooling, and mixing models. Many students today seek to obtain key information as quickly as possible.

Step-by-step guides accompanied these texts. Searching for practical examples in books, I found exercises on the concepts covered in the texts. However, those examples that were most related to ecology and biology were selected to align them with the objective of the edublog. Based on these examples, detailed guides were developed, typed, and explained in Word each step of the solution of the exercises. These examples were reviewed by math experts, who provided observations that allowed corrections and adjustments to the exercises, improving their accuracy and clarity.

To make the guides more visual and appealing to students, some handwritten examples were integrated into a tablet connected to the computer. Equations were drawn using both Word and the Pages application to make the solutions more dynamic and improve their presentation.

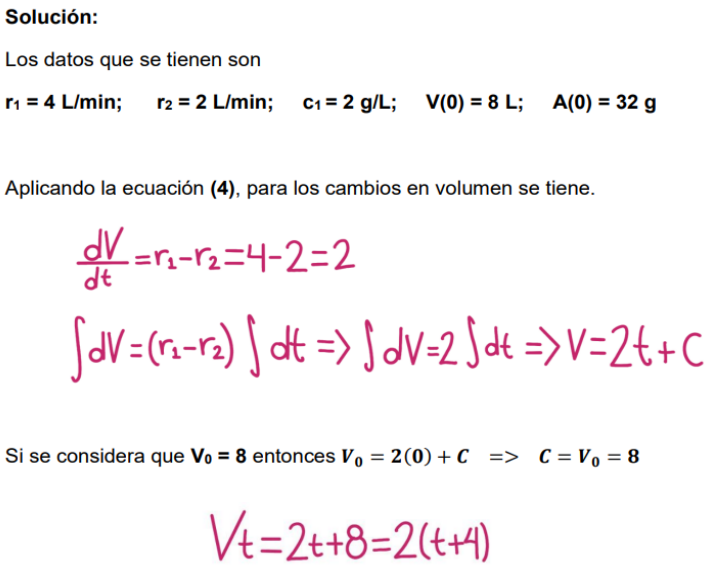

Figure 1. Model of mixtures typed and drawn on a tablet

For the edublog prototype, the WordPress tool was used, and it was given the title "Applications of Differential Equations." It clearly focuses on applying first-order differential equations in areas related to Biology and Ecology. The content was organized into six accessible sections through a straightforward and functional menu: Presentation, Growth and Decay, Law of Cooling, Mixing Model, and Credits.

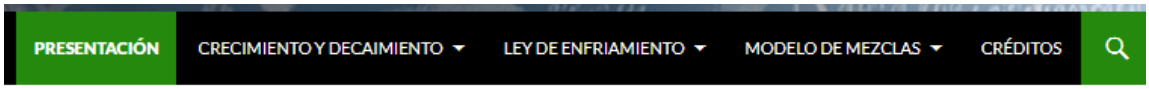

Figure 2. Menu on the blog "Applications of Differential Equations"

Through different sections, the blog introduces the theoretical foundations of mathematical modeling and offers step-by-step examples. The content of the main sections is detailed below:

Introduction: This section introduces mathematical modeling as a process for representing real phenomena through equations. With a focus on integral calculus and differential and linear equations, applications in chemical-biological areas such as growth and decay, the law of cooling, and the mixture model are mentioned. Growth and Decay: Explains the biological concepts of individual and population growth, as well as decay in ecological terms. It covers three subsections:

- Exponential Growth: Details how the growth rate of a population is proportional to its size and shows the mathematical expression. Two subsections were included: one dedicated to developing the exponential growth model and another with example statements and links to the guides to the solved exercises.
- Exponential Decay: Describes how the rate of decrease is proportional to the size of the population, showing its mathematical expression, including examples with step-by-step solutions.
- Logistic Growth: Explains how the growth of a population stabilizes due to limiting factors. Population behavior regarding carrying capacity is analyzed, with detailed examples and solutions to the model.

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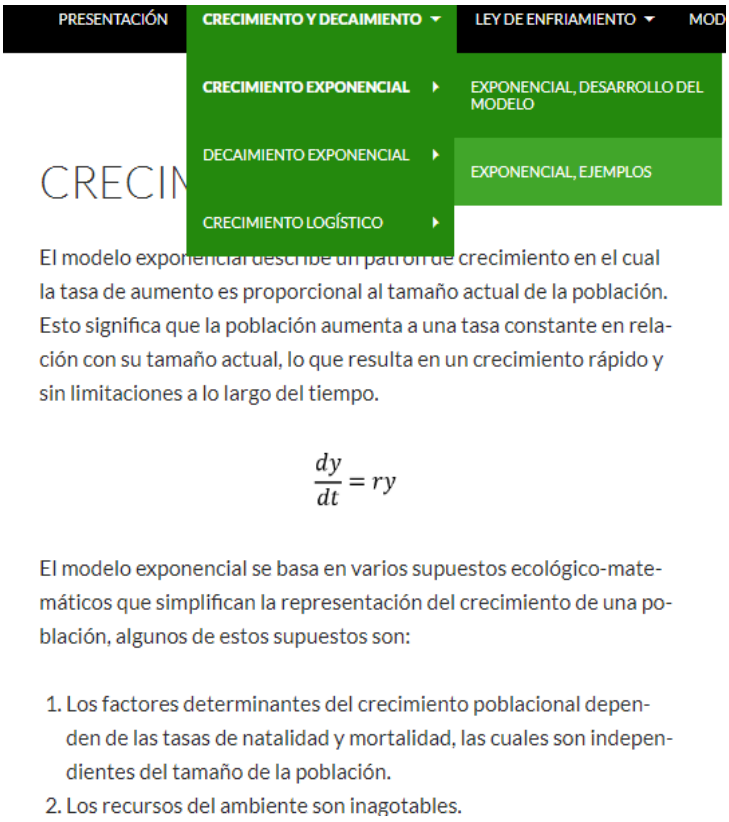

Figure 3. Exponential Growth Model in the edublog

Law of Cooling: Presents the differential equation that describes an object's temperature change in relation to its environment. Focuses on biological and forensic applications, covering two subsections:

- Newton's Law: Shows and explains its mathematical expression for predicting cooling and the solution to the equation given.
- Cooling Law Example: Presents the statement of the cooling law example and the link to the guide with the step-by-step solution

Model of Mixtures: Describes how two or more substances mix in different ecological contexts, such as the dispersion of pollutants. The two subsections cover:

- Type of models: This explains the essential mathematical expression to be modified to obtain the two-component mixture model.
- One Component: The mathematical expression of the single component model is explained using an explanatory image of a substance entering and leaving a tank. Detailed solutions and examples are also applied to the one-component model. Here and in the example of the cooling law, the example with the equations drawn on a tablet has been added.
- Credits: Finally, the section where the names of the authors who contributed to developing the edublog were added.

The edublog was presented to a group of students in the Mathematics II course of the Biology degree, initially explaining its approach to how DEs can be applied in the context of biology and then the blog's structure by going through the menu, indicating the main topics in each tab. From there, each section of the blog was detailed, starting with the theoretical part where the mathematical expressions of the models presented and their variable forms are explained. Finally, the sections where the exercises come from were reviewed along with hyperlinks to access each one's step-by-step solutions to understand the edublog's structure.

Subsequently, the students offered feedback on possible improvements: mainly, they commented that more exercises with step-by-step solutions should be added. For the edublog prototype, six exercises were carried out on exponential growth, three on exponential decay, one on Newton's law, and one on the one-component mixture model. After receiving their comments, adjustments were made to the organization and presentation of the information.

The resource has been put to good use by the students. In the presentation on Newton's Law, several students used screenshots of the examples presented in the blog as support material in their own presentations, which shows that the resource is being used to understand and learn the concepts.

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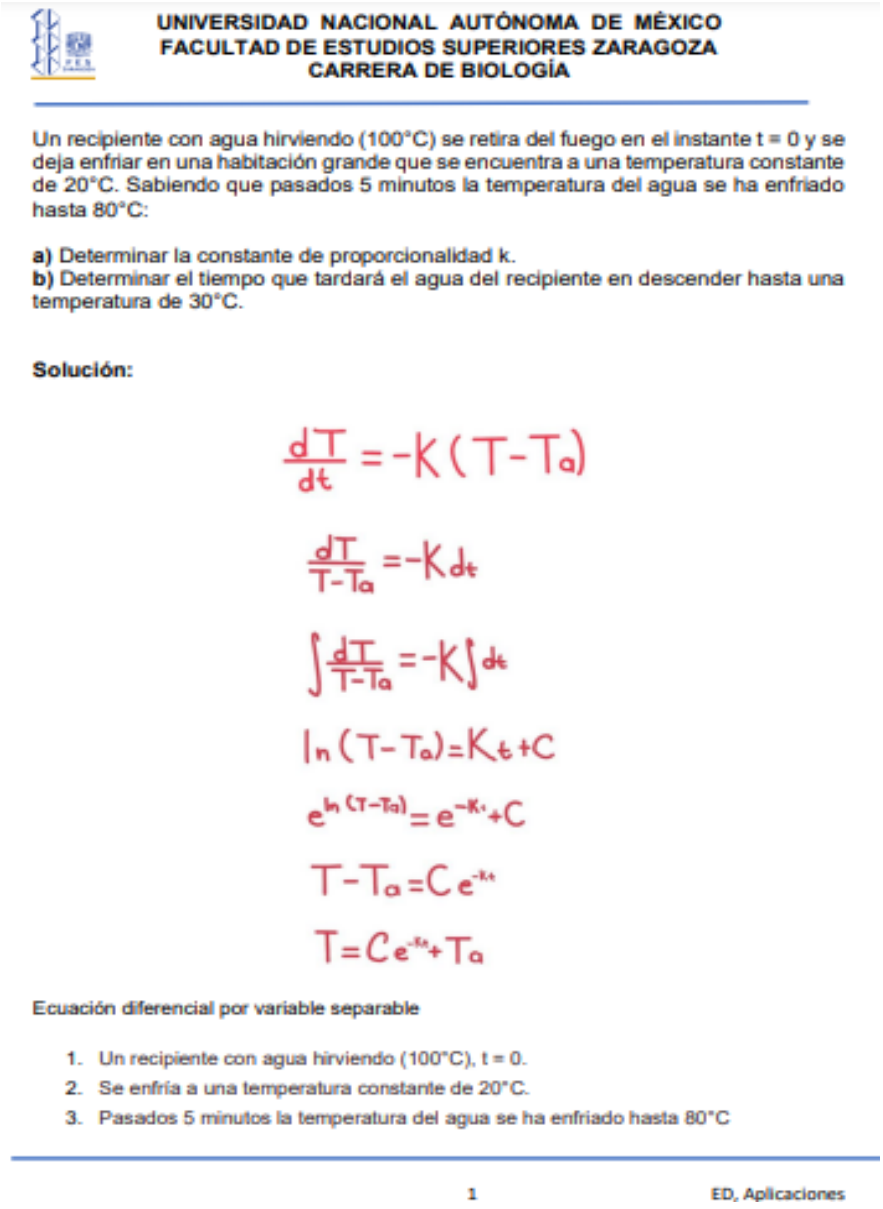

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Un recipiente con agua hirviendo (100°C) se retira del fuego en el instante t = 0 y se deja enfriar en una habitación grande que se encuentra a una temperatura constante de 20°C. Sabiendo que pasados 5 minutos la temperatura del agua se ha enfriado hasta 80°C:

a) Determinar la constante de proporcionalidad k.
b) Determinar el tiempo que tardará el agua del recipiente en descender hasta una temperatura de 30°C.

Solución:

$$\frac{dT}{dt} = -K(T - T_a)$$

$$\frac{dT}{T - T_a} = -K\,dt$$

$$\int \frac{dT}{T - T_a} = -K \int dt$$

$$\ln(T - T_a) = Kt + C$$

$$e^{\ln(T - T_a)} = e^{-Kt + C}$$

$$T - T_a = C e^{-kt}$$

$$T = C e^{-kt} + T_a$$

Ecuación diferencial por variable separable

1. Un recipiente con agua hirviendo (100°C), t = 0.
2. Se enfría a una temperatura constante de 20°C.
3. Pasados 5 minutos la temperatura del agua se ha enfriado hasta 80°C

1 ED, Aplicaciones

Figure 4. For example, the cooling law

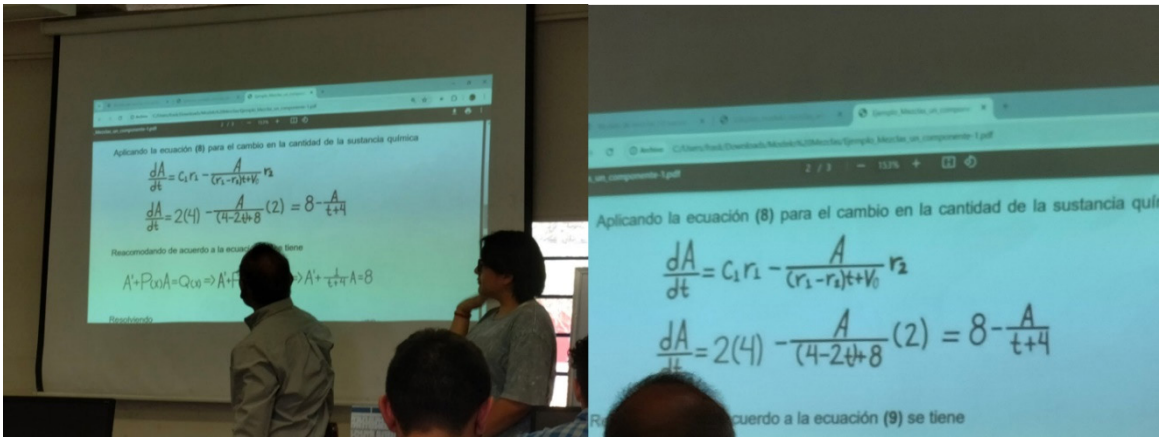

Figure 5. Presentation by students of Mathematics ll on the law of cooling, where screenshots of examples given in the edublog can be seen

DISCUSSION

The results show progress in developing an edublog prototype dedicated to applying ELDs in ecological processes and shaping a broader virtual learning environment. Another one complements this blog focused on

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integration techniques (available at https://blogceta.zaragoza.unam.mx/cintegral/) and a virtual classroom for the second year of the mathematics course, generating material that promotes an understanding of the mathematical concepts necessary for mathematical modeling in biology and ecology. Together, these resources make up a virtual environment that covers differential and integral calculus and, with the examples applied in biology and ecology, helps biology students learn autonomously.

Implementing the edublog prototype made it possible to validate the usefulness of the virtual learning environment. Through student feedback, the effectiveness of the edublog was validated, identifying areas for improvement, such as incorporating more practical exercises and optimizing the presentation of some content. The use of step-by-step guides proved to be important in fostering autonomous learning. These guides, revised and adjusted based on observations from mathematics experts, ensured accuracy and clarity in the examples solved. Thus, the students' positive response, who used material from the blog in their presentations, showed that the edublog not only met a need but also had a practical impact on their academic training. The fact that some students used screenshots of the edublog in their presentations indicates that the resource is helpful and applicable in different educational contexts.

CONCLUSIONS

It was possible to contribute to the development of a broader virtual learning environment complemented by a second resource on integration techniques, covering the area of applications of linear differential equations, helping to understand the mathematical concepts applied in the biological and ecological fields, allowing students to access teaching resources in an organized and accessible way.

Feedback from students on the maths course allowed us to identify areas for improvement, such as incorporating more practical exercises and optimizing the presentation of some content.

The usefulness of the edublog became evident through the students' direct use of its material in academic presentations. This suggests that the blog not only helps in learning but also motivates students to integrate what they have learned into their schoolwork related to mathematics.

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FINANCING

None.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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Drafting - original draft: Wendy Jaqueline García Reyes, Armando Cervantes Sandoval, Patricia Rivera García, Alejandro J. Perales Ávila.

Writing - proofreading and editing: Wendy Jaqueline García Reyes, Armando Cervantes Sandoval, Patricia Rivera García, Alejandro J. Perales Ávila.