Training on multi-agent systems, social sciences, and integrated natural resource management: lessons from an Inter-University Project in Thailand

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In this new century, there is an urgent need to integrate and organize knowledge into suitable frameworks to examine essential problems with the people involved in solving them. Recent advances in computer science, particularly distributed artificial intelligence and multi-agent systems (MAS), are creating a strong interest in using this new knowledge and technologies for various applications to better deal with the increasing complexity of our fast-changing world, particularly for studying interactions between societies and their environment. By emphasizing the importance of interactions and points of view, the MAS way of thinking can facilitate high-level interdisciplinary training and collaborative research among scientists working in ecology and social sciences to examine complex problems in the field of integrated natural resource management (INRM).

This paper describes how a recent project based on a series of short courses in the field of MAS, social sciences, and INRM at three different universities in Thailand tried to transfer European expertise and research results to an Asian audience of graduate and postgraduate students and young researchers interested in innovative and action-research–oriented interdisciplinary approaches. The course structure, organization, and contents are described and assessed. The course participants are characterized and their opinions are used to evaluate the strengths and weaknesses of this very interdisciplinary training program.

The first sustainable outputs and key preliminary lessons learned from this innovative collective learning experience are presented. In conclusion, the authors suggest ways to support the emergence of a regional network of "MAS for INRM" practitioners in Southeast Asia to build on the dynamics begun by this project and serve the need for such interdisciplinary training across Southeast Asia.

In this new century, knowledge management faces two major challenges. The first one deals with the adequacy between globalization and fragmented knowledge among disciplines on the one hand and multidimensional realities requiring transdisciplinary approaches on the other hand. The second challenge is the continuous and accelerated improvement of knowledge in many fields, which is making knowledge organization more and more difficult to achieve but also more and more crucial for students and educators. There is therefore an urgent need to integrate knowledge across scientific disciplines, as well as with other sources of information, into suitable frameworks

to examine essential problems with the people involved in solving them. Nowadays, it is necessary to give equal importance to stakeholders' opinions, traditional representations, and science-based information. Principles to organize knowledge to face the challenge of complexity, uncertainty, and fast changes are required. Edgar Morin (1999), who spent many years studying complexity issues, considers that training students to establish linkages among knowledge from different disciplines and sources is of paramount importance for the next generations.

In the field of renewable natural resource management, adaptive management is required to deal with complex and unpredictable situations (Holling 1978, Lynam et al 2002). The functional integrity of the ecosystem can increase in parallel with the adaptive capacity of resource managers. Particularly, this can be achieved through a better coordination among these managers and a greater collective ability to recognize and agree upon points of intervention to improve the sustainability of resource management (Ostrom et al 1994).

At the same time, modeling is increasingly seen as a suitable approach for examining complex resource management problems. In this field, it is now widely accepted that modeling should proceed iteratively, by successive approximations, usually from simple to more complex representations of the system dynamics. Far from being the work of scientists in ivory towers, these iterative, applied, and action-research–oriented modeling activities should be implemented in close interaction with field work and stakeholders looking for solutions to the real-world problem under study. Stakeholders should play an important role in the construction and the validation of such models. Later on, they should be able to use them with scientists to explore the effects of different options and scenarios of resource use to negotiate and reach a compromise on suitable rules and action plans to be implemented collectively. We call the "companion modeling" approach (Bousquet et al 1999) such a collective learning process for INRM. While it is usually easier to find scientists in the fields of agroecology and biology to analyze a specific resource management problem from their point of view, there is still a need for capacity building in the "softer" field of social sciences to examine such problems with "hard" scientists, and for training both types to collaborate in a truly interdisciplinary and innovative "third" way (Röling 1999).

Recent advances in computer science, particularly in the fields of distributed artificial intelligence (DAI), agent-based modeling (ABM), and multi-agent systems (MAS), have created a strong interest in using such innovative technologies to examine complex issues and better deal with the increasing complexity of the real world. MAS are computational systems relying on the technology of cellular automata, in which various autonomous agents interact in a given environment. They are based on the principles of distribution, interaction, and control (Ferber 1999). More information on MAS can be found in the introductory chapter of this volume by Bousquet and Trébuil. Recently, significant progress has been made in simulating societies in interaction with their environment (Gilbert and Troitzsch 1999, Jager 2000, Moss 2002) and innovative approaches such as MAS can create artificial societies (Weiss 1999).

MAS simulations are being increasingly used to deal with ecological and socioeconomic issues arising from the management of scarce resources by multiple

users (Janssen 2002, Bousquet and Le Page 2004). When this approach is applied to INRM problems, such as when modeling situations of conflict among stakeholders, the effects on the resource dynamics of the interactions among different agent behaviors and the associated feedback effects can be simulated and tested. Modelers use these methods to create computer representations of dynamics observed in the field.

The MAS way of thinking emphasizes interactions and diversity of points of view for analyzing interactions between societies and their environment. It could facilitate the design of high-level interdisciplinary training and research among ecologists and social scientists working in renewable natural resource management and on INRM problems. Many case studies examining concrete resource management problems have recently started in several Southeast Asian countries and a sample of them are presented in the contributed chapters of the present volume.

Today, these problems at the interface between the environment and society are frequent in the fast-growing economies of several Asian countries, particularly in situations where limited, or even shrinking, natural resources are exploited for multiple uses by competing users. Many examples in forest, water, and biodiversity management, etc., are regularly making the headlines of local newspapers. At the same time, there is a trend toward the decentralization of natural resource management. For example, in Thailand, Tambon (subdistrict) Administrative Organizations (TAO) have been installed across the country under the new "people" charter approved in 1997 and are managing an increasing share of the public budget. It is therefore urgent to train a new generation of natural resource managers equipped with approaches, concepts, methods, and tools to face the increasing complexity and uncertainties of situations at the grass-roots level. They should be able to organize and interconnect knowledge from various sources to rapidly manage changing ecological and socioeconomic environments and avoid the occurrence of acute resource management conflicts.

To contribute toward such a goal and as MAS for resource management are still little known in Southeast Asia, in October 2001, we implemented a training project composed of a series of eleven short courses on MAS, social sciences, and INRM that were organized in rotation at three public universities in Thailand: Chulalongkorn, Chiang Mai, and Khon Kaen universities. It was financially supported by a grant from the Asia IT&C initiative of the European Commission, the French Cooperation, the International Rice Research Institute (IRRI), and the Centre de cooperation internationale en recherche agronomique pour le développement (CIRAD).

Objectives

This article describes how this interdisciplinary training project was designed and implemented to transfer European expertise and research results in the field of MAS, social sciences, and INRM to an Asian audience composed of mainly graduate and postgraduate students or young researchers interested in interdisciplinary approaches to research in the field of renewable natural resource management.

Following a presentation of the course structure, organization, and contents, the way the project is improving knowledge and technology cross-flow and the management of interdisciplinarity is assessed. An analysis of the participants and collaborative institutions is made. Their inputs helped to evaluate the strengths and weaknesses of the program design and mode of implementation. Its effects on the extent of partner-

ships in this fast-developing scientific field are also described. The presentation of the first sustainable outputs of this project and useful lessons learned to facilitate the implementation of similar training activities in Southeast Asia in the future are also dealt with. Finally, several perspectives and prospects for reinforcing the momentum created by these training activities are suggested.

Materials and methods

Sources of information

The information analyzed in this article comes from various sources and materials. The initial project document (Bousquet 2001) was used to present the design and organization of the course. A series of successive training reports produced after each successive short course was used to analyze the participation and to monitor trainees' progress. The project database on trainees and their institutions provided information to prepare several figures illustrating this paper. The series of course evaluations by the participants carried out upon completing each of the 11 training sessions held from October 2001 to April 2004 was the main source of information to analyze trainees' needs, the relevance of the concepts and topics presented by the instructors, and the strengths and weaknesses of these short courses. Individual interviews with six core trainees who attended at least six courses were also conducted during the preparation of this article. The topics discussed during these interviews were as follows: efficiency of the transfer of knowledge and know-how, assessment of the organization and management of the courses and suggestions for improvements, management of interdisciplinarity, emergence of sustainable outputs and impact of these courses, and new partnership mechanisms emerging from the project activities.

The following indicators were monitored to assess the transfer of knowledge and know-how during the training process: evolution of the participation (number and educational background of trainees and collaborative institutions), number of trainees' own applications being developed, number of trainees' M.Sc. and Ph.D. research proposals and theses integrating the MAS approach, number of complementary MAS training courses taken overseas, and number of university courses including presentations of MAS for the INRM approach.

Course structure and organization

Figure 1 displays the general structure of this interdisciplinary training process, which took advantage of the respective expertise available at the three collaborating Thai public universities to organize each of the successive short courses.

Apart from the 2-week introductory course on MAS for social sciences and INRM, all the following ones were 1-week training sessions. A different instructor led each course. These instructors are specialized in diverse but complementary fields and are all recognized as leaders in their respective scientific areas. Almost all of them are members of a European community of scientists working on social simulations. Table 1 shows the scheduling, location, main themes, and key concepts introduced during the 11 successive short courses offered under this project.

Different combinations of teaching methods and tools were used during each course. Generally, on each day, two 90-minute lectures alternate with presentations of case studies, group exercises, hands-on exercises, or personal work. A large quantity of

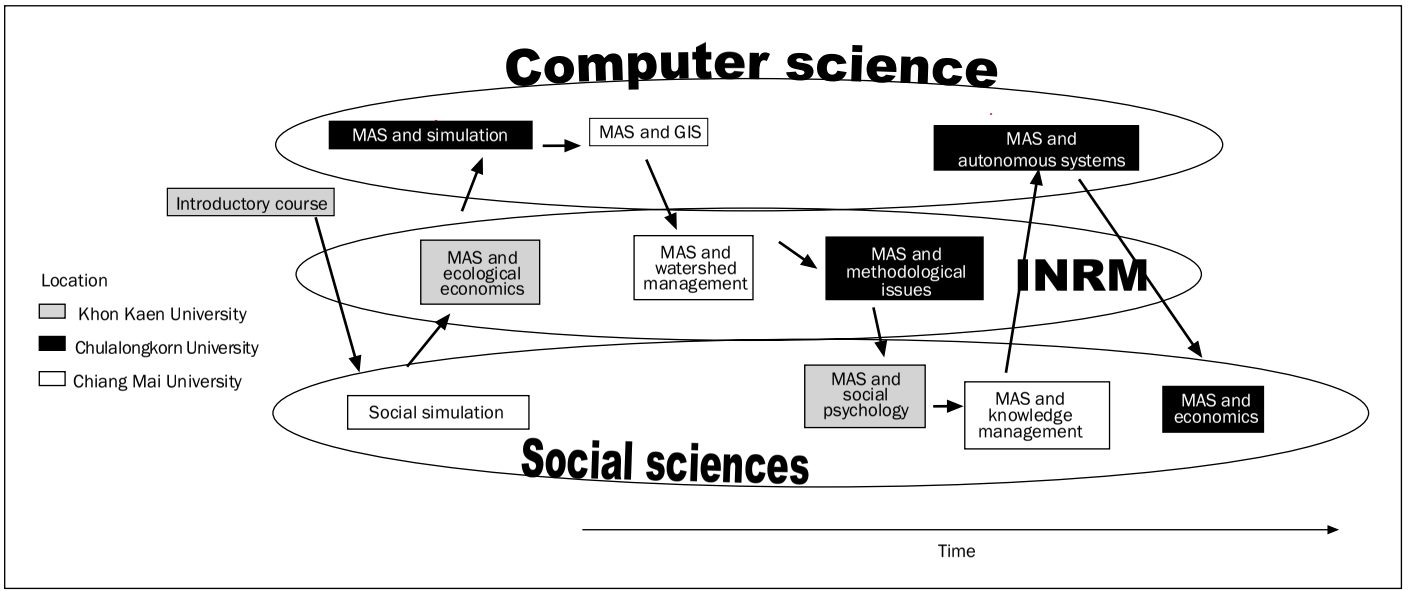

Fig. 1. General structure of the interdisciplinary training course on multi-agent systems, social sciences, and integrated natural resource management in Thailand.

visuals were used as most of the sessions rely on video projections. At the beginning of each course, all the slides used by the instructors, a series of key reference papers for further reading, a CD with these files, and the software used during the course as well as the computer exercises were provided to the trainees.

Networking, exchanges, and group dynamics were sustained by the subscription of each trainee to a global electronic discussion list (with a Q&A service) linked to a Web site specifically designed for MAS users in INRM (http://cormas.cirad.fr). On this site, trainees could find more information (reference papers and tutorials, completed case studies, new versions of software, opportunities for further training, etc.) and particularly a library of already developed MAS models providing more inspiration.

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Following the main introductory course, the successive course instructors presented different disciplinary points of view, key concepts, and experiences on the use of MAS in social sciences and INRM (Table 1). Because several new concepts were introduced during each course and all the sessions were conducted in English, the contents were rather difficult to follow for some participants. The use of MAS simulations by all instructors established a link between sessions.

The teaching and use of the CORMAS (common-pool resources and multi-agent systems) simulation platform in most of the courses is another important linkage. Provided free to all participants, this simulation platform is the key reference computerized tool used in this program (Bousquet et al 1998, see also the contributed chapter on CORMAS by Le Page and Bommel in this volume). Vensim, NetLogo, and SDML (Strictly Declarative Modelling Language) were other software packages also introduced during these short courses.

As soon as this project began, the participants were encouraged to conceive, design, and gradually build a personal application on a concrete problem related to their academic interest or professional activity. In the middle of the week, time was made available to work on these personal projects through interactions with other trainees and the instructors. The last morning of each training session was frequently allocated to the presentation of several trainees' applications, each one being followed by a collective discussion and comments from the instructors. This was very useful because the quasi-absence of completed case studies in Southeast Asia at the beginning of this program limited the illustration of lectures by examples dealing with local problems in Asian contexts.

Participants and their institutions

Most of the trainees were graduate and postgraduate students, young or more senior university researchers, but also officers from development-oriented government agencies of the Thailand Ministry of Agriculture and Cooperatives (MOAC) who were interested in interdisciplinary and applied approaches to research in the field of participatory resource management. Figures 2 and 3 show that these trainees came from 11 countries and many more institutions. Of the current total of 85 participants, Thailand (47), the Philippines (14), and Vietnam (7) were the main contributors. The presence of a small minority of European trainees in several short courses had a posi-

Table 1. Contents of the Asia IT&C initiative training program on multi-agent systems, social sciences, and integrated natural resource management, Thailand, October 2001-spring 2004.

Step no.	Month /year	Location /univ.[a]	Main theme	Main instructor/ institution	Key concepts introduced
1	Oct. 2001 (2 weeks)	KKU	Introduction to MAS for INRM	Dr. F. Bousquet IRRI-CIRAD, Thailand	Overview of the main concepts
2	Feb. 2002	CMU	MAS & social simulation	Prof. N. Gilbert University of Surrey, UK	Simulation in social sciences, emergence
3	Apr. 2002	KKU	MAS & ecological economics	Dr. M. Janssen Vrije Universiteit, NL	Resilience, models in ecology & economics
4	Apr. 2002	CU	MAS & computer sciences	Prof. A. Drogoul Paris VI University, FR	Agents in computer science, distribution
5	Oct. 2002	CMU	MAS & geographic information systems (GIS)	Dr. S.P. Kam, IRRI, PHIL Dr. C. Le Page, CIRAD, FR	Spatial dynamics, scaling issues
6	Oct. 2002	CMU	MAS & integrated watershed management	Dr. O. Barreteau Cemagref, Montpellier, FR	Integrated modeling, companion modeling
7	Mar. 2003	CU	MAS & the environment: methodological issues	Prof. S. Moss Manchester Metro. Univ., UK	Validation of models, abstraction
8	Apr. 2003	KKU	MAS & social psychology	Dr. W. Jager University of Groningen, NL	Social psychology, decision-making processes of agents
9	Oct. 2003	CMU	MAS & knowledge management	Prof. N. Röling Wageningen University, NL	Tools for participatory decision-making, soft science
10	Mar. 2004	CU	MAS & autonomous systems	Dr. J.P. Muller CIRAD, Montpellier, FR	Autonomy, learning in computer science
11	Apr. 2004	CU	MAS & economics	Dr. A. Kirman, Greqam Aix-Marseille Univ., FR & M. Antona, GREEN CIRAD, FR	Decentralized economics, public policies, & public action

[a]CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

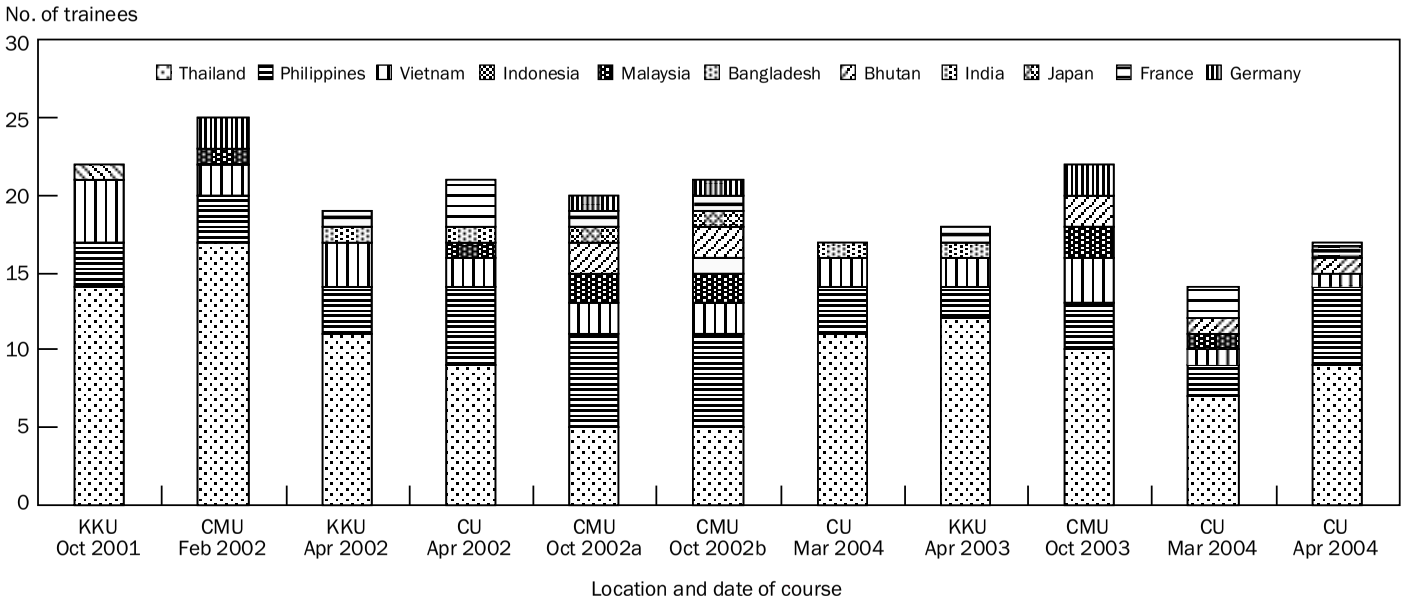

Fig. 2. Number and country of origin of the trainees who took part in the short courses of the interdisciplinary training program. CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

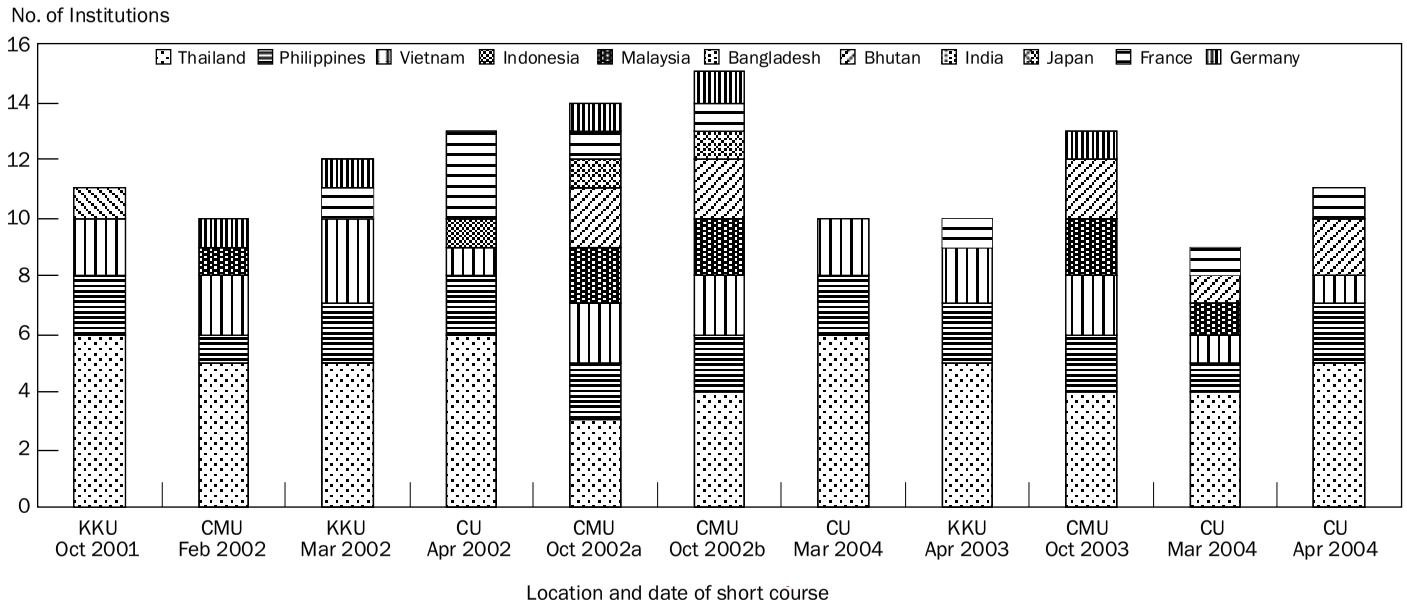

Fig. 3. Number of collaborating institutions by country in the short courses of the interdisciplinary training program. CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

tive effect on the group dynamics through the sharing of different viewpoints and the establishment of new professional contacts.

Trainees applied electronically to attend a particular short course, but many new ones were colleagues of former participants. No special advertising for these courses was done as the target size of the audience was limited to 16–20 full trainees per session plus several observers. This limited group size was set up to guarantee the quality of the support provided by the trainers, particularly during computerized hands-on exercises on new software or the design and construction of personal case studies.

The heterogeneity among the trainees, in terms of background knowledge about MAS, social sciences, and INRM, was important and tended to increase over time. Figure 4 displays the initial field of specialization of the trainees. This diversity of educational background among the trainees responded to a similar diversity of specialization observed among the main instructors.

At completion of the training process, three types of participants could be distinguished:

- A core group of regular participants who attended most of the short courses and who were also developing personal applications based on their new knowledge.
- Less regular participants who joined only the short courses dealing with themes of their interest; most of them were not involved in building their own applications.
- Observers who just wanted to familiarize themselves with MAS and attended one or several courses depending on their main themes.

Table 2 shows the changing sizes of these subgroups during the training process depending on the specific theme of each short course. In general, each course was attended by around 10 to 12 core participants, 6 or 7 less regular participants, and 2 or 3 observers. The management of such heterogeneous groups was a challenge for the trainers.

Results and discussion

Strengths and weaknesses of the training process

The following analysis is based on a review of the course evaluations by the participants. Table 3 shows that the overall course effectiveness assessed by the trainees was very satisfactory.

Organization and structure

Strengths. The diversity of disciplinary backgrounds among the different course instructors, all having the MAS approach and tools in common, could be seen as a "unique opportunity" (as one core trainee put it) to become familiar with MAS and their use in various fields. The organized interactions between trainers and trainees having a chance to interact with specialists about their own personal projects also received high marks. The choice of presenting a whole research approach and process during a five-day short course was also appreciated. Participants had time to discuss

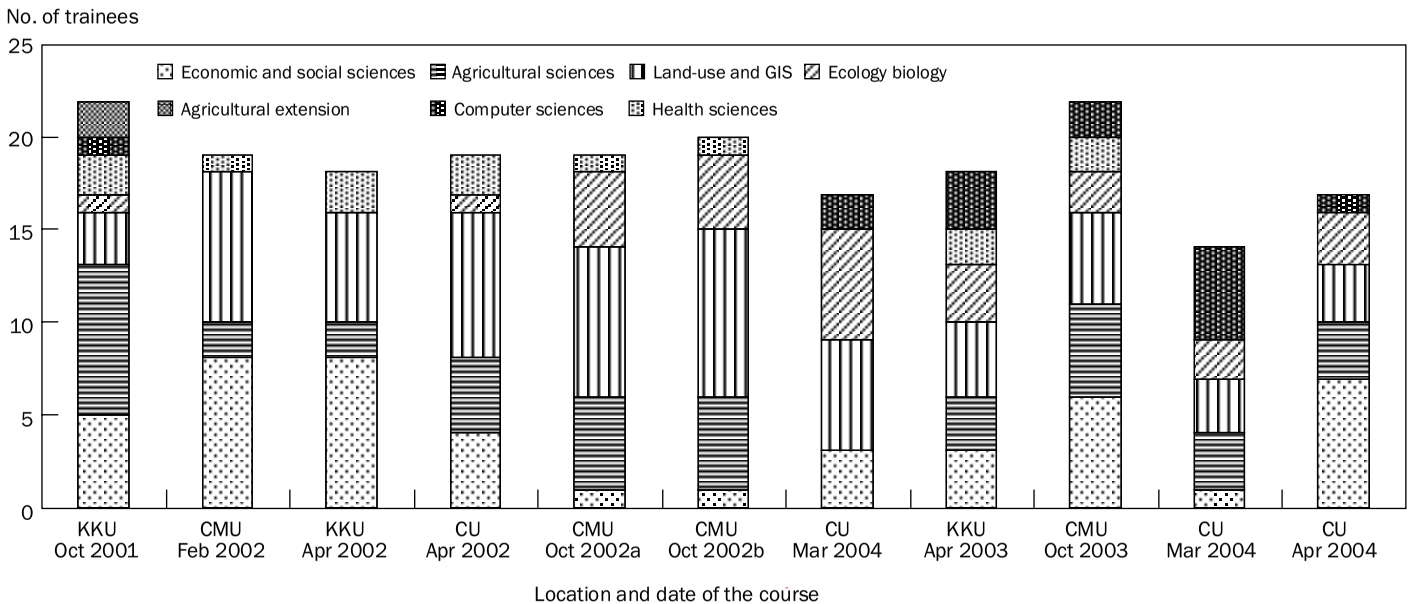

Fig. 4. Academic background of the trainees who took part in the short courses of the interdisciplinary training program. CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

difficult topics and to integrate relevant new knowledge into personal applications that were gradually built between successive courses.

The courses were held between university semesters. Their timing and duration were convenient to most of the trainees, who like this research-oriented training on a university campus providing a suitable atmosphere for the transfer of new knowledge. The networking of many institutions of higher education in the region along the way was also a plus according to many core trainees, and some of them found that the number of partner organizations and participants was still too limited.

Weaknesses. In theory, a better chronological order among the instructors and their respective disciplines could have been imagined to avoid too much "jumping" from one view to the next. Under an externally funded project mode of operation, many logistical constraints interfered and limited the possibility to plan a smoother succession of the themes and topics to be covered during the whole training process. But some trainees looked for ways to engage trainers further in the collaborative process.

The management of heterogeneous groups needed improvements as, in the beginning of the training process, few specific activities were available for newcomers who did not plan to build personal applications. During group exercises, techniques like the so-called "snowball" discussions (two trainees analyze a question, then they pool their findings with those of another couple of trainees, and so on, to produce a unified view and answer) were emphasized to help them catch up with the core group.

This short-course model was not very adapted to the construction of a full case study from A to Z to describe the problem, identify the relevant theory and concepts, make methodological choices, and continue with detailed stepwise procedures for model development. Such a process was requested by several core trainees and is being implemented with them under separate specific projects. The short course format did not allow enough time for computer exercises. Following a few courses, several trainees found that more real-world activities were desirable. Role-playing games (a tool frequently associated with MAS models in companion modeling) were inserted in the program of the following sessions, with one with villagers in Khon Kaen Province during the April 2003 course.

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Strengths. The fact that these short courses covered diverse themes and issues in MAS for INRM, from various disciplinary points of view, and were led by instructors who are leaders in their fields were seen as key strengths of this training project. Core trainees also found a suitable balance between theoretical/abstract and applied/practical contents to understand the subject matter and to be able to apply this new knowledge. The construction of a collection of models providing numerous examples and case studies ("I always need an example" said a trainee) was also assessed as an appropriate choice. Core trainees also liked the possibility to combine different tools in the development of their applications. Attempts at bridging the gap between computer scientists and other specialists by using simple tools to stimulate the collective construction of new models were also well received. In particular, the usefulness of the diagrammatic representations (class, activity, and sequential diagrams) of the unified modeling language (UML) for such a purpose was confirmed.

Table 2. Composition of the audience during the short courses of the interdisciplinary training program.

Numbers	Location and date									
	KKU Oct 2002	CMU Feb 2002	KKU Mar 2002	CU Apr 2002	CMU Oct 2002[a]	CU Mar 2003	KKU Apr 2003	CMU Oct 2003	CU Mar 2004	CU Apr 2004
No. of core trainees	10	14	14	12	10	7	7	11	10	11
No. of new trainees	12	7	4	7	10	10	11	10	3	3
No. of observers	5	4	1	2	5	0	2	1	1	3

[a]CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

Table 3. Average scores and standard deviation of the overall course effectiveness for the successive training sessions of the interdisciplinary training program according to the trainees. Rating scale: 1= poor, 5= excellent.

Item	Location and date									
	KKU Oct 2002	CMU Feb 2002	KKU Mar 2002	CU Apr 2002	CMU Oct 2002[a]	CU Mar 2003	KKU Apr 2003	CMU Oct 2003	CU Mar 2004	CU Apr 2004
Mean score	4.36	4.50	4.10	4.50	4.67	4.21	4.33	na	4.64	4.50
Standard deviation	1.03	0.50	0.29	0.50	0.47	0.41	0.60	na	0.48	0.63

[a]CMU = Chiang Mae University, CU = Chulalongkorn University, KKU = Khon Kaen University.

Weaknesses. Because there were several weak articulations between the themes of successive courses, the self-updating of the global picture by the trainees themselves was a difficult exercise. In the later courses, more support and time for critical discussions on the contents of the course were provided to help the trainees achieve such a continuous reconstruction by integrating the new knowledge acquired over the last course in the whole picture. But very few trainees managed to perform such a difficult intellectual process by themselves. Efforts were also made to better manage the language barrier by clarifying all key concepts and specific terminologies in lay language. With time, more Asian applications were made available in the second half of the training process to provide an easier understanding of case studies by the participants. At that time, some of the most advanced trainees were also requesting the introduction of other ways to represent and formalize knowledge in MAS in the remaining short courses.

Knowledge transfer: assessment of trainees' cumulative improvements

When asked if they observed cumulative improvements in their knowledge and skills related to these interdisciplinary courses, the core trainees answered "yes," "absolutely yes," "of course," or "yes, very effectively, more or less linear." If some of them found that these improvements are following a linear pattern, others say that a given course (usually the joint courses on watershed management and linking MAS with GIS held at CMU in October 2002) accelerated this process by providing them with a clearer view of several key concepts and a more global perspective of the training process in which they were taking part. They also agreed that such a progress was facilitated by the structure of the training process itself.

The fact that, altogether, 14 applications are currently being developed across five countries (seven in Thailand, two in the Philippines, Vietnam, and Indonesia, and one in Bhutan) to examine concrete INRM issues is also a relevant indicator of the progress made by core trainees. The development of such personal projects seemed to be necessary to guarantee continuity in the effort to improve the trainees' skills in using the approach, methods, and modeling tools introduced to them during the short courses.

Two core trainees have already taken several weeks of complementary training in France on MAS modeling using CORMAS and two more will follow their path in 2005. The MAS approach has also been integrated into the Master of Sciences theses defended by four project trainees from Bangladesh, Bhutan, the Philippines, and Thailand. Seven others from Bangladesh, the Philippines, Thailand, and Vietnam have prepared proposals for doctoral studies in this field and have been accepted at universities in France, Japan, Canada, and Thailand. They are going to invest in this field to deepen the transfer of knowledge and know-how on MAS for INRM as much time is needed to assimilate innovative approaches, methodologies, and tools for sustainable impact.

Several participants have already used MAS and shown their first applications in conference presentations. Other core trainees are already teaching MAS for INRM modules at their respective universities, particularly in Thailand and the Philippines. Trainees are becoming trainers as the contents of these courses are being introduced in graduate study programs at several universities: two short courses and workshops

for M.Sc. students were held in 2002 at the University of the Philippines-Diliman campus, a new course on "Simulation with the MAS Approach" is now being offered at Ubon Ratchathani University in northeast Thailand. This approach is also being presented in the new Post-Graduate Training Program in Systems Agriculture of the Faculty of Agriculture of Khon Kaen University and will be taught in the new Master of Science Program in Agricultural Technology and Natural Resource Management at Chulalongkorn University in Bangkok. Consequently, a significant dissemination of the contents of this training process across national institutions of higher education is already under way.

Management of interdisciplinarity

Interdisciplinary exchanges between instructors and trainees occurred permanently during this training project, but also among trainees. They were sustained by the diverse academic profiles and professional experiences (lecturers, researchers) of the European instructors and the selection of the Asian participants. Figure 4 shows that a high level of interdisciplinarity among trainees has been maintained during the whole training process. But the level of representation of the different disciplines has varied over time. Although many trainees coming from the social and economic sciences participated in the first four courses, their number decreased when the themes of the subsequent courses covered the use of GIS and watershed management; then, a partial recovery in their participation occurred during the last two courses focusing on economics and social psychology. While several agricultural scientists attended almost every course, more trainees coming from ecology and biology joined them at the end of the series of short courses. Figure 4 shows that, so far, the most stable group of participants had an academic background in land-use studies and GIS.

In this project, the interdisciplinary exchanges were guided by the existence of a broad common approach to the use of MAS among the trainers. This approach was explained to the trainees at the beginning of the process, but, with many newcomers joining in the subsequent courses, it was necessary to find ways to recall and re-explain it with more details. Several core trainees among the most experienced ones also requested to discuss explicitly the different points of view and possible conflicts between the contents of presentations made by different instructors.

It remained difficult to establish strong linkages among computer scientists, ecologists, and social scientists for them to work on common applications as interdisciplinary teams in their institutions. But the fact that several computer scientists joined in the last courses is encouraging. It is interesting to observe that it is not among the partner institutions that are well known for their early work on systems thinking in agriculture and resource management that we observe the emergence of interdisciplinary teams in MAS for INRM. The difficulty of establishing collaboration among staff from different faculties could partly explain this rather unexpected situation.

The use of simple modeling tools, such as UML diagrams, proved to be effective in stimulating interdisciplinary exchanges of views when conceiving a new model, and before its implementation and coding in a computer language by a specialist. The "snowball" discussion technique also created greater participation and interactions among trainees having different disciplinary backgrounds to produce ideas and come up with a unified view on the subject matter. The organization of the successive

courses in different settings, taking advantage of the strong expertise of each institution (GIS at CMU, role-playing games at KKU, ecology and social sciences at CU), also helped to sustain interdisciplinary exchanges. We see trainees becoming more and more interdisciplinary-minded, but we have yet to assess changes in their professional practices at their respective institutions. Nevertheless, some participants would like to see a suitable pathway along which trainees could monitor gradual improvements toward mastering interdisciplinary research.

Extended partnerships

The emergence of a regional network of core MAS for INRM practitioners was observed. Its members, linked by a strong bond and common interest (and friendship), are sustaining the effort thanks to regular "get-together" events during the past short courses. If this young network still needs external support at this stage, several core participants are already realizing that external funding is also a weakness of the current process. Fifteen institutions, particularly from Thailand, Vietnam, and the Philippines, are involved in sharing knowledge and experiences in modeling and simulation, but also differences in their respective social and cultural systems and environments. Their network of contacts, especially in Europe through the course instructors' teams, is already extensive. But it could easily be much broader if the trainees were more active exchanging messages on the global CORMAS electronic discussion list.

Beyond the joint publication of a first set of MAS-based applications in the present volume, core trainees said that more people and institutions will become involved in the undertaking in the years to come as they expect to initiate follow-up MAS-based applications projects among former participants in this project and their respective contacts. They also want to see a stronger Asian network of practitioners disseminating MAS-based modeling approaches applied to INRM and social dynamics.

Some trainees think that they will have the capacity to influence scientists and experts in mission-oriented research and interdisciplinary practices, particularly computer scientists. They think that they will be in positions to influence policy design through MAS simulations. They also want to move toward setting up an Asian Club for Social Simulation and organizing a conference on MAS for INRM in Asia to share and discuss experiences among project participants. Such activities could help widen the influence of their young network by inviting other Asian country representatives, such as from Japan, China, etc.

Conclusions: preliminary sustainable outputs and perspectives

On the basis of this series of 11 courses and numerous case studies being developed across the region, these project activities delivered promising collective learning methods and tools to enhance stakeholders' participation in resource management. Participants discovered a new way of thinking and an innovative approach to interpret their environment and real-world phenomena. They said that they were broadening their knowledge and vision. Now, they understand a new research paradigm for INRM, which is more applied, more "useful," and more action-oriented. This "different way to

look at things" is also characterized by an increased awareness of the need to take into account agents' behavior and diversity of viewpoints when designing applications.

We are now witnessing the emergence of a regional network of MAS for INRM practitioners in Southeast Asia who are selecting this field for their masters and doctoral studies. They are also disseminating the message in their respective institutions, developing practical applications on local real-world issues, and are already engaged in the joint publication of their results. They are also discussing ways to structure and reinforce their recent regional network.

Such innovative ways of looking at resource management problems and of thinking about how to alleviate them collectively need to be further introduced in existing graduate study programs at various institutions of higher education to meet the future demand in resource managers at the local level. It is also desirable to study how more young scientists could be exposed to these ideas and methods early in their professional career. In collaboration with Chulalongkorn University, the authors are currently in the process of establishing an international graduate study program in this field in Thailand. It will build on the dynamics created by the training process described in this article and serve the future needs for similar training across Southeast Asia. To avoid some of the weaknesses of the past project, such a new program would have to be more connected to local research support programs and less dependent on external funding. A specific "E-collective learning on companion modeling project" has also been launched recently to build a well-documented site on the Web that will support other types of learning activities such as lectures and training courses, participatory modeling and simulation workshops at different research sites, etc. Beyond training activities, these new projects should have strong research components to continue the adaptation of the companion approach to the Asian context and the development of local case studies examining concrete problems by using state-of-the-art methods and tools in the fast-developing field of MAS for INRM.

References

Bousquet F. 2001. Multi-agent systems (MAS), social sciences and integrated natural resource management (INRM). Project document submitted to the Asia IT&C Initiative of the European Commission (http://europa.eu.int/comm/europeaid/projects/asia-itc). 18 p.

Bousquet F, Bakam I, Proton H, Le Page C. 1998. CORMAS: common-pool resources and multi-agent systems. In: Lecture Notes in Artificial Intelligence 1416. Springer, Berlin.

Bousquet F, Barreteau O, Mullon C, Weber J. 1999. An environmental modelling approach: the use of multi-agent simulations. In: Blasco F, Weill A, editors. Advances in environmental modelling. Elsevier. p 113-122.

Bousquet F, Le Page C. 2004. Multi-agent simulations and ecosystem management: a review. Ecol. Modeling 176:313-332.

Ferber J. 1999. Multi-agent systems: an introduction to distributed artificial intelligence. Addison-Wesley Longman, USA. 509 p.

Gilbert N, Troitzsch K. 1999. Simulation for the social scientist. Buckingham (UK): Open University Press. 288 p.

Holling CS. 1978. Adaptive environmental assessment and management. London (UK): John Wiley.

Jager W. 2000. Modelling consumer behaviour. Kurt Lewin Institute dissertation series. Netherlands: Rijks Universiteit Groningen and Universal Press. 225 p.
Janssen MA, editor. 2002. Complexity and ecosystem management: the theory and practice of multi-agent systems. UK: Edward Elgar Publishing Ltd.
Lynam T, Bousquet F, Le Page C, d'Aquino P, Barreteau O, Chinembiri F, Mombeshora B. 2002. Adapting science to adaptive managers: spidergrams, belief models and multi-agent systems modelling. J. Conser. Ecol. 5(2):24. www.consecol.org/vol5/iss2/art24.
Morin E. 1999. Relier les connaissances, le défi du XXIème siècle. Le Seuil, Paris. 472 p.
Moss S. 2002. Policy analysis from first principles. In: Proc. Natl. Acad. Sci. USA 99-3:7267-7274.
Ostrom E, Gardner R, Walker J.1994. Rules, games, and common-pool resources. Ann Arbor, Mich. (USA): The University of Michigan Press. 369 p.
Röling N. 1999. Modelling the soft side of the land: the potential of multi-agent systems. In: Leeuwis C, editor. Integral design: innovation in agriculture and resource management. Wageningen (Netherlands): Mansholt Institute. p 73-97.
Weiss G. 1999. Multiagent systems: a modern approach to distributed artificial intelligence. USA: The MIT Press. 619 p.

Notes

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