Teaching companion modelling to agronomy students: an original way to integrate concepts in agriculture and environment.

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Abstract

Companion modelling is an approach based on the use of models as tools to facilitate the understanding of multi-functionality, and adaptive management. It uses multi-agent models and role-playing games as mediation tools stimulating the implementation of new ways to build and share information. Emphasis has been recently placed on using the approach as an educational tool to increase awareness of the interactions between stakeholders and resources, to experience mediation processes among users of the same land, and to simulate decision-making in the implementation of a concerted land management plan.

Due to the lack of integrated teaching on agriculture and environment relationships, a specific educational programme was designed to make agronomy and forestry students understand the complexity of the interactions between agricultural activities, landscape dynamics and biodiversity management. As environmental issues are strongly scale dependent, the interactions are tackled at different scales from the farm to the catchment or the landscape. The training course is based on the conjunction of lectures, computer based exercises and interactive workshops. According to the length of the course (2 days, 4 days, 2 weeks), the students go more or less deeply through the main steps of the companion modelling approach. First, students try to understand a complex agricultural system by representing it in the form of a conceptual model describing the interactions between stakeholders and resources on a given territory. Secondly, they visualize the dynamics of this system by means of a multi-agent model, and a wide range of indicators, corresponding to the implementation of their conceptual model. Then, they play the role of the main stakeholders in the system by experiencing from inside the interactions with the other stakeholders and bearing the consequences of their decisions on the environment. Lastly, according to their experience during the role-playing game, they propose alternatives of management to improve the current situation, according to a set of available techniques, on which they have been previously trained.

Key-words : companion modelling, role-playing game, scenario simulation, agriculture, environment

Introduction

Companion modelling is an approach based on the use of models as tools to facilitate the understanding of multi-functionality, and adaptive management. It uses multi-agent models and role-playing games as mediation tools stimulating the implementation of new ways to build and share information (Etienne, 2006). Emphasis has been recently placed on using this approach as an educational tool to increase awareness of the interactions between stakeholders and resources (Etienne, 2003; Mathevet et al., 2007), to experience mediation processes among users of the same land (Etienne, 2006), and to simulate decision-making in the implementation of concerted land management plans (Etienne et al., 2003). This paper deals with teaching applications developed in France and aimed at agronomy or forestry students.

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Objectives

Due to the lack of integrated teaching on agriculture and environment relationships, a specific educational programme was designed on the basis of the companion modelling approach. The target of this programme is to train agronomy students (future generalist engineers dealing with rural issues) to understand the complexity of the interactions between agricultural activities, landscape dynamics and biodiversity management. As environmental issues are strongly scale dependent, the interactions were tackled from different scales: the farm, the catchment or the landscape. At the farm level, the course enhances knowledge of the organisation of the farming system. At the catchment level, it emphasizes land use systems, runoff and crop production sector organisation. At the landscape level, it deals with livestock farming systems, forest management, nature conservation and landscape dynamics.

Organisation

The training course is based on the conjunction of lectures, computer based exercises and interactive workshops or role-playing games. According to the length of the course (2 days, 4 days, 2 weeks), the students go through the main steps of the companion modelling approach in more or less detail and in the two-week option obtain a fair level of self-sufficiency in the use of the corresponding tools. The course is always divided into four steps. First, students try to understand a complex agricultural system (an agroforestry farm, a multi-cropped water catchment, a multiple-use landscape) by representing it in the form of a conceptual model, describing the interactions between stakeholders and resources on a given territory. Secondly, they visualize the dynamics of this system, by means of a multi-agent model and a wide range of indicators, corresponding to the implementation of their conceptual model. Then, they play the role of the main stakeholders in the system, by experiencing from inside the interactions with the other stakeholders and bearing the consequences of their decisions on the environment. Lastly, according to their experience during the role-playing game, they propose alternatives of management to improve the current situation, using a set of available techniques (agroforestry, differed grazing, shrub clearing, etc) on which they have been previously trained.
The choice of the territory depends mainly on the selected stakes and associated scales but can also be adapted to the location of the school of agronomy, in order to work on the most common surrounding farming systems, or to places where the students have already performed field work so that the results of their filed survey or enquiries with stakeholders can support the co-construction exercise.

Disciplines

One of the important aspects of this educational program is to integrate knowledge referring to a set of complementary disciplines related to agronomy. Students have to appeal to what they learnt in crop, livestock, forestry or life sciences, and must deal with concepts issuing many other sciences that they have to discover and learn by doing: human geography, ecology, conservation biology, genetics, sociology and economy. This mind-opening is facilitated by the multidisciplinary background of the students participating to master level courses.

At the farm level, livestock breeding and agroforestry techniques are combined with social (labour organisation, welfare) and economic aspects (cost/benefit approach). At the catchment level, cropping techniques and cropping plan optimisation should be thought and planned according to market price, product demand and soil erosion processes. Political decisions involve also the possibility of taxing bad agronomical practices, subsiding good agronomical practices and investing in runoff stocking equipment. At the landscape level, knowledge on livestock farming systems, grazing management and forest management are confronted with knowledge on environmental stakes. The latter covers both ecological (pine overspreading, rare species home ranges and habitats, grazing impact on vegetation structure and composition) and political aspects (agri-environmental policy, conservation policy). At the three levels, students are asked to think about relevant indicators of sustainable development.

Tools

Three tools contribute to stimulate a multidisciplinary approach on the question: the co-construction of an integrated conceptual model by means of the ARDI (Actors, Resources, Dynamics, Interactions) method (Etienne et al., 2007); a workshop where students experience situated actions through role-playing games (Bousquet et al., 2002); and the set up and simulation of management scenarios by using an agent-based model (Etienne et al., 2003).

The **ARDI method** consists of four steps for building up a collective understanding of how a particular socio-ecological system functions. The method is aimed at helping students to formalize a common representation of the system, and share points of view. It is conducted in a collaborative workshop where diverse groups of students come together to co-construct a shared representation of how they perceive a socio-ecological system, to which they have been introduced through a previous field-trip, or by visioning a slideshow on the territory. The common understanding of the system is synthesized in a conceptual model taking the form of an interaction diagram. When students are split into several groups, they have to defend their diagram from the remarks and critics of their classmates.

Teaching games were specifically developed as an adaptation of companion modelling role-playing games and according to a set of topics related to agriculture and environment interactions. CherIng deals with the individual or mutual collecting of a resource with limited growth. It aims mainly at increasing progressively the awareness of students of complexity in natural resources management and discussing on the interest of coordinating management decisions (Etienne et al., 2008). SylvoPast (Etienne, 2003) accounts for the set up of a fire prevention management plan combining forest, sheep-rearing and hunting activities. It is an autonomous teaching game emphasizing differences in stakeholders' points of views and negotiation processes. RuisselPois models runoff and erosion on a water catchment according to cropping practices and highlights the interactions between crop farmers, water agencies, village mayors and agricultural cooperatives (Etienne & Souchère, 2006). MejanJeuBiodiv deals with the management of biodiversity in a protected area where livestock farmers, foresters and conservationists must compromise on the best way to live together (Etienne, 2006). Agrofor simulates the establishment of an agroforestry management plan on a sheep farm according to a set of agroforestry techniques (Etienne & Monteil, 2007).

All these games are based on computer models (agent-based models) that were co-constructed and validated with local stakeholders, and technicians or experts. The models and role-playing games were used by these stakeholders to learn collectively by creating, modifying, and observing simulations. The production of knowledge aimed at: i) an improved knowledge of actors/decision-makers, ii) a facilitated dialogue among stakeholders (including experts) providing a framework for discussion and sharing of information, an exchange of viewpoints, knowledge, and beliefs among them, iii) a negotiation support system aiming at closing the gap between diverging points of view in a given conflicting situation (Collectif Commod, 2005). The adaptation of these tools as teaching games was based on the hypothesis that, as they did with stakeholders, they will help students to govern a complex situation along a continuous and gradually enriched itinerary, instead of proposing ready-made expert solutions.

And I assume this means that you, as a researcher, have been talking to all these different stakeholders in order to be able to model their responses. Have you asked feedback from stakeholders about this? Do they recognise their response in the models? If this has not been done, could this be something for the future? Or do you think interaction with stakeholders is not important? Whatever is your opinion, please make this explicit.

The common representation of the system and the behaviour of the players during the games are implemented into an **agent-based model** using the Cormas multi-agent platform. This model is used to simulate scenarios built up by the different groups of students, and to stimulate them to elaborate key indicators allowing them to understand precisely what is wrong or right in their project. These scenarios help to compare different ways of applying agroforestry techniques (Agrofor), reasoning cropping systems (RuisselPois) or coordinating livestock, forestry and conservation activities (MejanJeuBiodiv). This type of model is very effective to encourage students to evaluate their management projects according to both ecological, sociological and economic aspects. An evaluation questionnaire filled up at the beginning and at the end of the session permits to follow up on which aspects students learnt more.

Discussion

This type of training courses can aimed at reaching 3 main targets: an initiation into companion modelling, to obtain a common understanding of complex agricultural systems, to be able to apply companion modelling and put into practice the associated tools. In the first case, students will go quickly through the 4 steps of the approach by working on one specific case study. In the second case, students have the opportunity to go deeper into the different methods and practice the 3 tools at different scale levels. In the third case, the previous experience is reinforced by learning key aspects of the computer language and by an introduction into computer modelling through a learning-by-doing process that allows them to develop a progressively more complex agent-based model or role-playing game.

Training sessions have already been organised in agronomy schools in diversified thematic modules: associated crops at AgroParisTech Paris, sustainable agriculture and landscape multifunctionality at ENSA Toulouse, integrated management of agrosystems and forests at ENITA Bordeaux, companion modelling on agriculture and environment at Esitpa Rouen. Table 1 summarises the results of the course evaluation by the students in 3 different contexts: biodiversity management (Paris & Toulouse), agroforestry (Bordeaux), and agriculture and environment (Rouen).

Students were particularly grateful for discovering by themselves the interactions between stakeholders and resources, to measure concretely the impact of agriculture or forestry on different environmental aspects, and to get aware of the relevance of taking into account the correct space and time scales. Learning by doing, learning by playing and learning by simulating were key original points commonly mentioned in students' comments during the debriefing of the courses.

Table 1: Evaluation (max 20) of the companion modelling course in 4 Universities : Paris and Toulouse (30 students), Bordeaux (24 students) and Rouen (39 students)

	Paris	Toulouse	Bordeaux	Rouen
Interest of the topic	17.9	18.2	15.0	15.0
Global score	17.6	17.2	16.5	17.9
Introduction	16.1	15.7	15.2	14.0
ARD steps of ARDI	16.2	17.0	15.2	14.9
I step of ARDI	17.2	16.2	14.8	15.1
Model comparison	17.2	16.2		15.1
Selecting indicators	16.6	16.7		14.2
Simulating scenario 1	16.1	17.0		16.0
Role-playing game	18.4	18.7	17.3	18.8
Simulating scenario 2	18.7	17.5		18.6
Learning something new	15.3	14.3	12.5	17.8
Learning on man & nature	11.9	10.2	14.1	14.9
Learning on mediation	14.2	12.2	14.7	9.4

They have also been adapted to forestry students in the area of land management planning (school of forestry at Nancy) or interactions between forest, nature and society (school of forestry at Montpellier). Other sessions focused more on biodiversity management have been proposed as part of Master's course proposed by the Universities of Brest (management of coastal ecosystems and urbanism and environment), Paris (biodiversity and society) and Toulouse (biodiversity management). Currently we are developing a project to experiment the use of this approach at a high school level and to train officials working in territorial communities.

Complementary specific courses are available for more complete information concerning the tools (multi-agent platform, role-playing games), but they are currently more adapted to researchers, professional people or post-graduate students. They are regularly organised in France but some sessions have been adapted (http://cormas.cirad.fr/ComMod/fr/training/sessionsComMod.htm) to international topics such as water management (Negowat project in Bolivia and Brazil) or nature conservation (UNESCO project on Western-Africa Biosphere Reserves). Lastly, other projects related to training companion modelling followed the path of the e-learning perspective, such as the e-commod project that developed an internet-enabled learning and communication tool by gathering experiences from 3 countries of South-Eastern Asia (http://www.ecole-commod.sc.chula.ac.th/www2/index.php).

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