Design and application of a proposal for cooperative learning for the contents in the field of ecology through case studies

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Abstract
This article presents a web-based platform (http://www.creaf.uab.es/AprenEcolgia/) containing 13 case studies with the goal of improving the learning of contents related to ecology in a variety of university degree programmes. The case studies can be chosen from the website based on their subject, although they are also categorised according to eight different educational criteria that can help each user chose the right case study depending on their goals, and allowing the professors who have used them to add their assessment. The case studies can be downloaded freely from the website by any user, and there is also the option of adding suggestions or assessments of how they work, as well as the ability to generate new case studies using a template. Most of these case studies have already been used in teaching Biology and Environmental Sciences at the UAB, and from the perspective of both faculty and students, they have been useful for learning the contents, both conceptual and methodological, of the different courses.

General area of interest of this innovation
In addition to the different areas of study that involve issues related to ecology in the organisation and approach of the project, this innovation might be useful in general for many different university courses on the sciences, as well as for baccalaureate programmes.
1. Objectives
The general goals of the project were:
1. To design a series of case studies that would bolster the efficiency of the learning of the contents and skills related to ecology for university students at a variety of levels and from different degree programmes.
2. To present the case studies on a web-based platform that would enable users, mainly professors, to get all the material they needed, as well as an implementation guide for using the case study in their teaching.

The skills that are honed in the different case studies are not always the same, plus they can fluctuate in each case depending on how each teacher decides to use the case studies. For this reason, the information on each case study outlines the different skills that are meant to be practised in each specific case.

2. Description of the project

2.1. Background of the innovation
The need for this innovation emerged from the response by a group of professors in the Ecology Unit at the Universitat Autònoma de Barcelona to a series of shortcomings detected in our students’ learning of the ecology contents in the Biology and Environmental Sciences programmes. We noticed how often the successive courses in this field of knowledge repeated the same syllabus with increasing degrees of complexity, but leading students to lose motivation when faced with concepts that they did not identify as new. The field of ecology is particularly sensitive to this due to its conceptual load. One alternative to this situation is the gradual acquisition of knowledge and skills using practical tools that are familiar to the students, taking advantage of some of the qualities of the young generations (Internet, visual communication, languages, etc.).

For years, the Ecology Unit in the Department of Animal Biology, Plant Biology and Ecology at the UAB has been conducting experiments with the goal of increasing students’ active, practical learning. However, despite the positive results of many of these experiments, certain problems also came to light:
1. A great deal of time must be invested in acquiring the information.
2. It is difficult to share the professionals’ vision.
3. Evaluation is difficult unless it is performed based on pre-established cases.
4. There is an overall lack of planning of the goals, methods and evaluation.

This series of problems could be improved via the proposal described herein, that is, by ensuring that part of the teaching practice of ecology revolves around case studies with different levels of specificity and methodologies. The case study methodology seemed appropriate because it is a practice that in many different settings has demonstrated its vast educational potential, especially because of its ability to foster reflective learning and to facilitate the understanding of complex issues. Case stud-
ies enable students to not just recall information and methods, rather it also helps them to know how to apply them within a specific context: «students have to know not just the “what” but also the “when”, “where” and “how”» (Dochy, Segers and Dierick, 2002). Its main characteristic as a teaching method does not lie in the fact that it uses cases, rather in how these cases are dealt with. The core of this methodology is discussion, the possibility of developing questions, comparing positions and putting into practice theoretical and practical concepts using dialogue. Therefore, as a method it does not work in itself, rather it depends on teachers who know how to use it in all its potential, professors who are capable of generating an interesting, reflexive educational atmosphere (Blythe, 1999).

2.2. Characteristics of the innovation
In this field, we consider that learning in ecology based on the globalising approach provided by the case study method allows for: cooperative work, active learning, realism, application of the knowledge in different contexts, transversality with other disciplines and the integration of knowledge and skills. Therefore, the content of this innovation involves the development of working techniques based on case studies in order to gradually organise the acquisition of knowledge and skills in the field of ecology within the Biology and Environmental Sciences degree programmes. Each case study has a description that includes its goals, a proposed guide for conducting the case study and all the materials (maps, databases, diverse documents) for conducting it in the classroom. The case studies can be chosen from the website based on their subject, although they are also categorised according to eight different educational criteria that can help each user choose the right case study depending on their goals. The case studies can be downloaded freely from the website by any user, and there is also the option of adding suggestions or assessments of how they work, as well as the ability to generate new case studies using a template.

3. Methodology
Thirteen case studies were designed focusing on the contents of ecology that were to be resolved by students in different degree programmes and at different university levels. The case studies are presented on a website: http://www.creaf.uab.es/AprenderEcologia/2008.

Each case study has a guide sheet for conducting it that contains the following sections:
1. Title of the case study: This refers to its content.
2. General introduction: This tells for what type of students and class/group the case study was designed, and some defining element is highlighted.
3. Description of the case study: The case study is categorised according to eight strands or characteristics related to their contents or the skills they hone. Each character-
istic has a variety of alternatives, which are indicated for each case study and are not necessarily mutually exclusive, as shown in Table 1.

Table 1. Characteristics used to define each case study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Possibilities of each characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of course</td>
<td>Compulsory – elective</td>
</tr>
<tr>
<td>Conceptual complexity</td>
<td>Abstract or concrete</td>
</tr>
<tr>
<td>Applicability of the concepts</td>
<td>Basic or applied</td>
</tr>
<tr>
<td>Information management</td>
<td>Acquisition, critical analysis or transmission of information</td>
</tr>
<tr>
<td>Type of skills</td>
<td>Transversal, scientific or specific to ecology</td>
</tr>
<tr>
<td>Professionalisation</td>
<td>From low to high</td>
</tr>
<tr>
<td>Analysis of dynamics</td>
<td>Pattern interpretation, process modelling, prediction</td>
</tr>
<tr>
<td>Degree of formalisation of problems</td>
<td>Qualitative, semi-quantitative or quantitative</td>
</tr>
</tbody>
</table>

4. **Goals**: The learning goals for the case study are explained.

5. **How to conduct the case study**: A proposal is offered for how to conduct the case studies indicating the different associated materials for examining it (these materials can be gotten by clicking on the name). In some cases, these materials are for the professors themselves, but the majority are there to help the students solve the case study.

6. **Evaluation**: Each case study proposes the evaluation system used in our classes as well as other possible systems. The goal was to offer different evaluation tools with special attention to formative evaluation, self-evaluation and peer evaluation as a sound complement to traditional evaluation systems (Brown and Glasner, 2003).

7. **Time**: This indicates the amount of time needed by both professors and students, specifying in-class work or individual independent study or group work.

8. **Notes**: This includes possible difficulties or factors to bear in mind, often based on the experience of having used the case studies in our classes.

9. **Supplementary activities**: Suggestions for supplementary activities or possible modifications in how the case study is conducted that might help to improve the learning of certain aspects dealt with in the case study. The website is designed so that the professors can freely download each case study and apply them to the class without having to make virtually any changes. Table 2 lists the case studies, and Table 3 shows their categorisation according to Table 1.
Table 2. Titles of the 13 case studies generated

<table>
<thead>
<tr>
<th>Case</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The ecological foundations of ecological agriculture</td>
</tr>
<tr>
<td>2</td>
<td>Atmospheric CO₂, global warming and effects on the biosphere</td>
</tr>
<tr>
<td>3</td>
<td>Proposal for forest management</td>
</tr>
<tr>
<td>4</td>
<td>Effects of herbivore behaviour on plant species and communities</td>
</tr>
<tr>
<td>5</td>
<td>Population dynamics of the forests in Collserola</td>
</tr>
<tr>
<td>6</td>
<td>Proposal for a plan to biomonitor atmospheric pollution</td>
</tr>
<tr>
<td>7</td>
<td>Analysis of factors that influence infections on the leaves of holm oak trees</td>
</tr>
<tr>
<td>8</td>
<td>The plasticity of the leaves of holm oak trees</td>
</tr>
<tr>
<td>9</td>
<td>Hydraulic properties of the xylem of different woody Mediterranean species</td>
</tr>
<tr>
<td>10</td>
<td>Readings on conservation biology</td>
</tr>
<tr>
<td>11</td>
<td>Endocrine disruptors: «new» water pollutants</td>
</tr>
<tr>
<td>12</td>
<td>Proposal for post-fire forest management</td>
</tr>
<tr>
<td>13</td>
<td>The sludge from waste water treatment stations</td>
</tr>
</tbody>
</table>

Figure 1. General appearance of the http://www.craaf.uab.es/AprendeEcologia/ website showing the catalogue of titles of the different case studies on the left.
Table 3. Main characteristics of the 13 case studies designed according to the classification on Table 1 (case study number according to Table 2).

<table>
<thead>
<tr>
<th>Case Course</th>
<th>Concepts</th>
<th>Application</th>
<th>Information</th>
<th>Competences</th>
<th>Prof.</th>
<th>Analysis</th>
<th>Formalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compulsory Abstract and some basic</td>
<td>Applied and some basic</td>
<td>Analysis</td>
<td>Ecology</td>
<td>Average</td>
<td>Interpretation and modelling</td>
<td>Quantitative</td>
</tr>
<tr>
<td>2</td>
<td>Compulsory Abstract Basic</td>
<td>Basic</td>
<td>Analysis</td>
<td>Ecology</td>
<td>Low</td>
<td>Interpretation, modelling and prediction</td>
<td>Quantitative</td>
</tr>
<tr>
<td>3</td>
<td>Compulsory Concrete Applied</td>
<td>Applied</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>High</td>
<td>Interpretation and prediction</td>
<td>Quantitative</td>
</tr>
<tr>
<td>4</td>
<td>Compulsory Abstract Basic</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>Average</td>
<td>Interpretation</td>
<td>Quantitative</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Compulsory Abstract Concrete</td>
<td>Basic</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>Average</td>
<td>Interpretation</td>
<td>Quantitative</td>
</tr>
<tr>
<td>6</td>
<td>Compulsory Concrete Applied</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>High</td>
<td>Interpretation</td>
<td>Quantitative</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Compulsory Abstract Basic</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>Low</td>
<td>Interpretation</td>
<td>Quantitative</td>
<td></td>
</tr>
<tr>
<td>Cours</td>
<td>Concepts</td>
<td>Application</td>
<td>Information</td>
<td>Competences</td>
<td>Prof.</td>
<td>Analysis</td>
<td>Formalisation</td>
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<tr>
<td>8</td>
<td>Compulsory</td>
<td>Abstract</td>
<td>Basic</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>Low</td>
<td>Interpretation</td>
</tr>
<tr>
<td>9</td>
<td>Compulsory</td>
<td>Abstract</td>
<td>Basic</td>
<td>Analysis and transmission</td>
<td>Ecology and transversal</td>
<td>Low</td>
<td>Interpretation and modelling</td>
</tr>
<tr>
<td>10</td>
<td>Elective</td>
<td>Concrete</td>
<td>Applied</td>
<td>Analysis</td>
<td>Ecology and scientific</td>
<td>High</td>
<td>Interpretation</td>
</tr>
<tr>
<td>11</td>
<td>Compulsory</td>
<td>Concrete</td>
<td>Applied</td>
<td>Analysis</td>
<td>Ecology and scientific</td>
<td>High</td>
<td>Interpretation</td>
</tr>
<tr>
<td>12</td>
<td>Compulsory</td>
<td>Concrete</td>
<td>Applied</td>
<td>Analysis and transmission</td>
<td>Ecology</td>
<td>High</td>
<td>Interpretation and prediction</td>
</tr>
<tr>
<td>13</td>
<td>Compulsory</td>
<td>Concrete</td>
<td>Applied</td>
<td>Analysis</td>
<td>Ecology and scientific</td>
<td>High</td>
<td>Interpretation</td>
</tr>
</tbody>
</table>
4. Results

4.1. of case studies in the practices on General Ecology in the Biology and Environmental Sciences programmes

Case studies 4, 5, 7, 8 and 9 (Table 2) have been used in the practical classes of the General Ecology course in both Biology and Environmental Sciences programmes. However, in this case data that the students themselves gathered in the field were used instead of the databases presented on the website. In fact, this type of field trip in groups of 20-25 students and lasting an entire week has been part of this course for many years. The students’ assessment of the usefulness of these practical experiences in learning ecology is quite positive (Figure 2).

Figure 2. Number of responses from students in the fourth year of the Environmental Sciences programme according to their degree of agreement (1 - not at all to 5- totally) with the statement «The second-year ecology practices were useful for my learning of ecology».

Likewise, the type of formative evaluation proposed in these case studies helps students to attain different competences related to ecology and scientific learning in general (Rodrigo and Ecology Unit, 2006).

4.2. Application of case studies in the theoretical classes on General Ecology in the Biology and Environmental Sciences programmes

Case studies 1 and 2 (Table 2) were used in academic year 2005-06 in the theoretical classes on General Ecology in the Environmental Sciences programme. These case studies are meant to be used in theoretical classes (60-70 students) with the primary goal of supporting the learning in the theoretical syllabus of the course. As shown in Figure 3, in this course, too, the students viewed these case studies as useful for helping them to understand the theoretical contents of the class, as well as to see the usefulness of the course and, therefore most likely to increase their motivation.
4.3. Application of case studies in the theoretical classes on Applied Ecology in the Environmental Sciences programme

Case studies 3, 6 and 12 have been used since academic year 2005-06 in the theoretical classes of Applied Ecology in the Environmental Sciences programme. Their goal is to apply the contents and methodologies taught in a specific class, as well as to guide students in doing a project in the course that consists of resolving a similar case, but one that they have to pose and resolve independently. In order to analyse the result of this case study, we rated the students’ perceptions. According to them, the three main
goals were fulfilled: the cases were useful for helping them to understand the concepts, for knowing how to use the process in another real case, and even, though to a lesser degree, for their future professional activity, an important goal for a course in the fourth year of the degree programme that aims to be applied (Figure 4).

A comparison among the courses in terms of numerical results of the final marks is quite difficult, especially in this course. For example, we could compare the marks earned for the independent project in the course in which the case study was not done in class and in those in which it was done in class, but the problem is that the project itself was altered. However, one figure that might be illustrative is the percentage of students who did not do the project, that is, those who received an incomplete in the class. Before doing the case study in class, the proportion was 17 % and 14 % in academic years 2003-04 and 2004-05, respectively, whilst after doing the case study in class there is a now solid trend in which practically all the students do the project, with incomplete rates of 9.8 %, 5 % and 5 % in academic years 2005-06, 2006-07 and 2007-08, respectively.

5. Conclusions
The main conclusion is that working based on resolving the case studies proposed improved attainment of both the specific Ecology skills and the general scientific and transversal skills. We can say that the exercise of applying the different knowledge and skills involved in resolving these case studies has enhanced the consolidation of these contents by students, while it has also improved their perception of their competence in Ecology.

Specifically, in the teaching of Ecology in the Biology and Environmental Sciences programmes at the UAB, we can claim that working with the case studies included in the project:
1. Has reinforced the students’ knowledge about basic aspects of the syllabus.
2. Has consolidated more general scientific skills such as: resolving scientific questions based on rigorous discussions, which are in turn based on data, logical reasoning, formulating hypotheses and analysing statistical results.
3. Has been useful for working on transversal skills related especially to writing reports and doing oral presentations, as well as the skills involved in group work and taking joint decisions.
4. Has improved students’ overall attitude towards the course.

From the teaching standpoint, the case studies designed are useful for the professors because:
1. They improve the monitoring of the learning process and students’ understanding of the material.
2. They make it easier to implement different types of evaluation, including self-evaluation and peer evaluation. This way of evaluating enables teachers to detect gaps in students’ knowledge or misunderstood ideas in order to correct them during the learning process itself.
3. They make it easier to including small-group tutorials; in the cases when these sessions have been added, they have proven to be a powerful learning tool for students. In terms of the case studies themselves, when applying them we have detected the following two needs:
   a) There need to be more case studies that involve modelling and predicting instead of just analysing the information. These would most likely be cases designed for small groups in elective courses.
   b) There need to be more cases based on animal populations in aquatic and marine environments.

References

Interesting links
· Innovation website: http://www.creaf.uab.es/AprenEcologia/ [under construction]

Keywords
Case studies, ecology, formative evaluation.

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Supplementary materials on the CD-ROM
Demonstration of the website CASE STUDIES FOR LEARNING ECOLOGY: virtual tour of materials for "Atmospheric CO₂, global warming and effects on the biosphere".

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Presentation of the working group
The working group is made up of professors from the Ecology Unit at the UAB and researchers from the Centre for Ecological Research and Forestry Applications (CREAF) with experience in teaching innovation and generating multimedia teaching resources, including websites.

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