

# Developing virtual and interactive problems for learning microbiology

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## Abstract

The Interactive Microbiology website promotes the learning of microbiology by resolving theoretical and/or practical problems. The material was designed to be used in the classroom, as well as for independent learning. The most noteworthy innovation is the integration of the theoretical and practical aspects, thanks to the fact that in addition to theoretical contents the website also includes a virtual microbiology laboratory where students can practice a variety of basic microbiology techniques with a simulation of the results. The website is targeted to students who are entering into contact with the invisible world of micro-organisms for the first time, that is, to students in their first or second year of the university degree programme that covers this material.

A prototype of this new tool was implemented as a pilot during academic year 2007-08 in the Microbiology course (Biology degree programme) and the Microbiology I course (Biotechnology degree programme). The evaluations from this first term show a high degree of acceptance by both the students and the professors who have implemented it. This evaluation also identified certain dysfunctions of the website which have already been corrected in the final version, which was also simplified and contains a variety of help resources. This tool, which is considered unique, will serve as the foundation for the development of future websites dealing with learning microbiology at a more advanced level.

## General area of interest of this innovation

The development of this tool is interesting for both university professors and for teachers at other levels (secondary, baccalaureate and vocational education) who are involved in teaching microbiology. What is more, the idea of a virtual lab, as it has been developed in this project, may be applicable to learning any other discipline within the life sciences and other experimental sciences.

## 1. Objectives

The overarching goal was to develop a virtual space for learning microbiology where students could learn independently by resolving theoretical and/or practical problems, as well as to integrate theoretical and practical factors.

## 2. Description of the project

In order to accomplish the project, the work was divided into two phases:

### 2.1. Constructing the Interactive Microbiology website

This phase of the project was conducted from January to September 2007 in order to have the prototype of a website ready at the start of academic year 2007-08 and be able to conclude the definitive website from September 2007 to February 2008. Below is a summarised description of the steps:

#### 2.1.1. Defining the formal spaces on the website

The thematic spaces on the website that correspond to the different parts of a course on microbiology were defined. Therefore, there is a space on the website for each of the following teaching units:

1. Introduction to microbiology techniques
2. Structure and function of the microbial cell
3. Microbial growth and control
4. Molecular microbiology of micro-organisms
5. Microbial physiology and metabolism
6. Virology
7. Microbial ecology
8. Microbial diversity

Plus, it was determined that each teaching unit would contain the following windows:

1. Problems
2. Laboratory
3. Resources
4. Multimedia
5. Gallery of images

In the Problems window, students begin their learning with problems, by working and resolving the theoretical and/or practical questions that are posed. In order to achieve these goals, students have at their disposal a microbiology lab equipped with the materials and apparatuses needed, with the content they will find in the Resources, Multimedia and Gallery of Images windows.

### 2.1.2. Defining the skills and contents of each teaching unit

In view of the type of student to which the website is targeted, the specific skills and content of each teaching unit were defined.

### 2.1.3. Devising problems and designing the microbiology laboratory

According to the skill to be developed, a variety of kinds of problem were drawn up. The website offers the following:

1. Practical problems that require an experiment in the virtual lab
2. Theoretical problems requiring chained logical reasoning
3. Theoretical problems that have to be solved by consulting the information provided in the Multimedia and Gallery of Images windows.

This type of resource came from the faculty who have participated in the project, or from the educational resources available from the American Society for Microbiology, the Centres for Disease Control and Prevention (USA) and other websites for educational purposes. In contrast, the material made available in the Resources window includes pdf documents drawn up by the faculty participating in the project and must be consulted by the students to solve the problems posed.

Likewise, the microbiology lab was also designed. It consists of a work station, a store of samples and a record on the manipulations that the student has done at the work station. Furthermore, the following windows were defined that contain all the materials, solutions and instruments needed for the experiments:

- Tools
- Apparatuses
- Material
- Pipettes
- Dilution solutions
- Liquid solutions
- Solid solutions
- Semi-solid solutions
- Tinctures
- Supplements

Finally, there is also an option to clean the laboratory when the student finish their experiments.

In order for the virtual experiment in the lab to be as realistic as possible, we had to assign a given specification to each type of material, solution, tool or equipment. For example, for a 1 ml pipette, the virtual pipette had to be able to measure out volumes of liquids between 0.1 and 1 ml. Another example, if you want to visualise microbial growth in a dish containing a nutritious solution which was previously inoculated with a micro-organism, colonies will only be visible if the student has incubated the dish at the right temperature and for a given amount of time. Therefore, this part of the laboratory design was crucial for ensuring that the experiment proposed in the problems is feasible.

On this point, it was necessary to define which samples and which micro-organisms would be used in the virtual lab, and once chosen, to introduce into the programme all the characteristics and parameters needed for each micro-organism so that the simulated experiment could be as realistic as possible.

#### 2.1.4. Developing aids and tutorials

In order to make it easier for students to use this tool, a variety of aids were developed that consist of explanatory tags about the use of some of the tools and materials in the microbiology lab. Tutorials were also included on how to perform the most basic microbiology procedures in the virtual lab.

#### 2.1.5. Editor for adding new problems

One characteristic that makes this tool dynamic is the fact that the faculty can enter an editor and add new problems or to modify the existing problems. This enables each professor to adapt the website to the characteristics of the degree programme the students are in and to further emphasise a given type of concept.

You can see the Plana supplementary materials at [plana.pdf](#) and a demo of the website at: <http://microbiologia.uab.cat/microbiologainteractiva/>(2008).

### 2.2. Introduction to the Interactive Microbiology website for microbiology learning

The second phase of the project consisted of applying the prototype website for learning microbiology. In academic year 2007-08 the students in the Microbiology course (Biology degree programme) and the Microbiology I course (Biotechnology degree programme) were chosen for the pilot test. Both courses are required and are taught in the second year of the first cycle of the degree programme. The Microbiology course is yearlong, and its syllabus includes all the teaching units on the Interactive Microbiology website, while the Microbiology I course lasts one term and covers five of the eight teaching units on the website.

Given the fact that the students to whom the Interactive Microbiology website is targeted are not familiar with the area of microbiology, the website was planned to be used in the classroom to gradually introduce the material, while also teaching students the basic microbiology techniques in the virtual lab. Later, as the course went on, the students had to use the website on their own as an independent learning tool. Provisions were made so that professor could activate or deactivate the different teaching units on the website, so students may only enter the space(s) that are relevant to the theoretical and practical topics being covered in the class.

Finally, in this phase we are currently evaluating the use of the website by both faculty and students in order to find out how useful it is for microbiology learning.

### **3. Methodology**

The website was made using Macromedia Flash® v8. The images were processed using Adobe Photoshop CS, the web screens were edited using Macromedia Dreamweaver® v8, and the video capture was done using Autoscreen Recorder Free (Wisdom-soft).

## **4. Results**

### **4.1. Introduction of the new tool in teaching**

During the first term, the Interactive Microbiology website was accessible to a total of 381 students (82 from the Microbiology course and 299 from the Microbiology I course), and it was used in four theoretical groups and two classroom practice groups.

The introduction of the new tool in the learning process was a clear support for the professors when explaining what a microbiology laboratory is and for explaining the most basic microbiology methodologies and how they are used. In fact, the use of the website in the classroom, as well as independently by students, has gone a great deal to pave the way for the first lab practices, as well as for understanding them. Likewise, the professors of both courses have included in their presentations the different problems that are proposed on the website for each topic or teaching unit, which helps students to achieve the goals through a not just passive but also active learning procedure based on solving the problems posed on the website.

During this pilot test, several dysfunctions in the website were noticed, which have already been corrected on the final website that is currently available. What is more, help tags and tutorials were also including, following students' suggestions.

### **4.2. Evaluation of the website**

In mid-December a voluntary questionnaire was administered to the students involved in this pilot test. The survey was conducted anonymously in the classroom, and 142 students in the Microbiology course and 53 in the Microbiology I course responded, which accounts for 47.5 % and 64.6 % of the students in each course, respectively. The results of both surveys are shown in the supplementary materials (Enuesta\_Microbiologia 1.ppt and Enuesta\_Microbiologia.ppt). In these documents, we can see that the opinion of the majority of students was that the website was a very useful or necessary tool to supplement the classes (80 % in Microbiology and 57 % in Microbiology I). The difference in percentages between the two groups of students was due to the fact that 26 % of the students in Microbiology I chose the option Other in response to this question, indicating that the website was useful. Despite the fact that the majority of students believed that the website was a good learning tool, only 26 % from Microbiology and

23 % from Microbiology I said that they used it more than six times. The main reason stated by many students to justify why they did not use the website as much as they wanted was a lack of time. There was also a high degree of agreement that the website helped them to better understand the concepts explained in the theoretical classes (74 % for Microbiology and 71 % for Microbiology I), the practical classes (79 % for Microbiology and 68 % for Microbiology I) and the classroom problems (58 % for Microbiology I). There is also a high level of agreement among the students with regard to the fact that the website developed is a good independent learning tool and that it should not be used to conduct online evaluations (75 % Microbiology and 81% Microbiology I). The students in Microbiology (53 %) found it more intuitive and user-friendly than the students in Microbiology I (42 %). Fifty-one percent of the students in Microbiology found the problems difficult, while 40 % consider their level to be appropriate. With regard to the students in Microbiology I, 42 % found the problems difficult and 48 % found them appropriate. Almost 50 % of the students experienced some sort of technical glitch (51 % in Microbiology and 43 % in Microbiology I), while 20 % from Microbiology and 25 % from Microbiology I had no problems. When asked about the technical problems, the majority of responses referred to problems with the network but not with the website itself.

The results of the survey also revealed a series of areas that needed improvement on the website, as well as the need to provide help, such as the help tags that were designed for the definitive version.

Finally, it is also worth stating that the opinions of the professors involved in this experience were very positive, as the tool is attractive for students, easy to use and allows them to learn independently and practise in the virtual microbiology lab as much as they want. Worth highlighting is the opinion of the professors who teach the practice classes, as they stated that the use of the virtual laboratory before the students did the lab practices helped them to attain their goals and skills much better in the practical part of the course. This could be seen in the evaluation conducted on the last day of practices, as only three students doing the practices in the courses Microbiology and Microbiology I failed.

## 5. Conclusions

From the results from the pilot test implementing the Interactive Microbiology website in learning microbiology, we can conclude that the tool developed is attractive for the students, who rated it quite highly. In the final version of the website, the dysfunctions that were identified in the first few months that this resource was implemented were resolved, and the elements that students requested the most in the surveys, namely explanatory tags and tutorials, were added.

This problem-based learning experience, which combines theoretical with practical aspects thanks to the design of a virtual laboratory and simulations of experimental results, should serve as the foundation for developing new projects targeted at

students in more advanced microbiology courses. Furthermore, the experience may also be useful for learning other disciplines within the life sciences and other experimental sciences.

#### **Interesting links**

Innovation website: <http://microbiologia.uab.cat/microbiologainteractiva> [2008]

#### **Keywords**

Website, microbiology, problems, virtual laboratory.

#### **Financing**

This project was financed by the AGAUR programme on Improving the Quality of Teaching at Catalan Universities (MQD) for 2006 (ID number 2006 MQD 00027).

#### **Supplementary materials on the CD-ROM**

Demonstration of the INTERACTIVE MICROBIOLOGY website: virtual laboratory in which experiments can be carried out.

#### **Project leader**

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#### **Presentation of the working group**

The majority of members of the team of professors participating in this project, as well as the professor in charge of it, have been teaching microbiology in different degree programmes at the UAB for more than 20 years. Furthermore, this faculty is also involved and in charge of the Microbiology specialisation track offered by the Biology degree programme in the Faculty of Biosciences. This specialty offers 112.5 elective credits, the majority of which correspond to the specific contents of microbiology and include credits for practices in companies and institutions in the field of microbiology. This faculty also coordinates and participates in teaching the Master's in Microbiology and the Doctorate in Microbiology offered at the UAB, which has earned a distinction for quality since academic year 2003-2004.

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