

Enseñanza de las Ciencias Biológicas, desde un enfoque anatómico, fisiológico y biofísico. La neurona y sus respuestas eléctricas como modelo de trabajo

Biological Science education, from an anatomical, physiological, and biophysical approach. The neuron and its electrical responses as a working model

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Resumen

A partir del año 2008, la Benemérita Universidad Autónoma de Puebla implementa el Modelo Universitario Minerva (MUM), modelo fundamentado en el humanismo crítico y el construccionismo sociocultural, apostando por la implementación de nuevas TIC's en los procesos de aprendizaje, investigación y gestión. En este sentido la Escuela de Biología llevó a cabo una reestructuración en su programa de estudios lo que permite garantizar, en todo momento, que el estudiante comprenda desde un punto de vista comparativo, al individuo y sus sistemas pasando por tejido y llegando hasta niveles de organización biológica celular y molecular a través del estudio de los movimientos transmembrana. Para cumplir con este objetivo los estudiantes deben cursar en orden jerárquico las materias de Morfología Animal, Fisiología Animal y finalmente Biofísica (entre otras). La experiencia aquí aportada gira en torno a la implementación, dentro de las materias antes mencionadas, de la utilización de la plataforma virtual "Moodle" y de "simuladores", herramientas mediante las cuales se fortalece el entorno de aprendizaje de los jóvenes universitarios. Finalmente se observó que el uso de plataformas y simuladores virtuales juegan un papel

clave para lograr que los alumnos utilicen todos los recursos proporcionados y logren hacerse de su conocimiento y que este sea significativo.

Palabras clave: Moodle, Simuladores, Morfología Animal, neurona, electrofisiología neuronal

Abstract

From the year 2008, the Autonomous University of Puebla implements the Minerva University-Model (MUM), model based on the critical humanism and sociocultural constructionism, betting on the implementation of new ICT in learning, research, and management processes. In this sense the school of biology carried out a restructuring in its curriculum, to ensure at all times, that the student understands, from a comparative point of view, the individual and their systems through tissue and reaching levels of biological organisation cellular and molecular study of transmembrane movements. To meet this objective students are taken in hierarchical order the materials of Animal Morphology, Animal Physiology and Biophysics (among others). The experience provided here revolves around the implementation, within the above mentioned subjects, the use of virtual platform "Moodle", "simulators", tools by means of which the young University learning environment is strengthened. Finally it was noted the use of platforms and virtual simulators to play a key role for students to utilize all the resources provided and manage to obtain knowledge and find it meaningful.

Key words: Moodle, Simulators, Animal Morphology, Neuron, Neural electrophysiology

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Introduction

The Information Communication Technology (ICT) play a very important role in the European Space of Higher Education as significant teaching, in which the student is the active subject and protagonist of his learning process. The success or failure of educational innovations depends, to a large extent, on the way in which the different educational actors interpret, they redefine, filtered and give way to the changes proposed by the European

Space of Higher Education (Kahale Carrillo, 2011). To achieve a positive effect, it is necessary that the teacher has a set of competencies, through a proper allocation of the Information Communication Technologies and to the different facets of the process of teaching and learning.

Online learning is defined as the use of the Internet to access learning materials in order to interact with the content and the Professor, and acquire in turn, knowledge, personal meaning and grow from the learning experience (Ally, 2004, Kahale Carrillo, 2011). In other words, virtual environment training, known as e-learning, i.e. not face-to-face teaching which is made by platforms or technological means. However, this does not mean that face-to-face education is outside ICT, but quite the opposite, as it is also for you very interesting having those, so that coming together the combined training arises, called blearning, in which both face-to-face elements intersect with virtual elements (Kahale Carrillo, 2011).

In the year 2008 the Autonomous University of Puebla (BUAP), specific the Minerva University-Model (MUM), model based on the critical humanism and sociocultural constructionism, betting on the implementation of new ICT in learning, research, and management processes. Two years later (2010) the Vice Presidency of teaching of the BUAP forms the School of Teacher Training and Academic Development, which offer educational update programs. For this, it envisions a program of comprehensive training that includes initial, continuous training and professionalization in the didactic-pedagogical area.

As a result of the aforementioned learning courses in the fall of that year, the School of Biology BUAP implemented in their classrooms using the Moodle platform, web application type "Learning management system", from which teachers make learning communities online. One of the advantages that virtual learning environments is to allow private communication between those involved, while group interaction is propped. Note that the server for this application is located in the same academic unit, under the administration of personnel computer area. When speaking of "Moodle" (Modular Object-

Oriented Dynamic Learning Environment) application or Modular Environment Dynamic Learning Object Oriented, referred to a "technological platform" or system management courses at no cost on the year 2002 thanks to its creator, Professor Martin Doigimas, WebCT administrator at Curtin University, Australia.

Content development

The neuron and its electrical responses as a working model for the School of Biology BUAP

As already mentioned, the present teaching experience took place in the classrooms of the School of Biology at the BUAP. This academic unit offers two degrees, the Bachelor of Biotechnology (newly created) and a BA in Biology (with over 25 years experience), which is characterized as educational modality-face, with two levels in their curriculum map, Basic and Training. This degree has two axes, first called "Experimental Biology" and the other called "Biology of Organisms Groups" which, as its name suggests, are made up of a number of materials that strengthen training aspects toward the development of biological task in the field or in the laboratory. Specifically, within the Area of Morphophysiology Experimental Animal Morphology matters and Animal Physiology at the basic level, and matter of Biophysics level of training are provided.

Since the founding of the School of Biology (1987) to date, we can see a clear trend: Every year, a large number of students whose studies were concentrated in the area of 'Experimental Biology' enrolled as a last curriculum the educational level, matter of Neurobiology. Unfortunately, the reality is that for most, their theoretical and practical training in the field of Physiology and Biophysics, fundamental disciplines for a clear understanding of the basic mechanisms operative in neuronal functioning is poor (largely) because of the inability to find access to equipment as a means of analysis of nerve cells.

Approach from an anatomical-physiological

In this first part of reference to use of Moodle in teaching the topic "nervous system and sense organs" for Unit 9 Animal Morphology Matter of Degree in Biology BUAP done with which promote a constructivist and social pedagogy is exemplified, since

collaboration, implementation of activities and critical reflections is observed, among other features. All these activities are conducted as a supplement classroom learning to which the above subject matter. Using Moodle took place during the administration of the corresponding periods of spring and autumn of 2010 until the fall term 2012 courses.

Now we start from an important premise. In this case, the fact that students pursuing a degree in Biology, during the first quarters, the subject of "Development of skills in the use of technology, information and communication technology (DHTIC)", belonging to Area General Training College. On this subject, they are instructed in the use of e-learning platforms such as Moodle and / or Blackboard. In both cases you are required the student a series of changes in the learning process and the change of roles between the "participants". The teacher, who assumes the role of guide, facilitator or virtual mentor and student, who builds their knowledge reaching the level required in this educational stage. However, it was not until the implementation and actual implementation of these tools in "formal" matters such as those mentioned above when the student demonstrates and applies his skills.

While within any course the teacher is having control options, Moodle is very flexible in terms of the activities that can be developed from the modules which through "materials or resources", "Forum "" questionnaires "," glossaries "and" tasks "(among others) they increase means that the student will operate to get the information that allows forge your own understanding.

With the established platform and the student access to the same start developing the theme "Nervous System" was given. For this some "resources" were provided to students, which consisted, in the first instance, the curriculum of the subject (in Word format) including basic and additional bibliography, which should be consulted prior to the class. Likewise, it was made available to young people in a series of presentations with Microsoft PowerPoint © editor. This tool gives outlined text, allowing to address the issue in this case, from the general to the particular. That is, the approach was from the macro to point to the Central Nervous System and Peripheral Nervous System to the anatomy of the constituent cells,

this without losing definition images. While the above presentations are a summary of the topic, highlights its permanent availability for the student without spending paper, this clearly underpinned its previous reading and explanation of the teacher. With the images on screen sets out how the nervous system consists of the Central Nervous System (CNS) and the Peripheral Nervous System (PNS), the first one consisting of brain and spinal cord and the second by nerves and ganglia. In all unified by its most important features (like nerve tissue), arousal and conductivity (Kardong, 2011) cases.

As part of the CNS was already mentioned is the brain, comprising the forebrain, midbrain, and hindbrain. In the first of them is the portion of the brain where two small areas automatic regulating important body functions are located: the thalamus and hypothalamus. These two structures are located between the so-called corpus callosum, pons and medulla. From a physiological point of view thalamus spend all sensory stimuli to the brain (except smell) before transmission to the cerebral cortex and make them aware. For its part, the hypothalamus is formed by nuclei where vital functions such as body temperature, hunger, thirst and heartbeat are addressed. It also regulates some of the functions of the pituitary, one of the most important glands of the body which is located in the sphenoid cavity called sella (Kardong, 2011) bone. At this point the platform is enriched with more resources, as in the case of "Web material," including "pages" or "email addresses" video which, through three-dimensional animations, get them to clarify and analyze in depth the relationship anatomical between such parties. Of course the use of anatomical models is essential in this respect.

Continuing spinal cord indicates that it starts at the foramen magnum of the skull, where it binds directly to the medulla and reaches the lumbar vertebrae. The spinal cord is the communication path CNS, and as a way of much "traffic" has a double meaning of movement: movement or sensory afferent since the whole body leads stimuli to the brain, and motor movement or efferent, who takes the orders of the brain throughout the body. With the amount of scientific language used at this point comes into play another advantage of the Moodle platform, allowing to create and maintain a list of definitions that are used as "Glossary," which should increase with advancing issues allowing developing peer communication.

Once the basic anatomy of CNS analyzed is given to start the SNP study, which consists of that section of nerve cells located outside the CNS. The SNP is composed of twelve pairs of cranial nerves and spinal cord or spinal nerves emerging from the spinal cord 31. The latter are divided into cervical, thoracic, lumbar, and sacral, based on the region of the vertebral column which arise. Again the text outlined with anatomical models and the use of "web stuff" through videos shores, which allows the student to understand the functional anatomy of the pairs of cranial and spinal nerves in meaningful learning. Also, now the student understands how the division between the CNS and PNS is purely anatomical.

As mentioned earlier in this paper is part of a level of biological organization of systems and organs, briefly mentions the tissue and leads to the cellular level. In this sense it is that students understand that the above sections are based networks constitutional named cells "neurons", accompanied by "glial cells" or "neuroglia cells." The latter with a subdivision into astrocytes, microglia, oligodendroglial and ependymal cells.

Anatomically recognizes that a neuron is formed by the body or soma, dendrite and axon. This topic images from histological sections allows, accompanied by images of specialized texts, is observed and the different types of neurons based on the number of extensions (unipolar, bipolar and multipolar) are compared. These images and specialized texts can be anchored to the well platform or by leagues to be consulted by the student from the classroom, or anywhere where you are doing your analysis available.

To conclude the study of neurons should be considered that the anatomical Systems Division is accompanied by a successful language, for example. When a set of axons occurs in one way within the CNS nerve tract or be called via the other hand if it is set in the SNP, will be referred nerve. Another example is when several cell bodies unite or gather into the CNS, the core will be called when this meeting is in the SNP, is called; ganglia. In this case the use of "chat" or "forums" of conversation from the Moodle platform allows the interaction of participants in real time to discuss what they learned and resolve doubts.

Through slide shows, accompanied by videos, animations (taken from the websites of several reference books on the subject (<http://bcs.wiley.com/>; <http://highered.mcgraw-hill.com/> ; <http://bcs.whfreeman.com>) and / or reading informative articles (in Spanish), students are introduced to the study of the composition of the cell plasma membrane, according to the model of Singer and Nicolson (1972). This model describes the plasma

membrane as a fluid containing various proteins mosaic embedded in a matrix of phospholipids. The phospholipids in the membrane forming a lipid bilayer with polar heads directed outwardly and the hydrophobic tails towards the interior of the bilayer.

Subsequently, the students conduct a "task" (eg a conceptual map), which allows qualified by the submission seeking information, the degree of understanding and synthesis capacity requested. This technique is used especially in the final topic, the sympathetic and parasympathetic nervous system.

Note that the practical part is essential in this area so should be planned so that the hours in the laboratory are used to the full. To this end the student is provided on the platform of ALL the practices carried out throughout the course. This allows you to know the information provided and requested in the same, fully understanding what is presented on the day of its development, understand the material and equipment requested. Of course regulations and matrices for development are included during practice and to deliver it.

Finally if considered suitable you can generate a test, which will be underpinned by previous "questionnaires" or just one final character of examination performed differently on the platform: multiple, true or false answer or answer short etc. For this you can from a database of stored questions. Questionnaires can have a time limit, determined by consensus according to the complexity of the subject to be evaluated, be resolved.

-Biophysical approach from the physiological point of view

The lessons learned by the students so far in courses on "Animal Morphology" and "Animal Physiology" are taken up in the course of "Biophysics" to 'rebuild' the neuronal plasma membrane as a capacitor equivalent electrical model resistors and coupled parallel. To achieve this, a unit on "Introduction to the fundamentals of electricity" (current, voltage, resistance, capacitance, conductance, etc.), and each of those concepts lands to their biological functional equivalent in the membrane is added. This introductory unit is provided with a slide show accompanied by multiple videos, animations, simulations and numerical exercises of equations addressed; with all this is to make students understand the basic principles that enable the understanding of the processes of cell excitability.

The problem lies mainly in that the devices required for the teaching of techniques for analyzing the functioning of neurons (oscilloscopes, stimulators, function generators, etc.) are expensive and in Mexico, as in much of Latin America, These prices reach prohibitive for most public and private institutions offering degree in Biology and related careers. Added to this, investment in one of these teams is not justified given the number of students and days of use, each semester are required for this course.

A different alternative for learning, and even training in the use of sophisticated equipment, neuronal electrophysiology is the use of simulators. In developed countries, the concept of immersive education is gradually being installed along the various curricular networks. This concept raises a learning environment that uses simulators to transfer theoretical and practical concepts to their students (Chiang et al., 2011). There are several experiences in educational institutions (colleges and universities) and other informal education establishments (museums and libraries) mainly in the US and Europe, who have used simulators to transfer concepts of Physics, Mathematics, Ecology (Barab, Sadler, Heiselt, Hickey and Zuiker, 2007), Medicine (Potti, 2007; Salas & Ardanza, 1995) and History (Roussou, 2000) Students (quoted in Chiang et al, 2011).

Therefore, this section aims to bring my experience and thoughts on the joint use of animations, resolving numerical exercises and simulators for teaching 'Membrane Potential (PM) neuronal', from the physiological and biophysical sight, level undergraduate degree in Biology, School of Biology BUAP.

The study of the mechanisms that cause and maintain the constancy of neuronal PM is particularly important in neurobiology because of his understanding derives the electrical responses that can generate a neuron to a stimulus, to land in the generation of nerve impulse mechanism intercellular communication par excellence of nerve cells.

To address this issue requires the student to easily handle some topics: electrochemical gradient, active transmembrane transport and types of ion channels (particularly dependent

voltage). However, the problem that, in my experience, I have found to address them is that pupils have previously viewed superficially (without delving into the physical basis governing the conduct of transmembrane movements, for example) and 'little' visual .

Currently, education audiovisual projection slide mounts through some software (Power Point, for example) can be integrated into the teaching programs of any course or training activity, in addition to the written materials or the textbook. These mounts allow conceive a more dynamic teaching, incorporating alongside the textbook and the board, other motivators and impactful teaching resources (Aguaded Gómez and Martínez-Salanova, 1998). Therefore, for theoretical physiological approach to these concepts I've resorted to using images where the operation of these mechanisms Sketch, from books such as Molecular Cell Biology (Lodish H. et al., 2003) or Molecular Biology of the Cell (Alberts B. et al., 2007).

On the other hand, we must recognize that this traditional use of the slides in the classroom, has not been accompanied in many cases, a change from the traditional teaching methodology, since teachers have continued to provide only their lectures, adorned with said visual medium, but changing little or no methodology. Thereupon any projection should respond to a didactic planning does not have to be laborious, but explicit and shared by a team or seminar that incorporates previous activities of students and post-screening jobs that allow a deepening and interpretation review after seeing the series of slides (Aguaded Gómez and Martínez-Salanova, 1998). Considering this, the projections thematic animations accompany offered by portals development services multimedia material (<http://www.sumanasinc.com/>) and various reference books on the subject (<http://bcs.wiley.com/>; <http://highered.mcgraw-hill.com/>; <http://bcs.whfreeman.com>).

Once students understand how to operate these transmembrane movements and they generate the usual ionic gradients of cells (emphasizing the case of neurons), we are now ready to introduce the concept of Potential Balancing an ion (Ex) from a biophysical point of view. After reviewing the theoretical considerations necessary using projections with explanatory diagrams of books such as Fundamentals of Physics (Halliday D. et al., 2001) as well as

animations portals offered by various reference books, we proceed to the derivation of the Nernst equation, leaning on textbooks as Subjects of Biophysics (M. Parisi, 2004).

In practice part is used to exercise manual resolution by applying this formula to different cell types (including a neuron). The values of the intra- and extracellular ion concentration used in the exercises are extracted from neurobiology books (for example, Principles of Neuroscience, E. Kandel et al., 2004; Ionic channels of excitable membranes, B. Hille, 1992) for students to become familiar with the consultation of these texts.

After this step, it seeks to make students understand that the cell membrane is not permeable to only one ion species (K^+) but also to Na^+ and Cl^- (to varying degrees) with the consequence that the PM (now on, V_m) is an intracellular electrical potential difference whose value does not correspond to any E_x of a particular ion, but depends on a kind of 'dynamic equilibrium' to be established between the forces of the electrochemical gradient of these 3 ions, so that voltage value represents that membrane in which the net flow of ions is in equilibrium. But what should have this clear concept? Because all electrical signals (ie the responses generated by neurons) involving brief changes the value of the PM at rest, due to alterations in the flow of electric current through the resulting cell membrane of the opening and closing of the channels immersed in it (Kandel et al., 2000) ionic. They are used for that projections with explanatory diagrams, and proceed to the derivation of the equation of Goldman-Hodgkin-Katz (GHK), leaning on textbooks as the Parisi (2004). In my experience, it is at this point where the use of simulators plays a key role in bringing students to use all previously analyzed concepts and 'amalgamated' in order to formulate in their own words the mechanism of action of a physiological phenomenon: PMR. To this end, as intra- and extramural activities are asked to students, individually, using various simulators such as PotMem (© Soto E., 1989) and The NERNST / GOLDMAN simulator equation (© Arizona Board of Regents, 2013).

Particularly I will face the use of PotMem © program since it was developed by a researcher at the Institute of Physiology of the BUAP, Dr. Enrique Soto Eguibar, which serves students to realize that even in Mexico can develop simple software but highly

effective in teaching the neuronal electrophysiology. The PotMem © is a computer simulation of the generation of neuronal membrane potential. Its characteristics allow the user to vary widely concentrations intra- and extracellular Na^+ , K^+ and Cl^- ions, and determining V_m (using eq. GHK) and E_x (using eq. Nernst) for each ion. Considers the coefficient of permeability (P_x) for each, which can be varied, and also allows changing the temperature at which the "experiment" is performed. On the screen, all the modifications are summarized in a graph of V_m allows the user to visually locate the 'position' of E_x of each ion to the 2 other ions, and compared the resulting V_m . The advantages that this simulator provides include: 1) in a box, the direction and magnitude of the force of the electrochemical gradient is outlined that 'feel' each ion through the cell membrane in the form of arrows that change (increase or decrease) and move (entering or exiting) according to various parameters are changed. This allows the user to view that under certain conditions, the flow direction of a given ion can reach even reversed, which functionally brings great implications for the cell; 2) concentration-voltage curves obtained at any time that can be printed; 3) the user can select an option to 'voltage clamp' (voltage-clamp) that enables you to impose a certain value of the neuron PM and study the strength of the resulting electrochemical gradient for each ion (Fig. 1). Particularly, this option is very useful because it allows the natural entrance to the field of neurobiology, where the invention of this technique by A. Hodgkin and A. Huxley allowed in 1952 at describing a mathematical model, to explain the ionic mechanisms underlying describes how the action potential of neurons is initiated and propagated in the giant axon of squid, *Loligo spp.* This beautiful and elegant series of experiments allowed to receive in 1963 the Nobel Prize in Physiology or Medicine. The disadvantages of the program we have: 1) you can only do "experiments" using the ionic concentrations of 3 different neurons (giant squid axon nerve of cat and frog nerve); and 2) has not been updated to match the new existing operating systems, so it can only be installed and run successfully on versions of Windows © 95 to Windows © XP (although you can still use Windows © 7, but only for version Starter edition, which is the simplest and limited).

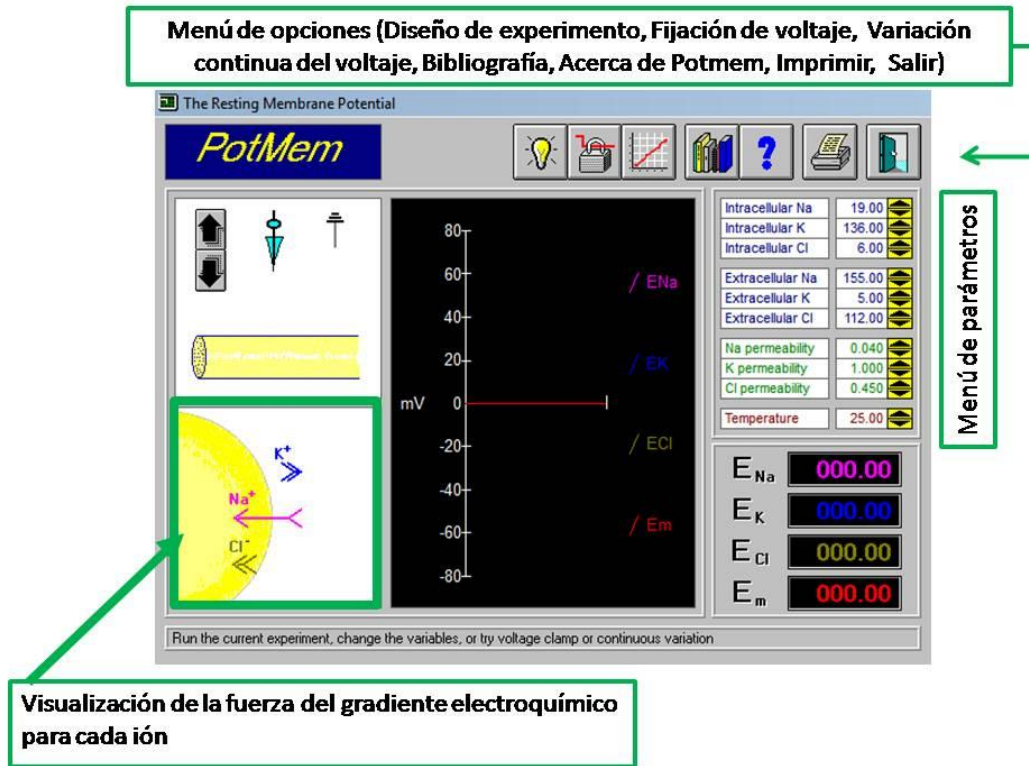


Fig. 1. Vista de la plataforma PotMem (©Soto E., 1989). Fuente: Elaboración propia.

Given these drawbacks, have complemented the rest PM exercises with the use of The NERNST / GOLDMAN equation simulator (© Arizona Board of Regents, 2013). Briefly, this software enabling input on PotMem are: 1) that changes can be made so that the parameters are analyzed in separate tabs, the equilibrium potential (although only one ion at a time) and V_m cell; 2) V_m -time graph of the trace shown in real time, the Nernst equilibrium potential calculated or estimated according to the GHK equation V_m . You can change the scale at which you want to display; and can change the scale (both as in x) of the graph as we require for better viewing; and 3) allows 'experiments' using the ionic concentrations of 1 generic cell (only as a starting point), 2 different electrically excitable cells (giant axon of squid and skeletal muscle) and 1 no nerve cell (erythrocyte) (Fig. 2).

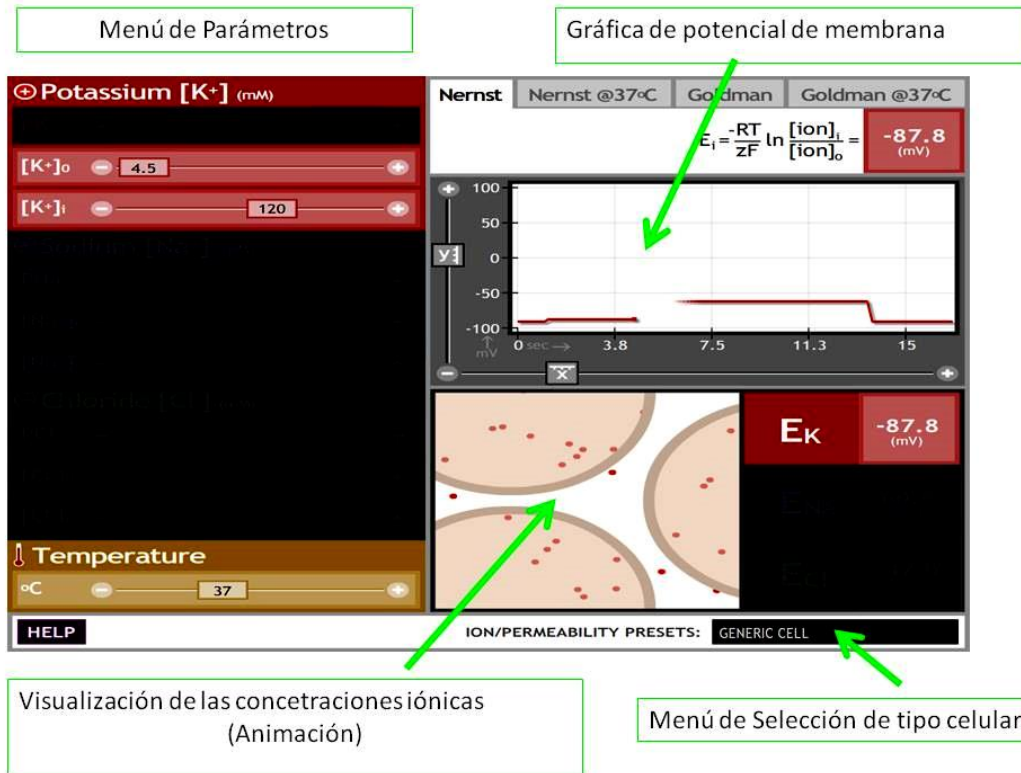


Fig. 2. Vista de la plataforma The NERNST/GOLDMAN equation simulator (©Arizona Board of Regents, 2013). Fuente: Elaboración propia.

For the correct application of new technologies in education - as seen educational preparation of both figures (student teaching) is essential. Otherwise the danger that "inconsistencies" are presented in this educational revolution runs.

Pedagogical innovation should include didactic tools (technological innovations) that allow the teacher to design quality learning activities for students, this part of constructivist and collaborative models (Weaver, García-Valcárcel and Prada, 2009).

Conclusions

The use of still images, videos, animations and models like software PotMem (C) and The NERNST / GOLDMAN equation simulator (© Arizona Board of Regents) courses in animal physiology and biophysics at the School of Biology have shown a useful tool in

teaching, then allow students to increase their learning dimensions achieving an understanding of the principles underlying the generation of neuronal membrane potential.

Application of Information Technologies and Communication in the classroom, appropriate educational practices associated with renewing the educational process allows crediting the contextualized learning.

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