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Abstract: *This presentation relates to a teaching exercise developed for the training of agronomy graduates at the AgroParisTech (France). Its aim is to show that agronomic knowledge (1) is useful to help us understand the ecological processes at the origin of a disaster, (2) must be related to other knowledge to be really effective in a context of action. The exercise is based on a role-playing game which leads the students to acquire by themselves most of the knowledge needed. The game context is the control of muddy flows in Normandy. The scenario is rather simple. A muddy flow occurs, in Normandy, at the outlet of a small catchment area composed of two villages: Hautville (upstream), and Basville (downstream). The damage occurs in Basville where some individual dwellings and a sugar refinery suffered severely from the muddy flow. A crisis meeting is organized. The students, divided into groups, are asked to play the role of the various participants attending the meeting, including the two mayors, the farmers, the sugar refinery manager and agricultural advisors. They are given specific details and a specific aim for the character they have to play. During the simulated meeting the teachers listen to the exchanges. At the end of the simulation they comment on the technical value of the arguments. Using the initial scenario and the specific details given to each group, the students have to understand that the muddy flow has two major origins. A sugar beet grower in Hautville is responsible for the runoff. A dairy farmer in Basville allowed the erosion of his soil by the concentrated runoff initiated in Hautville because he ploughed a previously permanent meadow. But the disaster is also due to the unsuitability of the damaged buildings downstream. The students are thus brought to propose some agronomic innovations via the collaboration between the different stakeholders attending the meeting. The students generally take a keen interest in this exercise. As a result, they acquire a fairly good understanding of how natural phenomena (runoff, leaching, etc.) may lead to problems and how the spatial organisation of the cultivation methods may interfere with these phenomena (reducing or increasing them). The students also learn about the roles of the various decision makers involved in the problems and their necessary coordination for the improvement of the environment.*

Keywords: *role-playing game, catchment area, erosion, training, agronomist engineer*

Context of the educational program

This presentation relates to a teaching module developed for the training of agronomy graduates at the AgroParisTech (France). The module is part of a master level degree called “Agronomy-environment” (550 hours + a six-month training course). This degree is dedicated to students interested in agronomy and its applications to production, environmental risk management, and land planning. The curriculum of this degree is divided into two parts. A first part (September to December) deals with common courses for all the students (about 35 students/year). These courses are disciplinary courses (agronomy, soil science, bioclimatology.) The second part, called “option”, includes specific courses applied to plant production, environmental risk management or land planning, depending on the training option chosen by the student. This option period is followed by a six-month training course that concludes the degree of agronomist. [1]

The teaching module presented in this paper is part of the “Agriculture and environmental risk management” option. This option targets jobs in private companies specialised in waste and water management but also in water agencies or state agencies dealing with socio-technical aspects of environment management in rural and peri-urban areas. The option lasts 2 months (January-February) and combines 5 thematic modules. Three of these modules are rather technical (water

[1] http://www.agroparistech.fr/-Ingenierie-de-l-environnement-eau-.html

quantity and quality management, waste management, environmental assessment techniques). These three modules are preceded by a preliminary one that presents to the students (1) the different types of decision makers they will have to deal with and their specific skills (2) a range of concepts (sustainable development, prevention and precaution principles) and devices (environment management systems, agenda 21 etc.) that can be used by local communities or private companies to integrate environmental protection into their action plan. The module presented in this paper takes place between this first and the three more technical modules. It lasts one week.

Aims of the educational program

The teaching module is called “Control of agricultural pollution”. It has various aims. The first is to give the students some fundamental information about the main types of pollution related to agricultural activities (Martin *et al.,* 2006). Because of shortage of time we limit this approach to issues linked to water (nitrogen and pesticide pollution, runoff and erosion) (Benoit and Papy, 1997). Particular attention is given to the space-and-time analysis of these issues (Martin, 2000, Joannon et al., 2005 ; Morlon, 2005). A second goal is to show the students how agronomic knowledge can be used for a better understanding of the ecological behaviour of a complex region, including farmland, public infrastructure (roads, schools etc.), agro-industrial plants and private residential areas (Martin *et al*., 2006;Le Bail *et al*., 2006). The third goal is to help students to understand how different decision makers and stakeholders may interact for different issues in the same region and how they can build compromises that include environment protection (Cattan et Mermet, 1998). The last, though not the least important goal is to help students to understand that agronomic knowledge must be related to other knowledge to be really effective in a context of action.

The research disciplines involved in the teaching module

This module was created by an agronomist for students in agronomy. It is based partly on results of research programs carried out by a multi-disciplinary team associating agronomists, sociologists and economists (Martin *et al*., 2007). It is also the result of several years of interviews (of farmers and local decision makers) carried out in Upper Normandy with different groups of students. The typical situation chosen for the game (a small catchment area composed of two villages’ environs) corresponds to a simplified aggregation of different situations that has been studied either for research or teaching needs over the last ten years (Martin *et al.*, 2004). An agronomist, a lawyer and a sociologist directly participate in the training module we present here.

General structure of the educational program

The module is based on a role-playing game (Mermet, 1993; Etienne, 2003) which the students have to prepare from the very beginning of the week. The group of 20 students is divided into 8 groups of 2 or 3. Each group has its individual goal to achieve during the game. Some *complementary courses* are given about important points that students need for the role-playing game and that were not presented during the common part of the degree and the first module. These important points are related either to the impact of agricultural practices or to the way one can manage an environmental problem consisting of many components. A list of *contacts* is also given to the students. These contacts are professionals whose activities correspond to the role the students have to play. The arguments can be supplemented by bibliographic data provided by the teachers and completed by the students, mainly on the internet. Each group has to write its own arguments (according to its initial goal) and give them to the teachers just before the beginning of the game at the end of the module. The game lasts 1.5 hours. The teachers don’t intervene during the game, that is numerically recorded. After the game, a debriefing is organised on different points: feed-back on the quality of the arguments that were developed by the different groups but also how did the students feel during the game, and the global satisfaction or disappointment regarding the results of the discussions. After this oral debriefing each group has to write a critical analysis of the way they acted during the game that can naturally include the way they prepared for it. Each group is evaluated according to the two written documents (structured argumentation given before the game and critical analysis written after it) and the way it interacted with the other groups during the game.

The role playing game scenario

The game context is that of Upper Normandy, where runoff on agricultural fields leads to ephemeral gully erosion in dry watercourse and muddy flows in villages and cities downstream These flood events are frequently associated with turbidity events that temporarily prevent water distribution to the local population. Moreover runoff can also lead to surface or ground water pollution by pesticides. The development of the local agriculture, as in many agricultural areas in Europe, led to an intensified use of chemicals (nitrogen and pesticides) and to a reduction in the area of meadowland due to the low profitability of dairy farms. The dairy farms that remained in business did so by using silage maize as a fodder crop that even in Upper Normandy yields higher and more stable harvests than meadows. After the CAP reforms (1992 and 2003) spring crops like potatoes, sugar beet or flax acquired great economic value. These crops are the basis of a local agro-industry that generates employment for the local population. But potatoes, sugar beet, flax and silage maize are crops that can lead to major runoff and erosion problems in spring. Since the early 90's the environmental pressure has increased both on farmers and on municipalities and industrial plants. The municipalities have to ensure the delivery of good quality water to the public. They also have to protect them from the damage generated by muddy flows, but this protection is very expensive and can hardly be afforded by small local communities. Indeed they also have to treat the waste water, as do the industrial plants. Farmers may have some fertilization restrictions due to the Nitrate Directive, but they also have to take into account the increasing local pressure against all the disturbance that their activities, including the generation of muddy floods, cause for residents who are increasingly cut off from their agricultural roots.

In this context the scenario is as follows: a muddy flood took place in Normandy at the outlet of a small catchment area. Two villages are located in the catchment. The upstream village (Hautville) has a low population density (mainly farmers). The downstream village (Basville) has a higher population density (blue and white collar workers). Damage occurred only in Basville: Individual dwellings recently built at the bottom of the small valley suffered severely from the muddy flow and a sugar refinery which processes the sugar-beet grown around Hautville also had to stop work for several weeks. This sugar refinery employed many people living in Basville and Hautville. Just after the muddy flood, a turbidity peak prevented water distribution for 15 days. Such a turbidity peak is not rare in this catchment, where water quality is also threatened by an increasing rate of nitrate combined with the frequent detection of excessive pesticide residues.

A crisis meeting is organised. The students, divided into groups, are asked to play the various participants attending the meeting. The 8 participants are: the mayor of Basville, the mayor of Hautville, the representative of a local association for environment protection, the director of the sugar refinery, a dairy farmer, a representative of the catchment syndicate in charge of the erosion issue (this syndicate includes the two municipalities but also a larger territory), a representative of the state administration and one of the water agency. The aim of this crisis meeting is to understand why the disaster occurred and to discuss the necessary changes to improve the situation.

The students get specific details and a specific aim for the character they have to act. In fact each character has his own strengths and weaknesses.

- Representative of the local association for environment protection: he organises the crisis meeting. He chairs the meeting and makes sure that all the environmental problems concerning the two villages are discussed during the meeting. He has to be aware of the main socio-technical aspects of each problem to be sure that the potential proposals made by one or another participant are realistic…but he can't know everything on all subject.
- The mayor of Basville : he doesn't know the local situation very well as he comes from another area. He had the new buildings built in the disaster area. He really wants to improve the environmental situation of his village as it will help him to get re-elected next year. He knows that environmental protection is expensive and needs financial help to reach his goal.
- The mayor of Hautville: He is convinced that the disaster resulted from the new dwellings the mayor of Basville decided to build. At the same time he is the farmer who cultivates all the fields which produced the runoff that eroded the field of another farmer in the Basville territory. He follows the recommendations of the sugar refinery that are responsible for the runoff.
- Director of the sugar refinery: his sugar refinery (which is in need of modernisation) was severely damaged by the muddy flood. He knows he is the employer of many people in both

villages. If possible the director would appreciate some financial help to repair and clean his industrial equipment. But he also knows that a growing part of the population works outside the area and doesn't appreciate the problems caused by this refinery very close to the houses. As the management of his industrial group decided to maintain this refinery, the director has to find an inexpensive way to satisfy the local people. He imposed specific cropping systems to maintain the profitability of the refinery.

- Representative of the catchment syndicate: he is a specialist in agronomy and hydrology working on the reduction of muddy flow risks. He has a comprehensive view of this problem that is not limited to the two villages of the small catchment. His territory includes 20 villages including Basville and Hautville. He tries to combine changes in agricultural practices with land planning solutions to limit the problem. He is not concerned with water quality issues.
- Representative of the water agency: he knows that he has the financial power in the meeting but he is only interested in preserving the water quality. His is not against the limitation of muddy floods if it is clearly established that it will also protect the water quality for the same cost. He will insist on the delimitation of a protection area for drinking water (ground water) that is still to be done for this catchment. This protection area implies some constraints on the cultivation practices. The water agency has to specify these constraints.
- A dairy farmer from Basville : one of his fields was severely eroded by concentrated runoff. He would like some financial compensation. This erosion occurred because he ploughed a meadow in the dry watercourse for maize cultivation. He ploughed this field because it was close to his new stable. Indeed, he had to remove his old stable from the village centre because his neighbours complained about the bad smell.
- Representative of the state administration: he has to ensure that the law is respected for the different problems presented in the general scenario. Moreover he would like to propose an experiment for this catchment - the setting up of a new type of PPRI (Prevention Plan against Flood Risks) that includes some obligatory practices for farmers as it generates constraints for the inhabitants. The representative of the state administration knows that this new system needs to be simple and not too restrictive for farmers.

Both the initial scenario and the specific indications given to each group point towards the fact that the muddy flow is mainly due to the cultivation methods of a particular farmer: the mayor of Hautville. But some of these cultivation methods result from the advice given by the sugar refinery to improve both sugar harvest and sugar quality. At the same time the mayor of Basville is also responsible for having built new buildings in a very sensitive zone. The students are thus brought to propose some agronomic innovations via the collaboration between the representative of the catchment syndicate and the agronomic department of the sugar refinery. The situation will also be greatly improved if one limits the building area in the valley (with or without a PPRI) while protecting the current infrastructures using the installations financed by the inter-commune solidarity and the water agency for the installations that protect the water resource.

Additional courses

To implement this role playing game, students need different kinds of information. Some is about the work of a water agency or a state administration for agriculture or environment. This kind of information is given in the first module of the option. They also need information about the pollution risks associated with the agricultural practices for nitrate, pesticide and runoff/erosion. Nitrate is an important issue for our students. No special course is given but applied exercises are given to check that students are skilled enough on this subject. Pesticide and runoff/erosion are new subjects for most of the students and require special courses. The course on runoff/erosion is important to help students to integrate a kind of up- and down-scaling approach to the region. The overall effect of agricultural practices on runoff production and soil erosion can only be estimated at the outlet of a catchment, but this overall effect is generated by the range of practices applied on each field of the catchment and by the hydrologic connections that exist between those different fields. This course on runoff/erosion is also important to help students to integrate the time dimension. Indeed the overall effect at the outlet depends also on the interaction between the type of farmers' practices, weather events, the resulting degradation of the soil surface and the subsequent production of runoff on each field. The course on pesticides is based on the same notions because pesticides can be transferred by runoff or erosion of soil particles. This issue is also more complicated if one considers that pesticide

can generate water pollution at a very low concentration. As a result the risk assessment at the catchment level is not the same. We also give the students information about some methodologies that can help to find collective solutions to collective problems (e.g the use of multi agents based models).

Role preparation and interaction between participants before the game

To prepare their role, students must first gather essential information and after that, must contact some professionals. Phone appointments were organised in advance by the teachers with the professional contacts, mostly based in Normandy whereas the training occurs in Paris. For the appointments and the bibliographical analysis (including listening to previously-recorded interviews with people in the business) the students are asked to stay in the same room equipped with phones and computers. They also have to frequently meet the teachers (agronomist and lawyer) in the same room to be sure that each group can progress normally.

One important thing is that no instruction is given to the students about the level of communication required between the groups. Each group knows the aim of the crisis meeting (given in the general scenario). He also knows his specific aim and some specific details associated with his role but nothing is said about inter-group information exchange before the crisis meeting. In fact we make all the students remain in the same room during the preparation period to encourage information exchange. These exchanges may be informal (due to the proximity in the room) or voluntary (due to a group strategy). This approach is a result of the theory of proximity economy. Another important point is that the general scenario is very open. In particular no detailed map of the imaginary watershed was given to the students. As a result the students can inject much new information that wasn't given either in the general scenario or in the specific role indications. The only limitation is that new information must be consistent with the general scenario, with the specific indications given to each participant and with the real world. For instance it's not allowed to refer to a law that doesn't exist or to propose the production of groundnuts in Normandy.

At the end of the preparation period, each group has to write its own arguments according to its initial goal. Students must also present how they think the meeting will proceed. Will they be verbally attacked by the other participants? Will they find some support among them to reach their aim? Which strategy will they develop depending on the course of the meeting?

The game and the following debriefing

A sociologist attends the meeting simulation in addition to the two teachers (agronomist and lawyer) who participated in the role preparation. The representative of the local association for environment protection begins the meeting. During the meeting simulation the teachers listen to the exchanges and intervene only if the scenario becomes confused. At the end of the simulation the teachers comment on the technical value of the arguments from both agronomic and legal points of view. The sociologist deciphers the types of argument and the strategies developed by the different players and compares them to what happens in the real world.

One must underline the fact that the result of the debate between the students may vary greatly from one year to another. In 2006 the group that played the role of the environment association began the negotiations with the other participants during the preparation period. They prepared a pre-project for the catchment and discussed it during the crisis meeting. They adopted a constructive approach to the problem without forgetting any point they wanted to be discussed. In 2007 the same role was played by students who decided to adopt a very aggressive attitude to all the other participants because they considered they were all responsible for at least one part of the problem. Of course they did not try to contact the other participants during the preparation period. During the meeting simulation the other students were very surprised by their behaviour. They tried to present their own proposals that were considered as inadequate by the association. After a few minutes the other participants wanted to discuss together without the association. These two opposed behaviours are interesting because they illustrate two real behaviours we encountered in the Pays de Caux.

The students are generally highly involved in this exercise that helps them to acquire by themselves most of the necessary knowledge. As a result, they acquire a fairly good understanding of how natural

phenomena (runoff, leaching…) may lead to problems and how the spatial and temporal organisation of farmers' practices (crop plan, crop sequence, crop management system) may interfere with these phenomena (reducing or increasing them). The students also perceive the role of the various regional managers and the need for their coordination to improve the overall environmental state. They also generally understand the differences and the synergy between the approach of an agronomist and a lawyer.

Elements contributing to the success or difficulties of this module

One major difficulty is the limited time (one week) devoted to this activity. In fact one must recall that this module is part of a training program that includes the common courses (first part of the degree) and the first module of the option. It would probably not be possible to reach the same aims in only one week without these foundations. Another favourable element is the professional network we have been building for ten years through different applied research programs in Upper Normandy. It's the same network we use for this training operation. Members of this network are generally happy to contribute to the teaching process without spending too much time (about half an hour for a phone call). They are also interested to learn what type of arguments was developed by the students who played their role. This is why we record the game asking the students to indicate who they are each time they take the floor. This recording can then be sent to those who helped us.

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