

ANIMAL NEUROPHYSIOLOGY VIRTUAL LAB: PEDAGOGICAL REQUIREMENTS AND TECHNOLOGICAL ISSUES

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ABSTRACT

As digital content is more and more present in our everyday life, universities, by the way of their teachers and course authors, have to be up-to-date by delivering pertinent, accessible and easily-handling courses. To reach this goal, many LMS exist to play online learning objects, but they often remain parody of classical support such as paper version of lecture notes: it appears finally as non-interactive classical books in electronic version. Inevitably, this situation shows the issue of designing some real interactive and electronic learning content, and not translating lecture notes to PDF files.

In this paper, we explain how multimedia learning support can meet pre-defined pedagogical requirements. Through a real case study, the Neuron Physiology practical course, we sketch the logical link between an educational objective, the choice of an interactive activity and the way to implement it from a technical point of view.

KEYWORDS

Pedagogical strategies, Virtual Learning Environments, e-Learning models, evaluation, multimedia activities.

1. INTRODUCTION

This paper deals with the impact of educational goals on the technological choice of some multimedia activities. These activities have been achieved as part of the design of an e-learning aid for the Neuron Physiology course; dedicated to students of the Bachelor Académique en Sciences de la Vie of the University of Luxembourg (UL)¹. Worked out in the context of the "e-FSTC" project², which aims to put in place an e-learning plan for the Faculté des Sciences et de Technologie of the UL, the e-learning support is used since the month of March 2007 as counterpart to the lecture and labs. Its main goal is to facilitate understanding of main mechanisms of the Neuron Physiology thanks to virtual experiences. Through the virtual experiences the student develops deductive reasoning, which can aid him to establish links between the theoretical skills and their practical application. This course improver is run on our own Learning Management System (LMS), Spotlight [1]: coupled with the proactive system currently designed by Zampunieris [2] and El Alami [3], it supplies a unique learning experience to the students.

The following text shows to what extent pedagogical goals influenced the design of the course structure as well as the choice of multimedia activities to create. Very relevant from an educational point of view, we introduce two kinds of animation in order to illustrate our purpose: the interactive video of a frog dissection and the membrane potential simulator. Then, we explain the technological issues and the solutions developed to implement this e-learning system.

¹ Professors Eric Tschirhart and Jean-Luc Bueb teach the Physiology of Neuron course at the UL. They took part to the content design of the Lab.

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2. DESIGN OF THE COURSE STRUCTURE

Defined during the step of storylining, the educational objectives determine the e-learning aid structure:

1. To master the frog dissection techniques,
2. To master the vocabulary and the basic notions required for a good understanding of biology and animal physiology,
3. To understand the relative importance of ions Na⁺, K⁺ and Cl⁻ in fixing and changes of the membrane potential,
4. To understand the activation and deactivation kinetics of conductance/permeability sodium and potassium in the action potential,
5. To understand the phenomenon of passive distribution of Cl⁻ ions depending on the values of membrane potential,
6. To understand mechanisms of the propagation of nerve impulses,
7. To know how to demonstrate and synthesize experimental results in the form of a report illustrated with graphics.

Presented in table 1, the chosen structure is directly inspired by a "real" lab session (i.e. physical attendance of students to an equipped room). It enables the student to implement the theoretical knowledge and to develop deductive reasoning, (which is essential to learn an experimental science) in order to understand the complexity of the cell's interactions.

Table 1. Course structure for the lab n°2 "membrane potential"

<p>1. THEORY (go into detail with one or several theoretical aspects introduced during lecture)</p>	<p>Reminders about the membrane potential: - the Nernst equation - the Goldman equation</p> <p>Differences between excitable and non excitable cells</p> <p>Example of a sensitive channel to potential Membrane potential simulator</p>
<p>2. EXPERIENCE (experimental part)</p>	<p>Empty text fields to fill in</p>
<p>3. ASSESSMENT (self-corrective exercises)</p>	<p>Series of two "true/false" questions</p> <p>Drag and drop: table to fill in</p>

Hence, the defined structure includes the four general skills which qualify as human learning acquisition [4]:

1. Information collection and explanation (theoretical part)
2. Knowledge replication or practical application (experimental part)
3. Analysis and assessment (with self-corrective exercises)
4. Meta-cognitive thinking (synthesis and rendering of experimental results at the end of the lab sessions)

The four skills are called *reception*, *replication*, *production and creation*, and *self-management* by Paquette. Our designation sums up the main functions of these skills. In order to denominate similar skills, Romiszowski [5] uses *perception*, *memory reminder*, *planning* and *performance*.

We opt for a linear browsing to insure uniform progression of the learning process. First, the student accesses compulsorily the theoretical part, then the experimental part, which is followed by self-corrective exercises, and finally designs a synthesis. Results synthesis (mentioned above as meta-cognitive thinking), pointed out in the objectives, do not appear in the e-learning counterpart. Indeed, the course author hoped to see a written report submitted by every student at the end of the lab.

3. ACTIVITIES CHOICE

3.1 Interactive Video of Frog Dissection

To acquire frog dissection techniques is one of the main educational objectives of this lab:



Figure 1. Extract from the interactive video of the frog dissection

This interactive video relates to the theoretical part of the first lab session. Specially designed for the e-learning aid, this activity enables substituting "real" dissection. Until 2007, the teacher used to proceed to the frog dissection during the first lab session, to show the sciatic nerve which is useful to study the propagation of the nerve impulses mechanism. Added-value of the video animation is twofold:

- On the one hand, it shows the main steps of the dissection and provides the students with an interactive tool which enables the mastering of dissection techniques without sacrificing batrachians.
- On the other, the learner memorizes details of the frog anatomy thanks to descriptive and interactive slideshow (composed with four images, extracted from the video).

The interactive video is a multimedia and "custom-tailored" activity, which supplies a flexible and autonomous learning process of the dissection. The student progresses to his/her own rhythm thanks to the teacher-author off-screen comments. Moreover, he/she assimilates the names of the frog's anatomic parts and visualizes the main steps of the dissection. More than just preparation of the labs, the video provides a better management of the "real" course sessions. The opportunity to visualize virtual dissection before the labs enables the student to prepare his/her questions for the teacher. Consequently, time is saved, as well as frogs, thanks to the video by reusing it and thus enabling the teacher to go deeper in the subject matter.

From a technical point of view, the video is different from a trivial one embedded in a web page. Indeed, it is divided in several sequences which can be watched in a linear or non-linear way. The video is embedded in a multimedia container empowered with tools for playback (stop, pause, forward, rewind, etc.). So, student can directly access the desired sequence without having to read the full video.

Another advantage of cutting the video into sequences is to avoid long loading times: five short video files are faster loaded than a single heavy one. Furthermore, a video file is loaded only if the student calls it with a mouse click, so "undesired" sequences are not loaded and the loading durations decrease.

To compress the video Flash file, Flash 8 Video Encoder [6] software was used. The video codec chosen is On2 vp6 with a rate of 400 kb/s, the audio codec is Mpeg Layer-3 with a rate of 128 kb/s. Regarding video dimensions, we opted for the QVGA [7] resolution (320 x 240 pixels).

3.2 The Membrane Potential Simulator

Understanding the membrane conductance of the neuron and assessing the changes of transmembrane ion concentration was the pedagogical aim of the experimental part of the second lab. The complexity of the mechanisms is better perceived by supplying the student with numeric values, which can be processed as real experimental values. The membrane potential simulator (as shown in figure 2) enables the student to visualize simultaneous change of all essential parameters needed to calculate the membrane potential. Indeed,

this visualization is not possible with the NeuroSim (version 2) simulation [8] software usually used by the concerned UL students.

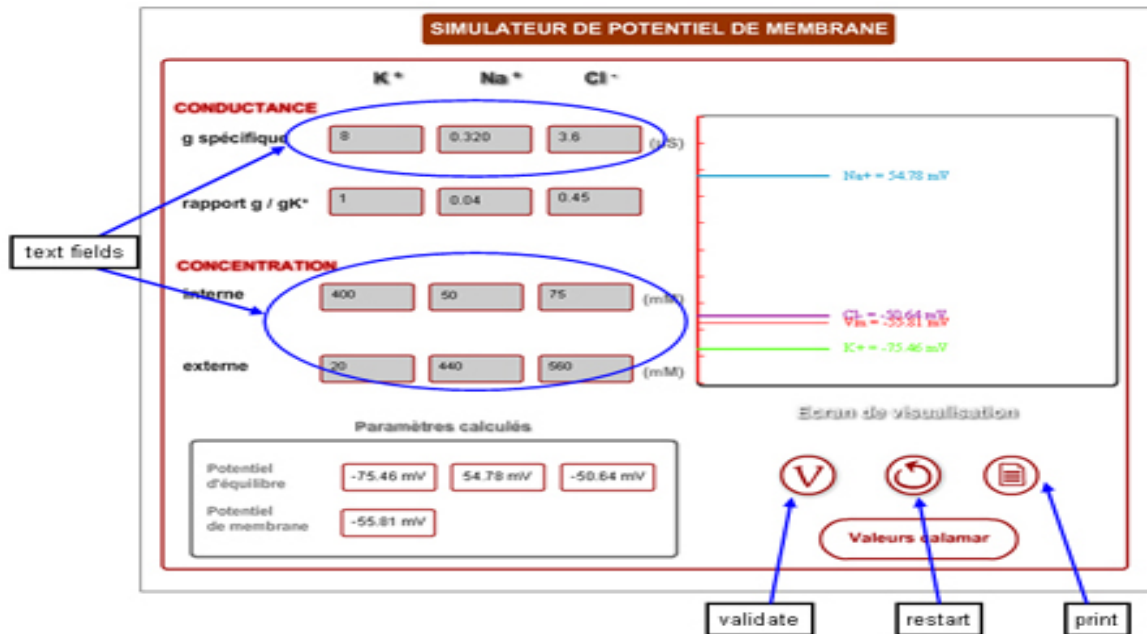


Figure 2. The membrane potential simulator

This screenshot shows a variation of three types of ions in order to estimate conductance of the neuron membrane. This simulation enables the student to interact with nine parameters and to observe changes in the membrane conductance as well as the change of ion concentration. To observe changes in parameters, the student types figures in the grey columns. The blue oval shapes on the figure specify where the parameters can be modified.

The animation of the membrane potential simulator gives the opportunity to modify all of the nine parameters simultaneously or alternatively. Moreover, the different interaction degrees implemented in this animation enable positioning it to the third level of interactivity of the taxonomy defined by Schulmeister [9].

Being available one week before the lab session, the simulator enables the student to achieve remote simulation on the membrane potential. The opportunity to use the online simulator is an outstanding asset for an autonomous learning acquisition. Handling numeric values gives the learner the possibility to measure their impact, making the experience closer to reality. Another advantage concerns the opportunity to vary simultaneously several parameters to evaluate the conductance of the neuron membrane and simulate the transmembrane in ion concentration difference. Our simulator completes the use of NeuroSim and contributes to the customization of the students learning path. Hence, students from the University of Luxembourg benefit from an online and freely available tool which is complementary to the lecture and labs and which helps them to prepare the membrane potential calculation lab.

To use the simulator, the student has to fill out text fields on the left hand side of the interface. Then, the ratio between the specific conductance and ions K⁺ conductance is automatically calculated and displayed thanks to the right mathematical formula. Results can be printed, so students can constitute a journal of tested simulation in order to compare changes. We give the possibility to print results because our simulator does not save them. Indeed, in order to be SCORM [10] compliant, the e-learning teaching aid is designed as an interoperable learning object. By definition, a learning object does not save any personal data, since we have to launch and play it with every LMS, like a fully-independent package. A solution to keep personal data exists with the database of our LMS [1]: the link between the learning object (i.e. our e-learning teaching aid) and the database is ensured by a dedicated API [11]. Currently, only assessment of the Neuron Physiology course is implemented with the saving of data.

4. CONCLUSION

Used as complement to the Neuron Physiology lecture and labs, our e-learning aid enables the student to acquire deductive reasoning, which is mandatory for experimental sciences, in a modern and pleasant way. The aim of this tool is to aid the student to learn the mechanisms of the Neuron Physiology through the virtual experiences. The video permits the student to understand the different stages of the dissection techniques, as well as memorize the frog's anatomy in order to be able to apply this knowledge in a real classroom situation. The membrane potential simulator, used to studying the propagation of the nerve impulses mechanism, aids the student to analyze the changing of the transmembrane ion concentration. The Animal Neurophysiology Virtual Lab can demonstrate the simultaneous change of ion concentration which was not possible with NeuroSim. So, this tool offers the student a possibility to observe the mechanisms of Neuron Physiology while working at home in order to be able to interpret and synthesize experimental results.

Durability of this tool seems to be confirmed by a high satisfaction rate from students and teachers. Indeed, they enjoy using it for the second year, and the teacher-authors requested us to design new online activities in order to develop the next final assessment. The next stage in the development of the tool will be to monitor the feedback of the users in order to evaluate how this tool has supported the student to prepare for the Neuron Physiology course. This feedback will help us to improve the tool and to share the experience with the interested members of the scientific community.

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REFERENCES

- Casel, N. et al, 2007. A new software architecture for learning management systems with SCORM support. IADIS – International Conference on e-Learning, Lisbon, Portugal
- Zampunieris, D., 2006. Implementation of a Proactive Learning Management System. Proc. of the E-Learn 2006 – 11th World Conference on E-Learning in Corporate, Government, Healthcare, & Higher Education. Honolulu, USA, pp. 3145-3151.
- El Alami, M. et al., 2007. An Architecture for E-Learning System with Computational Intelligence. KES – International Conference on Knowledge-Based and Intelligent Information & Engineering Systems. Vietri sul Mare, Italy
- Paquette, G., 2002. L'ingénierie pédagogique, Presses de l'Université du Québec, 456 p., p. 196.
- Romiszowski, A.J., 1981. Designing Instructional Systems, Londres et New York, Kogan Page et Nicolas Publishing, 415 p., p. 254.
- Flash 8 Video Encoder <http://www.adobe.com/products/flash/flashpro/productinfo/encoder/>
- QVGA – Quarter Video Graphics Array, <http://fr.wikipedia.org/wiki/QVGA>
- NeuroSim, neural function simulator, <http://www.biosoft.com/w/neurosim.htm>
- Schulmeister, R., 2003. Taxonomy of multimedia component interactivity. A contribution to the current metadata debate. Studies in Communication Sciences/Studi di scienze della comunicazione. (Edition Spéciale), pp.61-80.
- SCORM – Sharable Content Object Reference Model, <http://www.adlnet.org>
- API – Application Programming Interface, <http://en.wikipedia.org/wiki/API>