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Learning in context through conflict and alignment: Farmers and scientists in search of sustainable agriculture

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Abstract. This article analyzes learning in context through the prism of a sustainable dairy-farming project. The research was performed within a nutrient management project that involved the participation of farmers and scientists. Differences between heterogeneous forms of farmers' knowledge and scientific knowledge were discursively constructed during conflict and subsequent alignment over the validity and relevance of knowledge. Both conflict and alignment appeared to be essential for learning in context. Conflict spurred learning when disagreeing groups of actors developed their knowledge in order to strengthen their arguments. Conflict caused self-referentiality when the actors no longer listened to each other. This inhibited self-reflection, thus blocking ongoing learning. Nevertheless, after a period of alignment, scientific models and knowledge of farmers were reevaluated and recontextualized. Through determining how to use scientific models and farmers' knowledge for further learning, aimed at a shared goal, the participating actors also learned how to learn.

Key words: Alignment, Conflict, Dairy farming, Discourse, Farmers' knowledge, Learning in context, Nutrient management, Scientific knowledge, Sustainable agriculture, The Netherlands

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Introduction

Throughout recent decades, heterogeneous groups of farmers and scientists all over the world have complained about the lack of suitable knowledge about environmental friendly production (see Jarvis, 1997; Steenvoorden et al., 1999). An initial explanation for this lack of suitable knowledge is that, in the past, the prevailing research and extension systems were mainly focused on the issue of high yields and neglected the issue of sustainability. In this sense, they have "created ignorance" (Hobart, 1993; Van der Ploeg and Van Dijk, 1995).[1] A second explanation for this lack of suitable knowledge is that although science often claims to be universally valid, it cannot be applied to all situations or used by all the actors involved. Sociologists of science have demonstrated that scientific knowledge is socially constructed in a specific locality, for example a laboratory or a test plot (see Callon, 1986; Knorr-Cetina, 1981; Latour, 1987). This also helps explain why the scientific knowledge available today may be of little value in localities where actors want to pursue sustainable agriculture.

Rural sociologists also have pointed to the need to relate knowledge to specific socio-spatial environment, in order to realize sustainability. Furthermore, they have argued that scientists and farmers need to engage in dialogue and cooperate in order to create suitable knowledge (see Clark and Murdoch, 1997; Kloppenburg, 1991). However, to date the dynamics of actual co-operative development of knowledge have been insufficiently analyzed.[2]

More descriptions of cooperation between farmers and scientists can be found in literature dealing with learning processes (see Kibwana et al., 2001; Röling and Van der Fliert, 1998; Van Veldhuizen et al., 1997). These studies contain very interesting cases but, in our view, tend to gloss over any conflicts in social learning.

Where conflicts are addressed, they are mainly viewed as obstacles to learning, and the learning potential of conflict situations has not been discussed.

Development studies taking an "actor oriented approach" have addressed issues of knowledge in relation to conflict (Long and Long, 1992). Due to their focus on struggle, their analysis of the dynamics of dialogue and social learning is weak. Moreover they rarely relate the issue of knowledge to that of sustainability.

This article analyzes how heterogeneous groups of farmers and scientists learned together about sustainability, through active cooperation within a nutrient management project in The Netherlands. Within our theoretical framework, we will build upon a perspective of "learning in context" departing from literature on experiential learning and the sociology of knowledge (e.g., Kolb, 1984; Baars, 2002; Law, 1994). The interrelations between learning, conflict, and alignment are analyzed in the empirical section, thus drawing attention to the discordant character of learning for sustainability. In this section, we apply ideas about social learning (see Lee, 1993; Hamilton, 1995; Jiggins and Röling, 2000) to analyze the interactions between actors when they try to learn together.

Methodology

The article is the result of a reflexive analysis based on participatory inquiry in 1999 and 2000 within the "Vel and Vanla nutrient management project" in Friesland, The Netherlands. The participatory inquiry contained elements of action research (e.g., Argyris et al., 1985; Reason, 1998). Our concern was with the development of knowledge that was directly relevant to solving problems faced by the actors. An important aim was to gain insights into the (variety of) experiential knowledge of farmers in the project (see Eshuis et al., 2001). The goal was to make this knowledge explicit and facilitate its exchange within the project. As we studied these issues of knowledge, we became involved in arguments about the value of emerging bodies of knowledge. The project leaders and some of the farmers repeatedly stressed that our research had to be useful for the project. By responding to these requests, we built up relationships that were vital for our research. Our engagement with the farmers and scientists was crucial to our understanding of events.

The methods used during our participatory inquiry included interviews and participatory observation (see e.g., Atkinson and Hammersley, 1998; Burawoy et al., 1991). The participatory observation took place among the 60 farmers and 15 scientists involved in the project and was carried out during project meetings and other activities related to the project (such as producing project reports). We observed actors during project meetings. Informal conversations (i.e., unstructured interviews) were held with the participants during these activities to uncover their interpretations of what was going on (cf. Becker, 1970).

Theoretical framework

Knowledge can be understood as a "collection of interconnected 'schemes of interpretation' ... that we ... can mobilize to give meaning to a particular situation" (Leeuwis with Van den Ban, 2004: 94). Schemes of interpretation from several sources can be flexibly mobilized. They can be adapted and transformed to fit a situation. Fundamentally, all knowledge is contextual; it is constructed by interaction with the environment and is embedded in the practices and epistemology of actors (Latour, 1987; Law, 1994). The idea that knowledge is contextual implies the existence of heterogeneous forms of knowledge. Since the context in which actors (be they farmers, social scientists, or agronomists) produce knowledge differs, their knowledge will differ in both content and orientation.

In this article, we will use the term "learning in context" to stress this contextual or situational nature of learning.[3] Learning in context refers to the idea that actors actively and deliberately engage in a learning process in order to develop knowledge relevant to their specific situation. They can do this either individually or through interaction with others (Baars, 2002). In both cases, actors develop knowledge that fits their practices and their epistemology, sometimes drawing eclectically on different sources of knowledge (Walley, 2002).

During learning in context, actors draw upon existing discourses. Discourses can be defined as specific ensembles of "ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer, 1995: 44). Actors use categories that they recognize in these discourses. To put it more precisely, actors recognize objects within existing discourses, and they usually recognize the objects in terms of a known discursive category. When particular forms of knowledge emerge, they tend to be allocated to existing discursive categories (see also Clark and Murdoch, 1997). Heterogeneous forms of knowledge may be categorized and discursively treated as monolithic bodies of knowledge with certain qualities. The discursive (re)production and valuation of categories of knowledge are both embedded in, and constitutive of, social dynamics (cf. Walley, 2002). This makes the production and valuation of knowledge an inherently strategic and power-laden process.

Actors are not passive users of discourse. They are able to transform discourse by attaching new meanings to categories, or by creating new categories. As we learn from Giddens (1984), actors influence social structures, while at the same time, agency is influenced by social structures.

To further the analysis of learning in context we introduce Hajer's (1995) concept of story-lines: "Story-lines are narratives on social reality through which elements from many different domains are combined and that provide actors with a set of symbolic references that suggest a common understanding" (p. 62). Story-lines can be seen as simplified accounts of complex discourses, often packaged as "one-liners" that sound "right." Examples of story-lines are metaphors, analogies or clichés (Hajer, 1995: 63). In the Vel and Vanla nutrient management project one such story-line that emerged was "Measures which farmers know from experience work, even though science may not yet understand how they work."

Because story-lines sound right and suggest a common understanding (i.e., they do not go into possibly conflicting details), they create possibilities for alignment, forming coalitions, and avoiding conflict. As Hajer (1995) states, "Story-lines fulfill an essential role in the clustering of knowledge, the positioning of actors, and ultimately, in the creation of coalitions amongst the actors of a given domain" (p. 63). Story-lines provide a shared language. Thus, they are instrumental in developing a shared discourse and building a community of discourse.

While actors learn in context, they are influenced by existing forms of knowledge, views, ideals, and interests. For instance, a soil scientist may argue that scientific knowledge on soil dynamics is crucial for improving nutrient management on the farm. In this sense, he reasons from his views, opinions, experience, and interests. During learning in context, actors negotiate about what can be considered to be true or useful knowledge in their context. This negotiation involves elements of conflict, struggle, and alignment (Long, 1989; Long and Long, 1992).

Conflicts among actors can play an important role in learning in context. As Dewey (1922) argues, "conflict is the gadfly of thought. It stirs us to observation and memory. It instigates invention. It shocks us out of sheep-like passivity, and sets us at noting and contriving – conflict is a 'sine qua non' of reflection and ingenuity" (p. 207). Conflicts confront actors with variety of opinions and interpretations. This triggers learning and change (Termeer and Koppenjan, 1997; Upreti, 2001; Voogt, 1991). Moreover, in situations of conflict, problems become more urgent and the need to address them becomes more pressing. Problematic issues have to be resolved and new insights may be gained. Also, conflict urges those involved to formulate what they mean as precisely as possible in order to respond to the arguments of those with different views. By contesting the validity of each other's arguments, groups will be spurred to clarify the validity of their arguments and claims to knowledge. If they cannot prove general validity, groups will try to determine the situations in which their arguments are valid. Thus, they develop contextual knowledge.

Conflicts may also block learning in context, especially when these conflicts escalate. Susskind and Cruikshank (1987) argue that "as the conflict intensifies people are less likely to listen seriously and think clearly. Unfortunately, such behavior by one party merely encourages similar behavior by the others." They add that, "in the heat of an emotional dispute, common sense is often the first victim" (p. 93). People become cognitively closed to the others and are not susceptible to their ideas. On the social level, opposing groups may develop, demarcate their borders, and become closed. Communication can become a "dialogue of the deaf." Actors interpret phenomena solely according to the logic of their own frame. They become self-referential. As a consequence, they lose the ability to view their own arguments from different angles or to situate them. Their learning is limited to increasing knowledge within a specific frame of thought, without learning about the frame itself.

Even in situations of conflict, there are possibilities for alignment, even if these are often hidden. When actors depend on each other for solving a problem, they have to cooperate and take each other's perspective into account (Aarts, 1998; Kickert et al., 1997). This may be a first step in learning from each other. Actors may come to better understand each other's perspectives. They may start to appreciate the validity of different arguments when examined from different perspectives. Implicitly, they might come to use a new epistemology in which the validity of knowledge depends on the perspective and the situation, instead of being universally valid. Actors might start to reframe the problem and learn together (Gray, 1997).

The Vel and Vanla nutrient management project

Setting the scene

Dutch agriculture has caused serious environmental degradation during the last decades. For instance, within the dairy sector, high losses of nitrogen in the form of ammonia volatilization and nitrate leaching have been reported (Erisman, 2000; Jarvis, 1997). In response to societal and governmental demands for sustainability, many Dutch farmers are readjusting their farms. In 1994, the Dutch government agreed that dairy farmers belonging to the Vel and Vanla environmental cooperatives[4] would be allowed considerable freedom to choose their own strategies for reducing nitrogen losses. In return, the farmers promised to achieve the environmental targets set by the government faster than other farmers in the Netherlands (Stuiver and Wiskerke, 2004). The dairy farmers sought cooperation from agricultural scientists to realize these goals, which led to the creation of the ongoing Vel and Vanla nutrient management project (Atsma et al., 2000).

The goal of this project is to find cost-effective solutions for environmental problems that meet the government's environmental targets and that are appropriate to the local context (i.e., the local farming systems, agro-ecological and social environments). The project focuses on nutrient management and, in particular, decreasing the use of fertilizer, improving the quality of manure, adapting its application, and improving soil quality. The project involves a wide variety of farmers with differing farming styles, education levels, milk production levels, and environmental achievements. Various scientists participate in the project, including agronomists from the Research Institute for Animal Husbandry and from Wageningen University as well as soil-scientists and social scientists from Wageningen University.[5]

Developing a shared framework

From the outset of the project, farmers and scientists worked together on developing a common framework. This shared framework became a very important tool for learning in context. It was based upon earlier work done by two scientists from Wageningen University who developed a new perspective on dairy farming. This encompassed the idea that dairy farming can be carried out in a more sustainable manner by fine-tuning the subsystems of soil, plants, and animals, and making better use of available local resources. They sketched a framework elucidating nutrient flows in the soil-plant-animal system on dairy farms (see Eshuis et al., 2001; Reijs et al., 2004) that has subsequently been developed by the actors involved in the project.

The interaction between the different actors was crucial. For instance, the knowledge and experiences of farmers with different farming styles and scientists with different disciplinary backgrounds was needed in order to understand nitrogen efficiency in the soil. For this reason, the framework was discussed intensively among the actors. During these talks, the interpretation of the framework and a shared understanding of the hypothesis were constructed. In their interaction, they learned about the different farming styles, the individual goals of the farmers as well as the particularities of the farms. Actors also developed their understanding about the background of the data used in the framework. They came to understand why the nutrient flows on farms were the size they were and how the farmer managed the nutrient flows.[6]

The framework was a suitable tool for developing contextual knowledge for three reasons. First, the systems perspective corresponds with the way in which farmers view their farm. The framework shows both the whole system and the details. Farmers see their farm as a whole, in the sense that they fine-tune relationships between the sub-elements in such a way that the system as a whole functions well (see also Hasseinen and Kloppenburg, 1995; Roep, 2000). "While working on a detail, farmers monitor the effects of their work on the system as a whole" (Eshuis et al., 2001: 21). Second, the framework leaves open those issues that have to be determined on-farm (i.e., in context), such as the quantities of nutrients needed in the subsystems. Available knowledge on the local situation can be used to fill out the framework in an adaptive manner, thereby creating a contextualized version of the framework. Third, the framework appears to be a promising way to realize the environmental goals. It draws attention to nutrient flows that previously had been largely ignored in contemporary Dutch dairy farming.[7] By focusing on these nutrient flows, one can learn how they can best be managed and how to reduce nutrient losses. The framework appeared to be a useful tool for developing a new way of farming that promises to be both ecologically sustainable and economically viable. It offered a new perspective and new opportunities for the involved actors.

Thus, the framework became an important tool for creating mutual understanding among farmers and scientists. Each participating farm filled in their own framework, which embodied contextual knowledge based upon the cooperation among these actors. The frameworks became sources of knowledge to enhance further learning.

Throughout the project, group meetings appeared to be an important tool to enhance learning in context.[8] During these meetings, a specific topic related to nutrient management was discussed, based on the experiences of the farmers. Each farmer would recount his experiences of the topic at hand, thus explicating his knowledge on the subject.[9] The project-leaders would facilitate this process and subsequent discussions by asking questions, bringing in the experiences of other farmers, or drawing upon knowledge from scientific institutes.

This process of learning in context is best illustrated by an example. One important topic of discussion was the optimal application of manure and artificial fertilizer. In a group meeting of five farmers, one agronomist, and one of the authors, the question was raised as to whether the quantity of fertilizer could be reduced without causing a reduction in grass yield or milk production. Each farmer described changes he had implemented and the effects he had witnessed. The participants then discussed how the effects were caused and what could be improved. Thereby, they tried to relate their own experiences to those of the farmer whose farm was being discussed. Such discussions often revolved around finding out details about specific actions, their effects, and the circumstances under which they occurred. Participants tried to take into account each other's circumstances and farming styles. In that way, they tried to transpose their knowledge to each other's situations. They compared their different experiences, carefully situating them.[10] Reflecting on this process, one farmer said, "With the experimentation of methods, I cannot copy the methods of my neighbor, as he has other cows, other grassland, and other manure. Therefore I have to rediscover my own craftsmanship again."

During these meetings, the farmers and scientists learned from local variation. For example, farmers compared fields on which artificial fertilizer had been applied with one where none had been applied. They compared the growth of grass on soils with high and low percentages of organic matter. Instead of learning from universally valid formulas or from averages, they learned from specific situations, through observation and comparison (see also Röling and Van der Fliert, 1998).

Conflicts on the validity of knowledge

Inevitably, conflicts about the validity of knowledge arose during the project. We will use the example of the optimal application of fertilizers to illustrate these conflicts and explain why they were important for learning in context. The various participants had developed conflicting ideas about the optimal rate for applying fertilizer on their farms. The different actors reasoned from their own practices and epistemological and institutional traditions. A debate arose within the project about the validity of prevailing scientific models and guidelines for practice (i.e., Sound Agricultural Practices).[11] This debate led to the eventual emergence of two groups of actors with differing ideas about the utility and relevance of scientific and farmers' knowledge.

The first group was composed of a few farmers and scientists affiliated with the Research Institute for Animal Husbandry. They advocated applying manure and fertilizer in accordance with prevailing scientific models and guidelines for farmer practices. Their arguments were grounded in positivistic science.

These actors argued that it has been scientifically demonstrated that the models and guidelines provide the best results in modern Dutch agriculture. Accordingly, the more diligently farmers follow these scientific guidelines, the better their results will be. Science was put forward as a superior and universally valid source of knowledge. By stating that scientific models and guidelines lead to the best results, the scientists in this group implicitly challenged the validity of other sources of knowledge.[12]

A second group of actors emerged, advocating a different approach to manure and fertilizer application, known as the "Van Bruchem method."[13] This method is grounded in the experiences of some farmers within the project who realized a high nutrient efficiency, and by farming systems research carried out by scientists from Wageningen University and Research Centre.[14] The group was comprised of a considerable number of farmers who were enthusiastic about the Van Bruchem method together with a group of scientists from Wageningen University. The symbolic leader of this group was Van Bruchem, a researcher who was one of the project leaders. We were generally considered to belong to the second group, as we had criticized the universalistic claims about science made by the scientists from the first group.[15] The second group argued that the scientific models were far from universal and only valid in situations in which high amounts of artificial fertilizer were being applied, the manure and the soil had specific qualities, and the grass species were modern varieties of Ryegrass (*Lolium perenne* L.). In short, the models were said to reflect the conditions on research plots rather than local conditions in the project and on "real life" farms. This group was convinced that the prevailing models for agriculture were based on averages from different test plots and repetitions. It further argued that these models were derived from de-localized data and would not be suitable for realizing ambitious environmental goals.[16]

The scientists from the first group refuted this criticism. From their perspective, the use of statistical data and sophisticated models was a strength, rather than a weakness. They stated that their models were based on sound scientific research. They also criticized the Van Bruchem method, stating that it was more like a hypothesis than an approved method or sufficiently validated theory. They were particularly critical of Van Bruchem's claim that good manure enables a reduction in the use of artificial fertilizer without reducing grass production. According to them, "good manure" was insufficiently defined and these claims were not underpinned by evidence of causal relationships or statistical data.

On the basis of this reasoning, the idea took hold in the project that the arguments based on Farming

Systems Research and the Van Bruchem method were not "scientifically proven." The consequence was that actors supporting the Van Bruchem method found it more difficult to justify their argument from a scientific perspective. From then on, they relied more on the experiences of farmers to validate their arguments.[17]

Gradually, two discourses emerged based upon different lines of reasoning – one based on "scientific proof" and the other based on the "experiences of farmers." What counted as an argument in one discourse, did not count as an argument in the other. If actor A claimed something was true because it was proven on a research plot, then actor B would counter that the circumstances of the research plot were entirely different from the local situation. If actor B justified a claim on the basis of the experience of a farmer, then actor A would find this meaningless because it was not scientifically proven.

Also, the indicators used in the two discourses were different. If one actor used the percentage of mineral nitrogen in the manure as an indicator to make his point, then the other actor would use the consistency of manure. Thus, each discourse was based on a different language, which severely hampered communication. Due to the use of different arguments and different indicators, real discussion, in the sense of taking the other seriously and talking through each argument, became rare. Instead, actors repeated their own arguments without getting their message across. They started to improve their own discourse through their own arguments, thus furthering the construction and demarcation of two separate and competing discourses. Progressively, actors grouped knowledge into two categories, even though the knowledge was constructed from multiple sources. This furthered the discursive formation of two distinct categories of knowledge: farmers' knowledge and scientific knowledge.

Interestingly, the supporters of the Van Bruchem method attributed specific qualities to the category of scientific knowledge. They pointed out that a number of farmers who did not work according to the prevailing scientific guidelines achieved excellent innovative results. Referring to these "innovative" farmers and building upon their knowledge, these actors argued that it is possible to apply manure and fertilizer at lower, more optimal levels than the models suggest. They stated that the experiential knowledge of the farmers works, even though it is *not yet* scientifically understood *how* it works. This turned out to be an effective story-line. It implied that scientific knowledge was "lagging behind" and incapable of understanding farming in practice. Scientific knowledge was also implicitly depicted as being of an "average quality" because it leads to sub-optimal results. By contrast farmers' knowledge was portrayed as "practical knowledge" and "workable knowledge."

As the distinction between the two emerging social groups developed further, many participants in the project were labeled as supporters of one of the two discourses and effectively became members of the group that supported that discourse. Sometimes, actors discursively formed an "us-group" and a "them-group." This increased the separation and alienation of individuals belonging to different groups. People not yet belonging to a group were sometimes labeled as a member of one of the groups on basis of the arguments they used. Through this process, the scientists using farmers' experiences as a source of knowledge, successfully positioned themselves as spokesmen and allies of the farmers. Those who wanted to build bridges between the two groups and who did not want to be labeled had to formulate their arguments very carefully. They had to constantly avoid the impression that they were attacking or supporting either one of the groups.

Developing contextual knowledge through alignment

The discussion about optimal fertilization became heated. A deadlock was prevented by one of the project leaders who came up with a compromise. He suggested that the prevailing scientific models were valid when higher quantities of artificial fertilizer were applied, but not when lower quantities were used.[18] A new story-line emerged that suggested different sources of knowledge are valid in different circumstances. This story-line made it possible for actors belonging to the different groups to work together because it implied that each group had valid and useful knowledge, albeit for different situations. Instead of seeing each other's ideas as mutually exclusive, they were seen as complementary. Actors reframed their ideas about each other too. They now saw each other less as competitors and more as sources of knowledge useful in specific situations.

With a mutual agreement about this story-line, farmers' knowledge became more accepted by the supporters of the first group. More importantly, the idea that scientific knowledge was superior to and more valid than farmers' knowledge was abandoned. The participants of the project learned about the value of different sources of knowledge. Once this compromise became generally accepted, actors implicitly acknowledged that the existing scientific models were inadequate to realize the environmental norms and the goals of the project. This idea seriously started to undermine the authority of the scientific models. Participants became aware of a lack of knowledge regarding low nutrient inputs. Consequently, two lines of action were developed. The first one was learning by implementing and monitoring new farming practices. The second was learning from research and experiments.

Learning in context in terms of three learning loops

By taking small steps and carefully monitoring the effects, the participants made progress in developing suitable knowledge where it had previously been lacking. First, they developed an understanding of nutrient flows and management of nutrient flows on the farms. Second, they developed practical indicators that can be used on a daily basis. Third, they devised a means of cooperatively setting up research. Fourth, they interpreted research results together with different groups of actors. Fifth, they found the limitations within scientific models. Finally, they estimated the applicability of models in the local context.

Their social learning processes can be described in terms of the three learning loops developed by Argyris and Schön (1996). Single loop learning refers to learning that changes the way of working within a set frame of thought. Underlying principles are not questioned. The focus is on "techniques and making techniques more efficient" (Usher and Bryant, 1989: 87). In our case, single loop learning meant learning about useful measures for improving nutrient efficiency in the specific context of each farm. This learning provides practical and locally applicable answers to questions such as "when to apply fertilizer," "how to apply fertilizer," "how much fertilizer to apply," and "which fertilizer to apply."

Double loop learning refers to learning that alters underlying values, rules, and assumptions. In this project, it meant learning about the principles underlying the measures mentioned above. It involved the development of on-farm research and joint experimentation (see Baars et al., 1999). Participants learned principles about (a) the relationship between artificial fertilizer, soil, and yield; (b) the quality of manure; (c) the relationship between the quality of manure, soil, and yield; and (d) the role of soil and soil life in farming systems.

Triple loop learning means learning how to learn. Participants learned how to appreciate their own experiences, as well as those of others. For example, farmers learned which other farmers worked in a comparable manner and where they could obtain information that would be applicable to their own farm. Participants also learned about interpreting models and theories. Both farmers and scientists developed knowledge about setting up experiments on farms and interpreting the results.[19]

Discussion and conclusions

The participants in the nutrient management project of Vel and Vanla have been learning in context. They have used knowledge from different sources – in their terms, science, and practice – to create knowledge that is valid and useful in different contexts. Knowledge that is relevant to a specific context is not always readily available, but has to be constructed by giving meaning to existing knowledge. Knowledge stemming from sources such as theoretical models, rules of thumb, or the experiences of academics and farmers, has to be interpreted and fitted to the local situation. This article describes three ways in which knowledge becomes situated – through developing a shared framework, through group meetings, and through conflict and alignment.

Learning processes in the project involved negotiation between actors supporting different paradigms. These negotiations had several effects on learning. At first, conflicts stimulated actors to develop and refine their arguments. The conflicts spurred learning. Later on, however, conflicts impeded learning because actors in open conflict formed two parties and became less receptive to each other. They kept repeating the arguments from their own discourses without learning from the others' arguments.

When both parties acknowledged that each had valid knowledge for specific situations, and learned how to value each other's knowledge, an alignment took place. One strategy that assisted this process was learning to avoid contesting the core values of the other party. The scientist's models were no longer openly attacked and the value of farmers' knowledge was recognized. Another strategy was the explication of shared, underlying interests, namely the need for additional knowledge about sustainable agriculture and for more research in the nutrient management project.

During the negotiation process, the actors reproduced the categories of scientific knowledge and farmers' knowledge discursively, and gave them a new meaning. The differences between scientific knowledge and farmers' knowledge were discursively reproduced, rather than fundamental.

We draw four conclusions as to how learning in context can be facilitated. First, a variety of sources of knowledge and confrontation among them stimulates the process of learning in context. Therefore, it is unwise to present one source of knowledge as superior and debunk other sources of knowledge. Instead, one should stimulate several sources in order to develop knowledge through interaction. The project leader's proposal that both types of knowledge about nutrient management were valid in different situations exemplifies this.

Second, parties are more likely to accept knowledge when they have been involved in the generation of that knowledge. This is especially true when parties find themselves in conflict. A lack of involvement may lead to a rejection of one or the other bodies of knowledge (e.g., scientist or farmer experiments). A sense of shared ownership of knowledge is conducive to knowledge being accepted by all the parties concerned. In addition, being involved in a process of "joint fact finding" can bring conflicting parties together.

Third, creating good relationships between parties is an integral part of the contextual social learning processes. Forester (1999) provides an explanation of this when he writes, "learning occurs not just through arguments, not just through the reframing of ideas, not just through the critique of expert knowledge, but through transformation of relationships and responsibilities, of networks and . . . membership" (p. 115).

Fourth, we have seen the importance of stories that farmers and scientists tell each other about measures they have taken on farms and research-plots. As Forester (1999) explains, "The particulars others raise can seem irrelevant at first, and they may turn out to be irrelevant – but they may also turn out to be surprising, suggesting problems or opportunities. Participants may come to see that what *seemed* unimportant is important, what seemed *not* feasible is feasible after all. This 'coming to see' . . . is a matter of recognition – quite literally, re-cognition" (p. 133). Within the project, *indicators* are important expressions in story-lines. They provide simplified representations of complex phenomena. They show something specific and indicate something more inclusive or general.[20] For example, the consistency (i.e., thickness) of manure has come to be used as an indicator for quality. For a specific group of actors, thick manure symbolizes a sustainable way of farming and a trajectory for sustainable agriculture. For these farmers and other professionals, indicators suggest a common understanding of a complex phenomenon. When they use or hear these words, they more or less assume the same meaning and interpretation.

Learning in the Vel and Vanla nutrient project has continued. So did the conflicts and the alignments. The value of different categories of knowledge is continuously being renegotiated. The endorsement of different types of knowledge in the project, in our view, can be regarded in terms of a change in paradigms. A change in paradigms is not a single cataclysmic event during which the old fortresses of knowledge crumble and disappear. Rather, it is a slow and cumbersome change that is constantly renegotiated.

The shift of paradigms is not only restricted to this project. "Field laboratories" such as Vel and Vanla have triggered a growing discussion between scientists, experts, and farmers about scientific research methods and the suitability of existing agricultural models and guidelines (see Stuiver et al., 2003). Scientists are responding by attempting to develop an alternative pathway to approach sustainable farming. It is one that involves the adaptation of universal models to specific local situations and the recognition of variation between localities. Thus, scientists are assimilating different forms of knowledge and learning.

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Notes

1. The Transfer of Technology (TOT) approach, widely used in research and extension, has been criticized for assuming that scientists develop superior knowledge, that extensionists spread this knowledge, and that farmers are passive receivers and users of these packages of knowledge (see Engel, 1995; Leeuwis, 1993; Röling, 1988).
2. Kloppenburg (1991) argues that scientists should take into account local knowledge and that farmers need to assume an enhanced role in agricultural research. However, he does not analyze cases of cooperation. Hassanein and Kloppenburg (1995) describe a case of developing knowledge for sustainability among farmers, but the knowledge of scientists as experts plays a very minor role in this. Murdoch and Clark (1994) provide a thoughtful theoretical analysis on knowledge and sustainability, but do not elaborate on interaction between farmers and scientists. Clark and Murdoch (1997) describe cases of failing cooperation between farmers and scientists. They sketch how scientists unsuccessfully try to enroll farmers in their networks rather than engage in dialogue.
3. We will use the verbs "contextualize" and "situate" interchangeably.
4. An environmental cooperative is a regional cooperation of mostly agricultural entrepreneurs. It aims to integrate environment, nature, and landscape objectives into farming practices at a regional level (Stuiver and Wiskerke, 2004).
5. Farmers are in charge of the project. This is laid down formally in the organizational structure, which is headed by the environmental cooperatives. Two project leaders, an agronomist from Wageningen University and an employee of the farmers' union LTO, do day-to-day project management.
6. The framework was also useful in our study. We used it as a starting point for generating farmers' accounts about the nutrient flows on their farms. In this way, the framework played a role in explicating and developing learning in context.
7. For example, it considers the nutrient flow between manure, soils, and plants, or the flow of nutrients in the soil.
8. Several types of group meetings with farmers and scientists were organized. There were small meetings with five participants, large meetings with eighty participants, meetings to discuss results as well as meetings in the field.
9. All farmers active in the project were males.

10. If a project farmer had successfully postponed and reduced his application of artificial fertilizer in the spring, then this action would be discussed. Would it also be suitable on another farm, taking into consideration local soil dynamics, the grass yield needed, and the application of manure in spring?
11. Sound Agricultural Practices (called Goede LandbouwPraktijk or GLP in Dutch) are guidelines and models for agricultural practices developed by research institutes such as the Research Institute for Animal Husbandry. They are described in manuals and magazines (see Commissie Voedergewassen en Bemesting, 1998; Vellinga, 1998). The models play an important role in Dutch dairy farming, which is highly modernized and based on scientific models (Leeuwis, 1993; Van der Ploeg, 1992).
12. Following the models, they reasoned that using less fertilizer – as advocated by the project leaders and University scientists – would lead to yield losses. They claimed that there was no proof to support the argument that it would be better to apply manure with traditional methods (as one-third of the farmers in the project did) than to use modern methods of slurry injection. Through slurry injection, less nitrogen would be emitted into the air. Further, they asserted that the additives that farmers mixed into the manure did not make any difference to the quality of the manure or have any effects on the environment. To demonstrate this, they referred to scientific research carried out by the institute (e.g., Kant et al., 1998).
13. The Van Bruchem method is a way of organizing the dairy farming system. By managing the farming system as a whole and fine tuning its subsystems, the nutrient efficiency in the system can be increased. Important features include the reduction of external resources coupled with the optimal usage of internal resources. The aim is to increase the quality of manure, so as to improve the fertilization of the soil. This enhances soil life, increases the efficiency of nutrient uptake from the soil, and the quality of the grass. When cows graze on this high quality grass, the quality of their manure improves.
14. See, for example, Lantinga et al. (1999), Reijs et al. (2004), Van Bruchem et al. (1999a), Van Bruchem et al. (1999b), Verhoeven et al. (1998) and Verhoeven et al. (2003).
15. We agreed with the "Van Bruchem method" on the grounds that agricultural models and guidelines were inadequate due to their lack of measurements on "real-life" farms and their usage of statistical averages instead of relevant data reflecting the local variance of farms.
16. The re-interpretation or localization of models involves a complex process of comparison and estimation of specifics of different locations and contexts. This is why farmers and some scientists in the project wanted to know the precise effects of particular measures in specific circumstances. They needed this specific data to estimate what the effects would be on their own specific farms, in a specific season. Farmers' criticisms of scientific models often boiled down to the problem of working with the general, because they could not gauge the extent to which the general was applicable on their specific farm. Also, they found it hard to work with averages, since averages do not take into account the variations that occur in natural processes.
17. Although we focus on learning and the argumentative aspects of conflicts and alignments, it is pertinent to make a few remarks on power issues. The farmers involved had significant power because they were formally in charge of the project. Moreover, they were well organized via the environmental cooperative and received support from a farmers' union. These reasons all contributed to their success in claiming space for farmers' knowledge. The scientists from the Institute for Animal Husbandry had considerable influence on the project through their knowledge of research and dairy farming. They had an important say in research issues. This was not only because of their expertise, but also because the government had allocated a large part of the money for project research to their institute. The scientists in the Van Bruchem group derived power from several sources. One of the scientists was project leader and had an official status in both the farming and scientific communities. Further, these scientists were supported and trusted by a large majority of the farmers.
18. Farmers applying more than 180 kg of nitrogen per hectare would take prevailing scientific models as their starting point, while the other farmers would work according to guidelines established through experiential learning.
19. We learned about learning as well. We have learned from the project that it is unwise to see learning only as conflict. Alignment processes are essential for learning too, especially when the actors agree that certain knowledge is missing that can be of benefit to all the actors involved.
20. Thus, indicators influence observation and experience. Indicators focus observation. They enable and sharpen observation, but also narrow it. As a result, indicators may cause blindness to other phenomena that are not indicated, thus literally becoming blinding insights. The farmer who is focused solely on the quantity of milk, may unwittingly neglect the quality of the milk or the health of his cows. In experiential learning, indicators facilitate measuring (i.e., quantifying), registering, and monitoring. In social learning processes, indicators have an additional function. They provide a shared perspective. By using the same indicators, people focus on a common dimension, which facilitates comparison.

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