ACTIVITY THEORY: A FRAMEWORK FOR ANALYSING THE LEARNING PROCESSES OF NEW ZEALAND SHEEP FARMERS RELATING TO DECISION-SUPPORT SOFTWARE

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Abstract

McGown (2001) notes that in spite of 20 years of effort, electronic decision support tools and systems have not significantly changed farm management practice. This may stem partly from the mistaken notion that computer-owning farmers would naturally use decision-support software. There is a need, however, to analyse learning processes related to electronic decision-making tools in agriculture to shed more light on the issue. In this paper we discuss the applicability of the third generation of activity theory (Engeström, 1996). We show that activity theory is both a learning theory and a theory of practice. It has been applied in a variety of learning contexts and is currently being expanded to the agricultural sector (Seppänen, 2000).

This paper suggests why activity theory is an appropriate basis for analysing the learning behaviour of farmers. The framework involves analysing the farmer's motivations, the farmer's work tasks and the people and organisations with whom the farmer interacts; and how they perceive their joint activity and goals. In any particular situation, these relationships are also mediated by other factors (such as rules), which have both cultural and historical dimensions. Since the design of electronic tools also mediates farmer learning, there is a need to incorporate this factor into the analysis as well. Within an activity theory framework, therefore, *this overall activity system*, rather than the individual farmer, becomes the unit of analysis for research on learning processes. We develop our argument from early results and experience in a three-year programme of learning and behaviour change research. This relates to the use of electronic tools as an aid for decision-making by New Zealand sheep farmers. We conclude that activity theory provides an appropriate frame of analysis.

Keywords: Activity Theory, Farmers, Learning, Decision-Support Tools

1. Introduction and background to the research programme

This paper reports on one aspect of a three-year research programme on learning processes and behaviour change in New Zealand sheep farming. After the first year's research, the unit of analysis has shifted from the learning activity of the individual farmer, to the farmer's learning within the farm system *and* in its relationship to both the meat processor and R&D organisation. The paper shows how this decision was reached by drawing on insights from activity theory, which is both a learning theory and a theory of practice (Engeström, 1996).

Industry commentators see adult learning as a key ingredient in enhancing the capacity of farmers involved in New Zealand's agriculturally-based production systems and supply chains. They believe that continual improvement in rural human capacity in New Zealand is needed as market and business demands change rapidly with globalisation; and as new technologies become available to improve the efficiency and precision of the supply of new products.

Research on the learning challenges that farmers face was carried out within New Zealand's largest agricultural research institute, AgResearch, between 1998-2000. The AgSystems Group identified the importance that farmers place on being informed about changing market expectations and meat processing companies' response; about contractual opportunities and obligations; and about the technical factors that influence the timing of supply and quality of their product.

2. What happened in the first year of the research?

A new three-year programme of research commenced in July 2000. It aims to determine the effectiveness of learning processes for different levels of topic complexity and decision-making in sheep farming and dairying. In the first year, the research team began to investigate (a) the attributes of complexity of learning topics; and (b) the level, and duration, of interactive group and electronic-based learning required for each topic.

The AgSystems Group established a research partnership with 37 sheep and beef farmers in two rural centres in the South Island and with a local meat processing company. Farmers were encouraged to participate in the research and the research objectives were formed collaboratively. Farmers identified three areas of learning:

- To understand future developments that could impact on their farming activity
- To establish new supply arrangements with the processing company
- To redesign their farming enterprise in response to these developments

Two farmer groups were formed in Ashburton and Timaru, South Canterbury. Focus group meetings were held every two months, and the research team maintained contact with the farmers between meetings by e-mail and phone.

In early meetings, specialist advisers briefed farmers on the learning challenges that they faced in supplying lambs to specification in order to meet current and future market expectations. The research team determined the short- and long-term market information needs of the farmer groups. A preliminary assessment was made of the applicability of Internet connection to address these needs.

The team also identified the attributes of complexity of learning topics nominated by the farmers. These were: optimum stocking rate, animal nutrition, pasture management, soil fertility, animal health, animal general management, animal reproduction, genetic improvement, business management, maintenance of machines, farm maintenance and staff management. The team then asked farmers to rate these topics in terms of their complexity, and assessed the suitability of the Internet as an instruction medium for topics of contrasting complexity.

In subsequent meetings farmers were assisted in learning how to use a new on-farm, electronic decision-support tool developed by AgResearch scientists for precise lamb supply to the meat processing company. The tool assists farmers to plan their supply contracts, track progress, make ongoing management decisions on the basis of the information generated, and explore different lamb finishing strategies.

An AgResearch agronomist who works closely with the farmers, and had been involved in the development of the tool, gave one-on-one briefings and ran lab sessions for the two groups. After an introductory session, the farmers used their own farm data and carried out a series of 'homework' exercises on-farm. They returned to the computer lab for a second session in which they were able to get one-on-one, and group, feedback. This sequence was then repeated.

Our team used a variety of methods - observations, farmer feedback during group sessions, and monitoring of needs for ongoing support – to make a preliminary assessment of the effectiveness of these different learning processes. An analysis of the need for, and nature of,

a communication strategy relating to the tool's use was communicated to the meat processing company.

3. What we learned about the limitations of the research approach

During Year 1 a number of tensions surfaced in the research approach. The first related to the differences between farmers' motivations to participate in the research, and the meat processing company's objectives as a research partner in the development of the tool. While the company was driven by its need to satisfy new and increasingly stringent sets of market requirements, the farmers' motivations often reflected potentially conflicting goals. Discussion in the first meeting showed that the farmers placed considerable importance on maximising farm profits and building a viable farming business. However, emerging patterns of use of the Internet and the decision-aiding tool suggested that these sometimes conflicted with their desire to carry on with traditional farming tasks. A key question that the research team began to ask, therefore, was 'to what extent were the motives of the meat processor and the farmers in using the tool shared'; and, if they were not, 'what were the implications for farmer learning?'

A second set of tensions related to the design and use of the decision-support tool. For example, in the June 2001 computer lab session, farmers appeared to be experiencing considerable difficulty with some aspects of the computer programme that was first developed 18 months previously. We were told that 'so many problems are surfacing so late in the piece.'

In the light of the farmers' earlier experience in using the Internet during 2000, structured observations were made of each of the computer lab sessions and ethnographic data was obtained from informal conversations with the farmers, and with staff from AgResearch and the meat processing company. More structured scoping interviews were also held to try to understand the source of the farmers' difficulties. One explanation was that the programme had been developed by IT staff with insufficient input from the farmers, or from AgResearch staff who worked closely with the farmers. We were told that 'those who put the model together didn't have enough practical experience.' Farmers were 'put off because the programme made a nonsense of the farmers' own data which they had collected themselves'. One of the people we talked to, who had a science background, commented wryly on the design process: 'I suppose it's like all science people. We think we know it all!' By contrast, a recent interview with one of the IT specialists suggests a different explanation. It relates to the contradiction between staff working to a set of good IT design principles that are based on satisfying the needs of the users (the farmers), and the need for Ag Research staff to satisfy the requirements of the science funding agency as a 'pseudo-user'. This suggests that 'a purchaser/provider model for science and technology makes for distortions in the way signals are developed to guide the design, use and evaluation of innovations (Paine, *pers. comm*., 2001).

In summary, this preliminary data suggested that rich insights into farmer learning processes and behaviour could be gained through a cultural-historical analysis of the design, development and use of the decision-support tool. This would include the organisational learning of the meat processing company and AgResearch.

A third set of tensions related to our definition of 'the learners' in the project – the *subjects* of our research. How had we defined and located them? Who was the subject of the learning, the farmer or the farm system? What were the implications for the design of learning processes? For example, the majority of participants accepted the invitation to participate in the research as *individual farmers*, although three father/son partnerships, and two husband/wife partnerships came to the meetings. At different stages it was clear that each partner had particular roles within their farm system and, typically, one of the partners was

more comfortable in using the Internet and decision-support technology. This is likely to be true not only of the five sets of 'partners' who turned up to the meeting, but of a number of the other participants whose 'partners' did not attend the focus group meetings at any stage (Miettinen, 2000). Our research team concluded that we needed further information about the existing arrangements for learning and using computer technology on the farm both prior to, and following, the meetings and lab sessions.

In our work with the farmers and meat processing company, the research team also wrestled with the challenge of bringing science rigour and farm/industry relevance to the project, an underlying tension that is captured in Carberry's (2001) plenary paper when he asks 'Are science rigour and industry relevance both achievable in participatory action research?' We knew that the research had to add value for the farmers or they would not continue to participate. The meat processing company needed to see the relevance of the research as it tried to establish different supply arrangements with the farmers. The research also had to meet the scientific requirements of the research funding agency, the New Zealand Foundation for Research, Science & Technology. These three objectives were often in tension.

Taken together, the four sets of tensions raised questions about the underlying model of learning. We decided that the unit of analysis needed to shift to the farmer's learning within his or her farm system, and in its relationship to the organisational learning of the meat processor and AgResearch - the R&D organisation involved in the design, development and delivery of the tool. Expressed more simply, our team saw a need for a new analytical framework that could provide a better understanding of the learning context of farmers, and a perspective on how organisations learn while working with farmers.

4. What frame of analysis is appropriate for studies of agricultural learning and practice?

There is a growing body of literature that supports the view that farmer attitudes and behaviour cannot be adequately understood when separated from their practical context (e.g., see Seppänen, 2001; Paine *et al*, 2000; Paine *et al*, 1998; Paine, 1997). Similarly, commentators argue that studies need to be specific to the particular learning environment. Put differently, studies of knowing and doing need to be interdependent. Historically these studies have been conducted in isolation (Paine, *pers. comm.*, 1999).

In addition, 'communities of practice' are being seen as the prime unit for analysing knowledge and learning (Ahonen *et al.*, 2000; Paine *et al*, 1998). Learning processes also have to shift away from a static view of learning to one that is dynamic, particularly in complex, uncertain environments (*ibid.*).

In a review of the field of knowledge management, Blackler *et al.* (1998:74) point to the considerable recent interest in rethinking the concept of knowledge, and note that a consensus is beginning to emerge. Five images of knowledge can be distinguished in the literature (*ibid.*: 71-72):

Embodied knowledge	in which a physical presence is needed; involves 'knowing how'.
Embedded knowledge	knowledge contained in systemic routines; organisational capabilities.
Embrained knowledge	knowledge depending on conceptual, cognitive abilities; 'knowing that'.
Encultured knowledge	this is a process of achieving shared understandings.
Encoded knowledge	information that is conveyed by signs and symbols.

Blackler *et al.* (*ibid*:72) conclude that 'in the emerging global economy, knowledge that is embrained, encultured and encoded is of growing significance compared with knowledge that is embodied or embedded'. They also show that knowing is increasingly conceptualised in the literature as *a process* (e.g., see Ammentorp, Morgan and Roca, 1996). As they explain,

> *There has been a shift away from thinking about knowledge as a commodity that individuals and organizations have or may acquire, towards the study of knowing as something that they do. The key question arising from this perspective is: how do people do their knowing? Answers to this question have highlighted the link between knowing and social processes. (Blackler et al. op cit.:74).*

Paine *et al.* (1998) review three bodies of literature on different agricultural methodologies that are applicable to address farmer learning in real-life contexts. The authors group them into three clusters: symbolic interactionist, discourse and participatory methodologies; and examine the strengths and weaknesses of each (Paine *et al*, 1998). They conclude that, while each of the methodologies offers some unique perspective, the most promising is a participatory methodology known as Rapid Appraisal of Agricultural Knowledge Systems (RAAKS).

There appears to be growing interest in using participatory studies and action learning approaches in agricultural settings (e.g., see Australian Agronomy Conference, 2001), but these studies, like the RAAKS methodology, are founded on individualised conceptions of farmer learning. By contrast, Seppänen's (2000a) participatory study of organic farming in Finland during a major transition in the Finnish agricultural sector modelled organic vegetable farming as an activity system. She analysed disturbances occurring in farming practices, and the developmental histories of two organic farm sites. From this analysis, Seppänen developed a range of models and tools as interventions in farmer learning to bring about changes in farm practices at the two sites. Seppänen's intervention study was the first time that activity theory had been used in agricultural research.

Activity theory assumes, explicitly, that humans are co-creators of their learning environment and agents of change with the power to act (Roth, Tobin and Zimmermann, 2001). Human activities can be viewed as a system which has cognitive, socio-cultural and historical elements.

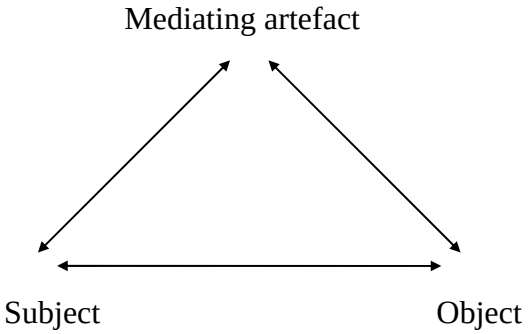
> *In most theoretical approaches, the unit of analysis is the individual human subject that engages with an object. In contrast, activity theory articulates activity not only in terms of subject-object relations but also accounts for other entitities (tools, community, rules, division of labor) and the mediating influence they have on pairs of other entitites (Engeström, 1987).*

Based on recent developments in theories of learning, practice, and knowledge management outlined above, and on our experience in the first year of the project, we concluded that activity theory was an appropriate framework for analysing farmer learning processes and behaviour. In the next two sections of the paper we give a brief summary of the origins and principles of the theory.

5. The origins of activity theory

Engeström and his co-workers have written extensively on activity theory. This section summarises Engeström's (1996: 131-133) analysis of the key stages in the evolution of the theory, which centre around particular theorists and concepts.

First generation: the idea of mediation. In contrast to the behaviourist model of action based on the concepts of stimulus and response (S-R), Vygotsky claimed that all actions were mediated by cultural artefacts. This has been commonly formulated in the following model:



Cultural artefacts could be physical as well as psychological tools. These include language, mental models and concepts and, like technical artefacts, are culturally and historically determined. The insertion of cultural artefacts into human action as the basic unit of analysis overcame the split between the 'Cartesian individual and untouchable social structure' (*ibid.*: 132). This meant that the individual could not be understood without an understanding of his/her culture and society and that society could not be understood without 'the agency of the individuals who use and produce artefacts' (*ibid*). The first generation of the theory was limited, however, because the unit of analysis remained primarily focused on the individual. The second generation addressed this issue.

Second generation: collective activity. It was Leont'ev who distinguished the crucial difference between an individual action and a collective activity, extending the focus to complex interactions between the individual and his or her community. This development in the theory centres around the Developmental Work Research programme at the University of Helsinki, associated with Engeström and his colleagues.

Building on Leont'ev's insight, Engeström developed a model of human action contained within an activity system. Not only were actions mediated by cultural artefacts, they also occurred within a social context. This included the rules by which that activity takes place, the community of practitioners (people associated with the activity) and the division of labour (who does what). At this time, the idea of internal contradictions as the central driving force of change and development in activity systems (as conceptualised by Il'enkov) became one of the guiding principles. A contradiction, or disturbance, could occur along any axis within the activity system. For Engeström, such disturbances create powerful opportunities for learnings to take place.

Blackler *et al.* (1997) provide an explanation of an activity system that is grounded in the study of management and work transformation (as illustrated in Fig 1 below). They note that the *inner triangle* represents the relationships that occur between individuals and their communities of practice when they participate in shared purposeful activity.

Blackler *et al* (*ibid.*) explain that the *outer triangle* represents the relationships, artefacts and technologies that mediate individuals and this activity. The diagram represents the 'social, cultural and technological infrastructure of expertise'. 'Mind' is social in construction and effect (Vygotsky, 1978) and arises from, and is maintained by, social interaction; and learning takes place in situations and through activities; what is sometimes referred to as 'situated learning' (Clancy, 1995). The second generation of theory, however, also had significant weaknesses - in particular an insensitivity towards cultural diversity (Engeström, 1996). As activity theory was disseminated internationally, questions of diversity and dialogue between different traditions became increasingly serious challenges (*ibid.*).

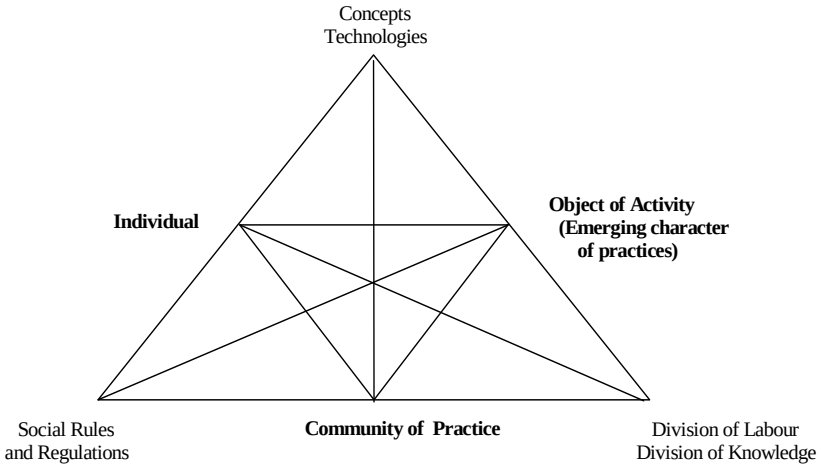


Figure 1: A 'Community of Activity' (Blackler *et al,* 1997, adapted from Engeström, 1987).

Third generation: dialogue, multiple perspectives and networks of activity systems. The third generation of activity theory is concerned with developing conceptual tools to understand the diversity and complexity that exists within activity systems and networks of interacting activity systems. For example, Blackler *et al* (1997) have reformulated Engeström's activity system model to networks of activity systems. Other researchers such as Wertsch and Ritva Engeström have explored ideas on 'dialogicality' while Holland and Reaves have explored notions of multiple perspectives (cited in Engeström, 1996). Engeström suggests that no clear model for the third generation has yet emerged except that, minimally, it is concerned with at least two interacting activity systems (*ibid.*:133).

6. Principles of activity theory

In this section of the paper we summarise the key principles of activity theory by drawing primarily from Seppänen's recent useful summary (2000b).

The unit of analysis is an activity system. The activity is an 'object-oriented, culturally and materially mediated system, with division of labour [or knowledge] and rules that regulate interaction between the participating individuals' (*ibid.*: 4). The distinction between the *actions* of *individuals* and *collective object-oriented activity* within this system is of central importance to the theory. Seppänen emphasises that the activity system, including its object or motive, is more durable and complex than discrete, goal-oriented actions. Actions can only be understood in relation to the object and motive of an activity system.

The object of activity is transformed, both in conversation and materially (eg in artefacts), into an outcome or a product. A collective activity is driven by a deeply communal motive, which is embedded in the object and the object is constantly transformed by the individuals participating in the activity over time.

Inner contradictions within and between the elements of an activity system can be identified and analysed. Contradictions are 'tensions between forces pulling in opposite directions in the activity' (*ibid.*) Engeström (*pers. comm.*, 2000) points out that the concept of contradiction provides a theory of how movement occurs in complex systems, both (a) from action to activity; and (b) through different types of contradiction within the activity system.

Disturbances and dilemmas are visible in practitioner's everyday actions. They are also expressions of the underlying contradictions between elements within the overall activity system. Encountering these contradictions through analysis of their history and development provides a way for the actors to find a 'springboard' for transformation of the system.
Seppänen (*op.cit*.) explains that major changes in the activity system happen through *expansive learning* in which the object and the whole activity system are transformed. Expansive learning is collective and takes long periods of time. It begins when participants start to question the aims of the activity, what is produced and why. In expansive learning, the practitioners create a new mode of practice that was not there at the outset. This type of learning is little discussed in standard learning theories' (*ibid*.: 4).

7. Discussion

Drawing on preliminary research into the use of electronic tools as an aid for the decision-making of New Zealand sheep farmers, we have argued that activity theory provides an appropriate framework for analysing the learning activity of the farmer. In the second year of the project we are focusing on the relationship between the farmer (within the farm activity system), his/her use of the electronic technologies being developed by the R&D company and the meat processor, and the goals of these different actors within this emerging activity system. The research team is now conducting interviews and observations on-farm, among relevant staff at AgResearch, and at the meat processing company. In particular, we are focusing the analysis on the computer-based planning and decision-making tool that helps the farmers decide on the best time for drafting their lambs to send to the meat processor.
During the first year of the project, the team identified five ways in which activity theory can be used (a) to gain a better understanding of how farmers learn, both on and off-farm; and (b) to design effective learning processes that could change their decision-making behaviour. These ways are:

- Farmers'on-farm and off-farm learning processes can be best understood using a systemic model of learning rather than a model of individual cognition. We suggest that farmer learning is mediated both by *tools* (such as language and decision-support tools) and by the less visible *social* mediators of their learning, including formal and informal rules (e.g., those relating to lamb supply contracts); the community of practice (such as stock agents, AgResearch scientists, meat processor staff) and the division of labour or knowledge on the farm (e.g., between father and son; farmer and spouse).
- Activity theory calls for a radical revision of the traditional view on design of technology. Among other things it questions the widespread belief that 'the focus of design should be predominantly on the structural and functional properties of the technology; proposing, instead, that the design focus should be on the joint mediated activity of people who use the technology in question' (Kaptelinin, 1998: 234). We suggest that rich insights into farmer learning processes, including how they are mediated by the organisational learning of the meat processor and the R&D organisation, can be gained by studying 'the problem trajectory' of the design, development and use of the electronic decision-making tool.
- Problems associated with the adoption of computer-based decision support tools may lie in the sometimes contradictory objectives of scientific rigour, industry relevance and traditional farming practices that motivate the activities of the funding agency, the meat processor, the farmers and the R&D organisation.
- When learning processes and tools are conceptualised in an activity theory framework, the relationship between the farmers, meat processor and AgResearch can be thought of as a network of loosely-connected actors and activity systems. Analysis of these networked systems can identify the organisational learning that has occurred during the research project, the barriers to that type of learning and the implications for learning on farm.

- Activity theory is also an appropriate framework for surfacing systemic contradictions in the activity of farmer suppliers, meat processor, R&D organisation and funding agency. Structured analysis can be carried out on disturbances and problems in the *everyday actions* of these actors, and the less visible contradictions within and between the different *activity systems*. The advantage of making these contradictions visible to the different actors is that they are potential springboards for behavioural and organisational change.

8. Conclusion

The first year's results suggest that a behaviourist model of learning and cognition has significant limitations. In the second year of fieldwork, the research team is analysing the learning processes and behaviour of farmers in a situated context of a network of activity systems. Preliminary data suggests that a more fruitful line of inquiry can be pursued by understanding the design and use of decision-support tools within this networked activity.
As we move towards an activity theory framework, we need a different form of group process than focus groups, both to surface the systemic contradictions and to stimulate cycles of expansive learning. At the same time, the next stage of grounded theory development needs to address several theoretical challenges. One is posed by the third generation of activity theory around the development of a model that is concerned with at least two interacting activity systems. Among other things, this raises practical research design questions about boundary definition problems. A related challenge is to engage actively in theory development with colleagues whose systems models (eg the interplay model) are grounded in agricultural learning practices like those developed within the Learning in Agriculture Research Network (Paine *et al*, 2000).

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