Problem-Based Learning in Plant Biology

E. Pérez-Urria, A. Avalos, A. Gómez Garay, L. Martín, B. Pintos

Departamento de Biología Vegetal I (Botánica y Fisiología Vegetal)
Facultad de Biología, Universidad Complutense de Madrid
elenapuc@bio.ucm.es, avagar@bio.ucm.es, magom02@bio.ucm.es, lmartin@bio.ucm.es,
bpintos@bio.ucm.es

RESUMEN

Aprendizaje basado en Problemas en Biología Vegetal

El aprendizaje basado en problemas (ABP) es un método de enseñanza-aprendizaje que usa el problema como punto de partida para la adquisición e integración de nuevos conocimientos. En el desarrollo del ABP el problema es el camino para que los estudiantes alcancen los objetivos de conocimientos, destrezas y habilidades. El ABP y el estudio de casos se centran en el estudiante lo cual implica necesariamente un cambio de función en el profesor que deja de ser protagonista para convertirse en una guía o en tutor. El tutor plantea problemas y cuestiones que contribuyen al entendimiento y a la resolución de problemas promoviendo de esta forma un aprendizaje significativo. Por otra parte, las nuevas tecnologías de la información y la comunicación introducen cambios importantes en el proceso de enseñanza-aprendizaje en base a lo siguiente: a) el acceso a la información y el modo de adquirir información, b) las nuevas formas de relación profesor-alumno. Este trabajo muestra algunas experiencias para el desarrollo de ABP, el estudio de casos y la elaboración de mapas conceptuales e infografías, experiencias realizadas en el aula con estudiantes de Biología de la Universidad Complutense de Madrid y en relación con dos campos de la Biología: la Fisiología Vegetal y la Biología Evolutiva.

Palabras clave: Aprendizaje Basado en Problemas (ABP), Fisiología Vegetal, Biología Evolutiva, Metodología de Enseñanza-Aprendizaje, Aprendizaje significativo.

SUMMARY

Problem-based learning in Plant Biology

The problem-based learning (PBL) is a teaching-learning method that uses the problem as a starting point for the acquisition and integration of new

knowledge. In the development of PBL the problem is the way to achieve the knowledge, skills and abilities. Problem-based learning and case study focuses on the student and therefore imply a change in the teacher role: from protagonist to tutor or guide. A tutor offers questions that contribute to understanding and managing the problem promoting meaningful learning. On the other hand, information and communication technologies introduces important changes in teaching and learning on the basis of two issues: a) access and how to acquire information, b) new forms of teacher-student relationship. This work shows some experiences for the development of PBL, case studies and concept mapping as classroom experiences for Biological Sciences students at the Complutense University of Madrid. Two biological sciences fields were considered: plant physiology and evolutionary plant biology.

INTRODUCTION

Problem-based learning is a motivating approach, linked to professional reality, which promotes meaningful learning bridge the gap between theory and practice. The goal of all teachers is that students understand and know their stuff, learn reasoning and memorizing. This course uses problem solving in many fields of physics, chemistry or biology, to name a few examples and exercises. We must distinguish between exercise and problem as in the first case to apply an algorithm while solving a problem is to give a coherent explanation for a set of data. The problems may or may not applications, but the greatest interest lies in the problem itself and in the process of resolution.

While problem solving is a practice of teaching, in reality, the sometimes disappointing results in terms of actually acquire knowledge even when students passed the examinations of the subjects. This usually presents as they advance courses and a new subject requires knowledge of previous ones in the curriculum. It is desirable that any new knowledge gained is linked to other previous way along the studies were constructed in the minds of students a "knowledge network" rather than a database.

On the other hand, information and communication technologies introduce important changes in teaching and learning founded on two issues: access and how to acquire information, and new forms of teacher-student relationship.

Problem-based learning and case study focus on the student and therefore imply a change in the teacher role of protagonist goes on to tutor lectures. A tutor poses questions that contribute to understanding and managing the problem. In addition, the active role of the student includes the following:
  • Identify what you know about the problem.
  • Identify what is unknown and needs to know.
  • Planning an information search strategy.

• Define the problem explaining what it intends to solve, show or respond.
• Interpret data.
• Provide coherent explanations.

Case studies usually represent a step in the learning process that serves to bring knowledge to professional and social reality. Two types of cases can be distinguished:
• Cases raised and resolved by specialists
• Cases set for students to apply principles and procedures and solve the case. This model is another definition of problem-based learning so that the process is described for PBL.

The cases raised and resolved by specialists can be presented to students in order to know, understand, analyze and / or evaluate both the processes that occur as the skills required for their understanding. The cases are based on a theoretical framework and without pretending to be merely descriptive solutions. In this sense, they can select those that describe a solution to a given situation so that their study included a first phase aimed at students aware of the situation described, and a subsequent step in the theoretical concepts are formulated and methodology derived from the case study. The aim will be to study, analyze, reflect, discover, learn, seek information and, ultimately, acquire knowledge as "the student asks," than by what is said. This process is very useful to develop concept maps as a tool to establish relationships between concepts.

This paper proposes an analysis of cases brought and resolved by specialists to guide the development of a theory, the resolution of cases for students to apply principles and procedures and the development of concept maps. The aim is to advance the field of education to improve learning and learning becomes meaningful. In a sense, poses a similar way to teaching as research, including knowledge of new methodologies, the practice of experts in education and teaching, and the results obtained by other professionals.

CASES RAISED AND RESOLVED BY SPECIALISTS

Since the beginning of the course students have a complete plan of the subject with the information on the content and development project. In plant physiology the subject is about the "Growth and Development" in plants, the system "Soil-Plant-Atmosphere" and "Plant Metabolism". These aspects may be arranged in the form of concept map so that along the course students may complete this map with the definitions of concepts (Fig. 1) to build an interactive map. The use of these maps in the first class or the first meeting between teacher and students will also serve as introduction and approach to the study of issues to address and set the "skeleton" of the knowledge network to be trained.

In the context of current environmental problems with scientific, political and social implications, the global warming associated with the emission of gases into the atmosphere and the greenhouse effects is a good subject or topic for scientific work in the classroom. Case study and problem based learning can

be developed based on this topic, global change, in order to gain knowledge of previously mentioned aspects of Plant Physiology (Fig. 1).

In this regard it is proposed the use of descriptive cases presented in video format. They can serve as an example the following videos:
1. http://www.youtube.com/watch?v=FgEZpX3n5mo&feature=channel
2. http://www.youtube.com/watch?v=H7sACT0Dx0Q;
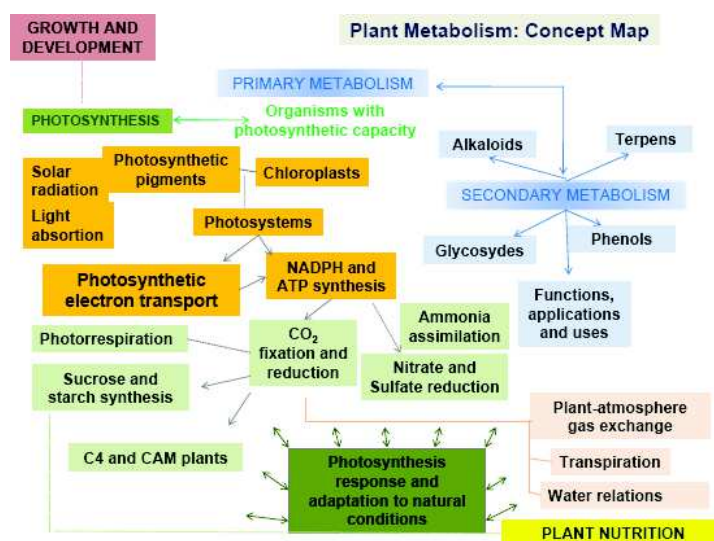3. http://www.youtube.com/watch?v=qyb4qz19hEk&feature=channel)

Figure 1. Concept map about Plant Metabolism (yellow: photosynthesis; green: primary metabolism; blue: secondary metabolism)

The steps in the development of the case are:
• video display in the classroom.
• Study by analyzing the situation described.
• Identify what is known.
• identify what is unknown.
• Collect information and data necessary to meet and / or understand the case.
• Examine each of the issues or problems and their solutions.
• Identify agenda items that correspond to the case study.
• Perform information graphics, an outline or concept map of the case containing information related to the topic and type of case described (the solution to a problem, a problem or a solution)

The study of such cases poses to promote learning, make use of prior knowledge, acquire new knowledge and develop basic skills in students such as analyzing situations and obtain, synthesize and connect information.

CASE 1: *Global change affects photosynthesis and productivity of Mediterranean crops.*

Researchers CK and PG, the Institute of Subtropical Plants and Olive of Crete, think that global warming will to make changes in ecosystems that affect photosynthesis and plant productivity. In this Mediterranean island (Fig. 2) the high temperatures and low rainfall during the summer are the main factors affecting the productivity of tree crops. According to the data recorded by the agency and European Climate Assessment Dataset (Fig. 3), the average temperature in the last 25 years has increased 0.3 º C
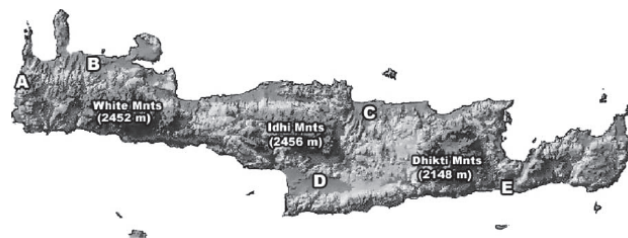

Figure 2. Crete Island showing the main areas of cultivation (A, Falassarna; B, Chania, C, Heraklion, D, Messara valley; D, Ierapetra) (From Chartzoulakis, K and Psarras, G. (2005). *Agriculture Ecosystems and Environment*, 106:147-157).
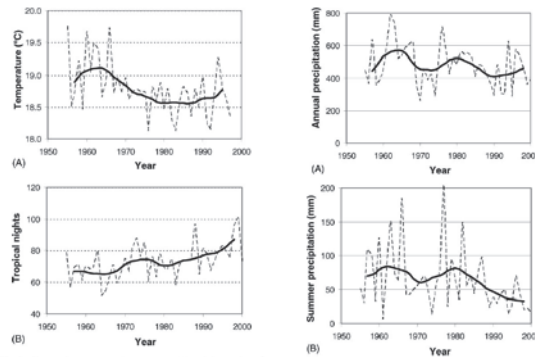

Figure 3. Annual changes in mean temperature (A, left), number of warm nights (B, left) (temperature above 20 º C), precipitation (A, right) and precipitation in summer (B, right) during the second half of the s. XX in the area of Heraklion. (From Chartzoulakis, K and Psarras, G. (2005). *Agriculture, Ecosystems and Environment,* 106:147-157).

Under this approach, the objective is to understand and analyze the factors that limit or increase photosynthesis and plant productivity. Here are some data for analysis:
• The concentration of atmospheric carbon dioxide is rising above the normal or natural consequence of the industrial revolution.
• UV-B radiation is increasing.

• The annual rainfall is also changing. During the twentieth century has been an increase of precipitation in the northern areas and a decrease in the Mediterranean area.
• In olive exposed to $[CO_2] = 560$ l / l is noted that:
• Increased photosynthetic rate.
• Increased efficiency of sweating.
• Reduced stomatal conductance.
• Less number of stomata.
• In lemon trees growing at high concentrations of CO2 is observed less chlorophyll per unit area and lower leaf nitrogen content
• In orange growing at a $[CO_2] = 700$ l / l biomass production during the first two years increased by 200% compared to the growth in terms of $[CO_2] = 400$ l / l. After seven years this production was reduced to 80%.

Questions:
• What effect does the increased levels of carbon dioxide on photosynthesis? Can be considered a general response of perennial plants to rising CO2 levels?
• What effect does increased UV-B radiation on photosynthesis?
• What effect does the rain fall on photosynthesis?
• What consequences can be reduced rainfall and increased temperature on the water status of crops? Make a concept map.
• Is it possible to determine the response of plants to a new warmer environment in semiarid regions of the Mediterranean?

You must know the following questions:
• Nature of sunlight and solar radiation spectrum.
• Photosynthesis: components involved, stages photochemistry and biochemistry.
• Response of photosynthesis to increasing atmospheric carbon dioxide.
• Mechanisms of CO_2 concentration.
• Response of plants to higher temperature.

CASE 2: *Evolutionary Plant Biology*.

Different techniques are used to compare characteristics of organisms aimed to analyze the similarity between them. They are also different characteristics that define organisms: molecular, metabolic, cellular, environmental, behavioral, etc. Based on the similarity, entities of the biological hierarchy are sorted and classified. This case proposes to study a property of organisms, their metabolism, in particular the metabolism of porphyrins and chlorophylls using cladistic procedures. The result of cladistic analysis is an evolutionary hypothesis, ie, a phylogenetic hypothesis.
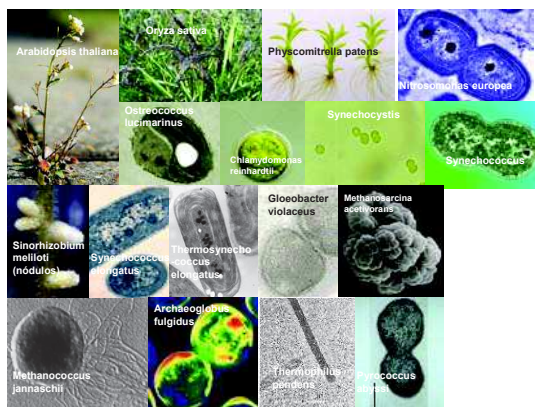
Figure 4. Study group.

Teachers proposes to analyze the phylogenetic relationships among three enzymes in the metabolism of porphyrins: the large subunit of rubisco (rbcL), porphobilinogen synthase and glutamyl-tRNA synthase For this, the teacher provide students with a study group (Table 1 and Fig. 4) and the sequences of the enzymes.

There are many free access databases from which students can obtain the sequences of the enzymes: GenomeNethttp://www.genome.ad.jp/, ExPASy Proteomics Serverhttp://www.expasy.ch/,European Bioinformatics Institute http://www.ebi.ac.uk/, National Information Center for Biotechnology http://www.ncbi.nlm.nih.gov,Genbankhttp://www.ncbi.nlm.nih.gov/Genbank/index.html.

ath	*Arabidopsis thaliana*	Plant
osa	*Oryza sativa*	Plant
ppp	*Physcomitrella patens*	Moss
olu	*Ostrococcus lucimarinus*	Alga
neu	*Nitrosomonas europea*	Beta-Proteobacteria
ret	*Rhizobium etli*	Alfa-Proteobacteria
bbt	*Bradyrhizobium*	Alfa-Proteobacteria
syn	*Synechocistis*	Cyanobacteria
syw	*Synechococcus*	Cyanobacteria
syc	*Synechococcus elongatus*	Cyanobacteria
tel	*Thermosynechococcus*	Cyanobacteria
gvi	*Gloeobacter violaceus*	Cyanobacteria
ana	*Anabaena*	Cyanobacteria
pma	*Prochlorococcus marinus*	Cyanobacteria
cte	*Chlorobium tepidum*	Chlorobiaceae
mja	*Methanococcus jannaschii*	Euryarchaea
afu	*Archaeoglobus fulgidus*	Euryarchaea
nph	*Natronomonas pharaonis*	Euryarchaea
pab	*Pyrococcus abyssi*	Euryarchaea
rci	*Uncultured methanogenic archaeon RC-I*	Euryarchaea

The data set, characters and taxa, is arranged in a basic data matrix. In phylogenetic analysis of molecular characters, each element of the sequence is a character. So that, each amino acid of the enzyme sequences is a character. But the same protein (homologous) in different species shows sequence variations (both in length and amino acids). Differences in the sequence itself is the aim analysis.

First of all, student needs perform the alignment of sequences using free programs like Clustal W (http://align.genome.jp/). The results of this alignment can be written in different formats and for this case the output format is called "PHYLIP" and consists of a matrix (basic data matrix) suitable for phylogenetic reconstruction programs that will be used then.

This basic data matrix containing n sequences (n taxa or species) and m characters (amino acids or positions) reflects in the first line these numbers (Fig. 5) (this configuration is required because the programs that will be used only read this format).

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            23      752
ath_ArthCp  ---------- ---------- ---------- ---------- ----------
osa_313146  ---------- ---------- ---------- ---------- ----------
ppp_Phpapa  ---------- ---------- ---------- ---------- ----------
tel_tll150  ---------- ---------- ---------- ---------- ----------
ana_alr152  ---------- ---------- ---------- ---------- ----------
gvi_gvip29  ---------- ---------- ---------- ---------- ----------
syn_slr000  ---------- ---------- ---------- ---------- ----------
syc_syc013  ---------- ---------- ---------- ---------- ----------
neu_NE1921  ---------- ---------- ---------- ---------- ----------
bbt_BBta_2  ---------- ---------- ---------- ---------- ----------
syw_SYNW17  ---------- ---------- ---------- ---------- ----------
pma_Pro055  ---------- ---------- ---------- ---------- ----------
bbt_BBta_0  ---------- ---------- ---------- ---------- ----------
bbt_BBta_6  ---------- ---------- ---------- ---------- ----------
nph_NP2770  ---------- ---------- ---------- ---------- ----------
pab_PAB158  ---------- ---------- ---------- ---------- ----------
afu_AF1638  ---------- ---------- ---------- ---------- ----------
mja_MJ_123  ---------- ---------- ---------- ---------- ----------
rci_RCIX22  ---------- ---------- ---------- ---------- ----------
afu_AF1587  ---------- ---------- ---------- ---------- ----------
cte_CT1772  ---------- ---------- ---------- ---------- ----------
ret_RHE_PF  ---------- ---------- ---------- ---------- ----------
olu_OSTLU_  MAPKSFEDMF ACSPASLTKL RASHAPHASP AASHARDYSP IAFPSMRRDD
```

Figure 5. Basic Data Matrix.

The parsimony program will be used is Protpars, one the many programs present in Phylip (a free package of phylogenetic inference programs). The ultimate goal is to analyze and interpret cladograms (Figs. 6 and 7) and here are some data and questions for the analysis and discussion:
. What organisms / species make up the study group?
. Basic characteristics of the organisms under study:
     prokaryote: bacteria and archaea
     eukaryotic: plants, algae
. Archaea: phylogenetically closer to eukaryotes than bacteria and do not contain peptidoglycan, or cellulose in the wall (as bacteria); other polysaccharides,

glycoproteins and proteins; aerobic and anaerobic species; autotrophic (primary producers using CO_2 or CH_4 as carbon source and obtain energy from the oxidation of inorganic molecules such as H_2S, H_2, CH_4; do not fix C through photosynthesis; chemosynthetic or chemolithoautotrophs.
. Chlorobiaceae: green sulfur bacteria, anoxygenic photosynthesis, use SH_2 or S as electron donor; S-rich zone, anaerobic lakes and some deep ocean vents
. Mosses: nonvascular plants, chloroplasts with chla and chlb, carotenoids, starch and cellulose; lignin have not.
. Algae: oxygenic photosynthesis
. Cyanobacteria: oxygenic photosynthesis
. Alpha-Proteobacteria: Purple bacteria; photosynthetic (photoautotrophic), bacteriochlorophyll and carotenoids; symbints or free-living forms.
. Beta-Proteobacteria: chemoautotrophs; chemosynthetic transform ammonia to nitrite.

Questions:
1. What is cladistic? 2. What are sister groups? 3. What is a cladogram? 4. What is a basic matrix of data? 5. What type of analysis performed PROTPARS program? What results provide? 6. Analyze rbcL, porphobilinogen synthase and glutamyl-tRNA synthase cladograms, both individual and comparative analysis.
7. What clades are distinguished in the most parsimonious tree of rbcL, porphobilinogen synthase and glutamyl-tRNA synthase? What sequences are plesiotypic? What explanation can be given to the presence of plastidial rbcL of "ath" between cyanobacteria? What explanations can be given to the similarity of archaeal rbcL (archaea) and other bacteria (proteobacteria and green sulfur bacteria) with the cyanobacterial rbcL? 8. What is the significance of the length of trees? 9. What is the length of porphobilinogen synthase and glutamyl-tRNA synthase sequences cladograms?. Do you get more than one cladogram? Are they identical cladograms?

You must know the following questions: Apotypic and plesiotypic characters, Basic aspects of cladistic analysis, Principle of parsimony, Basic aspects of organisms and taxonomy.
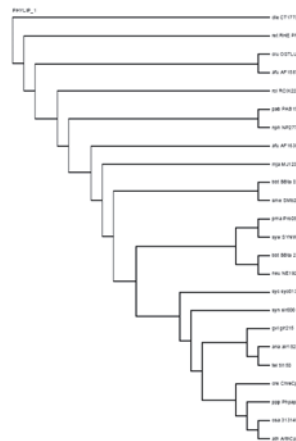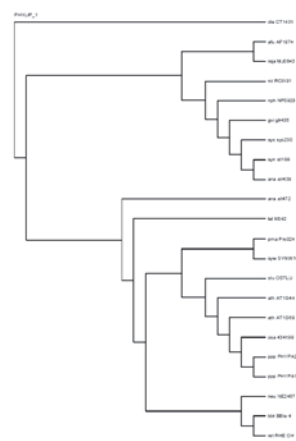

………Figure 6. rbcL cladogram   Figure 7.Porfobilinogen synthase cladogram

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Problem-Based Learning, University of Delaware

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