Engaging with individuality in agricultural learning: a sociocultural study of innovation in a farmer-scientist community

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Abstract. For farmers to succeed in today's complex environments, ongoing adaptation and the development of their capacities and practices are required. This paper uses sociocultural educational theory to explore farmer adaptation as a process of interactive learning. The traditional extension model's emphasis on improving individuals' knowledge is widely recognised to be deficient. In response, recent work emphasises complex systems theory that focuses on broader and more interactive relationships. We support this collaborative turn, but argue that when recasting extension as a more multi-functional system we should not lose sight of the importance of either scientific knowledge or individuality. A sociocultural approach to learning identifies the importance of the interplay between individual, interpersonal and cultural factors. This educational theory is illustrated with the experience of one farmer in a farmer-scientist community designed to promote learning exchanges about new forages.

Keywords: complex systems, dialogue, extension, individuality, farmer learning

Introduction

Agricultural extension is a field of considerable innovation and has been so for a long time, with a great diversity of new models still being developed and advocated across the world. Typically, these attempts to develop new approaches define themselves against what is called the 'traditional' model, in which extension is framed as the linear sending of knowledge from agents who know to farmers who do not (Leeuwis & Van den Ban 2004). Farmers are not passive receivers whose knowledge must be improved; rather, they are significant actors whose expertise is to be recognised, shared and enhanced (Cornwall, Guijt & Welbourn 1994; Leeuwis & Aarts 2011). Instead of a hierarchical 'acting upon', extension should be framed as an 'acting with'. We agree with this collaborative turn. The traditional transmission model of learning centralises agency and knowledge, but extension is more helpfully understood as a complex system of interactions between diverse agents. As a contribution to this understanding, this paper explores the significance of an extension programme based on the principles of sociocultural learning. These principles informed the design of group settings that engaged with the individuality of farmers and in so doing fostered substantial on-farm innovation.

The call for agricultural extension to persistently innovate and discover new ways of doing things is not surprising. The same call is heard throughout agriculture. Farmers today operate in a financially volatile setting with increasingly demanding regulations (such as nutrient budgeting and product traceability) and many technological opportunities (such as precision agriculture and new cultivars). For farmers to remain profitable and to reach their goals, ongoing adaptation and the development of new capacities and practices are needed. We argue that empowering agricultural innovation requires farmers to be actively learning and for them to have opportunities to do so. A plethora of collaborative approaches to support the adoption and adaptation of new technologies and practices have emerged, such as farmer-led projects and multi-sector partnerships. The evaluation of these approaches tends to focus on the amount of desired practice change achieved (Aarts, Humpheys & Le Gall 2014; Wegscheidl, Trendell & Coutts 2015). Much less attention has been given to their significance for farmers' learning.

Extension is more than just the movement of information, but it includes this movement and we should not lose sight of its significance while heading from linear transmission towards multi-functional systems. Here we argue that the knowledge dynamics of agricultural extension should be thought of as learning, an argument we make by drawing on sociocultural theories of education. The educational perspective of sociocultural theory provides a framework that enables researchers to examine farmers' learning and their practice changes as well as to understand the broader social and contextual factors that support this learning. This combination of overlapping factors motivates the use of new technologies and practices. Importantly, this framework highlights how an individual's personal agency is developed

through interactive participation in a learning community. We open this paper with a discussion of how this learning theory can contribute to thinking about agricultural extension as a system.

We illustrate our argument empirically by exploring the case of one farmer's learning. Since 2011, we have run a project, the Massey University Farmer Learning Group, that promotes learning exchanges about new forages in a learning community made up of sheep and beef farmers and university-based agricultural scientists. As previously reported, the project incorporates sociocultural principles in its design and the resulting operation of a collaborative learning community has sustained considerable innovation by its farmer members, including improvement in the management of new pasture species, increasing the area sown in these crops and changes in the livestock classes on these crops (Sewell et al. 2014; Sewell et al. 2017). Here we build on this work by examining in more detail the role of the group in supporting one farmer's learning and his subsequent practice changes. Sociocultural principles of learning enhance the personal agency of individual farmers and recognise the complexity of that learning as being embedded in its social and cultural context (Rogoff 2003). We introduce you to the experiences of one of the farmers in the Learning Group and demonstrate the valuable lessons drawn from this single case. We begin, then, by making the case for focusing on the learning activities of individuals in group settings.

Complex Adaptive Systems and Sociocultural Learning Theory

Many of the recent attempts to develop new agricultural extension approaches have appealed to system concepts. Against the traditional transmission model, which hopes to move innovations in linear fashion from individuals who know, to individuals who do not, a systems approach focuses on a much broader pattern of interactions that cannot be reduced to an individual-level such as a farmer's prior knowledge. A notable recent example is Agricultural Innovation Systems theory, with its focus on the diverse actors involved in producing and using knowledge and on the institutional and policy contexts in which they are embedded (Klerkx, Aarts & Leeuwis 2010). On the rise since the 1980s, system-based approaches continue to attract the attention of those seeking new ways to promote agricultural innovation (Darnhofer, Gibbon & Dedieu 2012). In making this move, however, we must remain attuned to the diversity of systems thinking. Of the many different approaches it offers, we argue that complex adaptive systems is a particularly useful paradigm for understanding agricultural extension.

Complex systems theory is an interdisciplinary field that investigates systems of interacting units, or 'agents', whose interplay produces collective actions that are more than the sum of individual behaviours (Newman 2011, p. 800). As Newman (2011, p. 806) comments, 'a common property of many though not all complex systems is adaptation, meaning that the collective behaviour of the agents in the system results in the optimization of some feature or quantity'. Biological evolution is the classic example, but complex adaptive systems figure in many other domains as well. According to Holland (2006, p. 1), agents 'adapt or learn' by sending and receiving signals to and fro between each other. The actions undertaken are conditional because typically they depend on the signals received. Agents thus change over time and learning takes place such that these changes tend to improve performance. These improvements are not the predictable outcomes of a pre-given rule that is systematically followed and that can be plotted in linear fashion. The agents' rules change continually, meaning that they 'rarely reach equilibrium' and 'optima and steady states are, at best, short-lived' (Holland 2006, p. 3). Given that the agents are continually revising and updating, the complex world they construct is characterised by 'regular innovation and perpetual novelty' (Holland 2006).

If farming is conceived as a complex adaptive system, then it is a domain of perpetual novelty. Innovation is widely promoted as something the agricultural sector needs. Rightly so, but innovation is not only large-scale change and shifts in behaviour; even the mundane practices of farming involve ongoing innovation. As such, we should not make light of the interactive learning processes that sustain these adaptations. The idea of farming as ongoing innovation chimes with the conception of farmers as adaptive managers. Darnhofer (2006, p. 232), for example, emphasises their 'constant experimentation'. Rather than a rustic immobility to be somehow overcome, farming is an enterprise practised with 'flexibility, self-organizing and learning' (Darnhofer 2006, p. 234). This paper focuses on farmer learning, arguing that it is sustained through mutually constituting interactions of the individual within his or her social and cultural context. As is the case with farming's perpetual novelty, so too we believe that farmer individuality within this complex learning system is worth emphasising.

Agricultural extension is about moving knowledge between people. Surely a one-at-a-time commitment to individuality must lack the generalising power that effective extension requires? Not so, we argue. The traditional transmission model of extension pays scant if any regard to

farmer individuality. In essence, this is a broadcasting approach that scatters the same seed everywhere and reduces its receivers to a homogenous mass. Turning away from this linear model means rejecting such homogeneity. Understandably, arguments for a more systematic approach have often included calls to acknowledge the significance of individuals. However, a more systematic approach has also regularly played out as less concern for individuality.

Consider for example the case of farm systems research. Whitfield et al. (2015, p. 55-56) comment that early definitions in the 1980s emphasised the distinctiveness of each farm, a move that 'corresponded closely with the participatory movement of the time, positioning farmers as the experts within their own farming system, which itself has an internal uniqueness'. Subsequently, however, the farm systems concept was used to construct aggregative typologies, a move driven by 'research agendas that aim to develop appropriate technologies at scale'. The use of such typologies has eroded concern for the complex dynamics that play out at farm level. As Whitfield et al. (2015) argue, while broader agricultural structures are important, 'the diverse dynamics, needs, opportunities, and levels of connectedness of these smaller unit systems, must not be overlooked'. In response to such oversights, more recent approaches have used the idea of hierarchically nested systems to cast the net widely while simultaneously re-emphasising the on-farm domain in which each farmer is the resident expert (IFSA 2009; Giller 2013).

Perhaps there is something about systems approaches in general that risks overlooking the significance of individuality. After all, such accounts explicitly demote explanations based on individual motivations and highlight instead an overarching pattern of interactions. Agricultural Innovation Systems theory (AIS), for example, positions itself as a complex adaptive systems approach and characteristically emphasises the importance of 'boundary spanning individuals' in particular (Klerkx, Aarts & Leeuwis 2010, p. 390). The theme of individuality is not strongly developed and, arguably, without it AIS risks reserving significant individuality only for those who span system 'functions' and that, like the linear model it seeks to surpass, undervalues farmer agency. However, refusing methodological individualism does not necessarily imply abandoning individuality and reducing actors to abstract types or roles. Indeed, acknowledging individuality is essential if we are to understand farming as a complex adaptive system. As Holland (2006, p. 6) puts it, all such systems 'have a hierarchical organization of boundaries enclosing boundaries, with signals that are attuned to those boundaries'. Boundaries are essential, for without them 'there cannot be individual histories, and without individual histories selection for fitness is not possible'. Learning and adaptation require individual histories: this is the theme that we emphasise here.

As Holland (2006) argues, learning and adaptation occur through interactions between people based on the exchange of signals. Holland formalises this idea by conceiving signal exchanges (i.e. communication) as binary routines that can be simulated by computers. We do not adopt this approach here. Our interest is not formal but phenomenological. We are interested in how these communications are culturally experienced by farmers and in the significance of this experience for their adaptive interactions. In order to explore this experience, we take sociocultural theories of learning as our guide. As in many fields, the complex adaptive systems approach is emerging as a new research agenda in the study of education (Lemke & Sabelli 2008). Jacobson and Wilensky (2006, p. 16) note the challenges involved, discerning a tendency 'to ascribe causal primacy to the macro-level of the system, which from a complex systems perspective is backward, because in general higher order properties emerge from the local interactions and not the reverse'. While the risk of prioritising 'higher levels' seems endemic in systems thinking, there is a rich vein of educational research that strongly emphasises the importance of local interactions. Like the complex adaptive systems approach, sociocultural theory takes learning as a social and cultural process involving communication between individuals within a learning community. Here, however, this communicative agency is seen as interpersonal interaction rather than as digital switching.

According to sociocultural theory, people adapt to their context by participating in learning groups, dubbed 'communities of practice' or 'learning communities' (Stoll et al. 2006). Indeed, adaptive learning is seen as an agency cultivated in groups (Rogoff 2003). This emphasis on collective interaction is critical, but in order to appreciate the interpersonal aspects of learning it is also essential to understand the individuals within these interactions and how they are both shaped by and shape the learning of others. The individual is therefore not in any sense side-lined. In tune with complex adaptive systems theory, Bandura (2001, p. 14) insists that sociocultural learning entails transactional dynamics and emergent group-level properties that cannot be reduced to the shared intentions or skills of group members. However, as Bandura also insists, these group properties do not operate somehow independently of the participating individuals: 'it is people acting conjointly on a shared belief, not a disembodied group mind, that

is doing the cognizing, aspiring, motivating, and regulating'. This personal cognizing is our chief concern here. On the basis of its analysis, we champion a personalisation of agricultural learning that fulsomely acknowledges the individuality of each farmer.

Sociocultural learning is sustained by group settings that flexibly adapt to the personal idiosyncrasies of their members. Typically, such settings adapt to individuals by privileging interactive dialogue. While dialogue can refer to a range of exchanges, here we focus on personal, language-based interactions. In educational literature, dialogue has been widely recognized as a significant mode of learning (Alexander 2008; Brown & Renshaw 2000). However, not all dialogue is equal. Disputational dialogue between peers, for example, where the exchanges are characterised by disagreements and dominance, is not strongly associated with learning (Mercer & Littleton 2007). Cumulative dialogue, on the other hand, where participants uncritically build on each other's ideas, is more positive, while exploratory dialogue, where participants constructively engage in discussion about the ideas themselves, has been connected with improvements in joint problem-solving and individual reasoning capacity (Mercer & Littleton 2007). During exploratory dialogue, participants' understandings are developed and challenged and new ideas can emerge.

Appropriate forms of dialogue enable groups to accommodate and respond to diverse individual learning. When faced with the prospect of new technologies and practices, learners often progress through stages, gradually acquiring the needed skills and becoming confident with increased complexity. Such progression has been shown, for example, in the experience of farmers adopting commercial decision support systems for precision dairy farming (Eastwood, Chapman & Paine 2012). One of the progressions that can occur is a shift in emphasis from tacit, uncodified knowledge to explicit, concept-based knowledge. Research suggests that learning communities which allow for the expression of tacit knowledge can help to make concept-based knowledge more accessible (Duguid 2005).

Learning through interaction helps individuals to do things differently by stimulating personal beliefs in the ability to achieve goals. This belief in one's capacity to succeed plays an important part in motivating farmer learning and practice change (Harms, King & Francis 2009; Ellis-Iversen et al. 2010). Sociocultural theory conceptualises the sense of personal ability as self-efficacy and research has shown how it is built up through a rich mix of vicarious experience (observation), personal mastery, verbal persuasion, and physiological and affective states (Bandura 1997).

Self-efficacy is promoted by group settings that create space for highly personal interaction. In the remainder of this paper, we investigate the significance of a group set up to promote precisely this sort of interaction between farmers and agricultural scientists. Focusing on the experience of one farmer member of a learning community, we show how a sociocultural approach to individuality sustains the adaptive learning that farming's complexities require.

Methods

Here we explore the case of a single individual in our Farmer Learning Group. Single-case studies are a common and accepted design in agricultural extension research. Moreover, such designs are appropriate for the study of complex adaptive systems. As Jordan et al. (2009, p. 5) comment, the ever-changing dynamics of such systems favour 'learning from small histories'. Given that events and trajectories are non-repetitive and unpredictable, 'researchers should develop and use designs that are appropriate for learning from samples of one or fewer'. We have also argued the case for our focus on one individual on theoretical grounds. Sociocultural learning relies upon and cultivates individuality. In order to explore how this takes place, we report on the experiences of one group member.

The Massey University Farmer Learning Group is now in its 6th year and second phase. The first phase of the project ran from 2011 to 2014 and involved eight agricultural and social scientists and 24 farmers meeting twelve times for six to 24 hours. Meetings incorporated observations of a trial of lamb performance on herb mix pastures (plantain, chicory, and clover mixes), complemented by relevant learning activities. The second phase of the project (from late 2015 to present) added more farmers to the original group, resulting in a group of 38 farmers. Eleven agricultural and social scientists, along with a research officer and PhD student, were involved with this phase and met six times over the 18 months for five-hour workshops. These meetings continued to follow research about sheep performance on herb pastures and to incorporate relevant learning activities.

From the farmers who had attended both phases of the project, we have selected one to study more intensively. Mark (pseudonym) was purposively selected as someone who regularly attended the Farmer Learning workshops and who was located relatively close to the University.

For the purposes of this paper, two previous interviews conducted with Mark during 2014 and 2015 were re-examined and one follow-up interview was conducted in 2017. All the interviews were semi-structured and audio-recorded, with transcription made of key sections as necessary. The 2014 interview focused on Mark's experiences with the Farmer Learning Group and included questions on what he had learned from the group, what supported and hindered his learning, and how he shared his knowledge with others. The 2015 interview was a conversational survey focused on his use of summer perennial forage crops. For the 2017 interview, a timeline of practice change was firstly talked through and reasons for these changes were discussed. Questions were also asked about what he had learned through the project, how that learning had come about, and the value and distinctiveness of the group from his perspective. Themes related to sociocultural theory and learning were coded in the interviews and discussed among the co-authors in an iterative fashion.

Results

Mark's on-farm practice changes

In late 2010, while in his early 20s, Mark started to work full-time on his family's 330 ha sheep and beef farm in the Tararua region of New Zealand's North Island. Around mid-2011, he started using a plantain-clover mix for some of his paddocks, departing from the previous practice of using these species as a component of a generic pasture mix used across the entire farm. In 2011, Mark took over responsibility for the family farm and continued to increase the area in herb pasture. He began using chicory in 2013, lucerne in spring 2015 (12 ha), and red clover (7 ha) in the autumn of 2017. Composed of about half and half flat land and hill country, the farm reached a maximum of about 180 ha (all of the flatter country) rotating into or out of herb pastures, with about 70 ha plantain and clover, 10-12 ha lucerne, and 10 ha mixed chicory and grass in November 2015. In 2016, Mark also purchased a separate bull beef block, which is currently being run on an Italian ryegrass system.

Mark was involved in the Farmer Learning Group throughout this time. He began attending the group at its inception in June 2011 and came regularly to the workshops throughout the first phase. Returning for the second phase, started in late 2015, he has been a regular and engaged attendee, present at five out of six workshops. Outside of the workshops, he has also been involved with Massey University research scientists, allowing them to use his farm as a basis for agricultural students' learning. He has also on occasion sought help from the scientists about issues on his farm.

The Role of the Farmer Learning Group

Mark's introduction to the idea of using herb pastures happened through his hearing about research conducted at Massey University. Once he became a member of the Farmer Learning Group, he developed the necessary confidence to begin to use herb-mix pastures. Mark sees the group as an important resource for growing his personal knowledge base of herb-mix pastures and he attributes much of his herb knowledge to the group. He commented that: 'I've built up quite a knowledge, I guess, on herbs and a lot of it has come from there [the Farmer Learning Group]'. His planting of red clover, for example, was directly related to his learning at a recent workshop, where a red clover breeder presented to the group and also answered his personal questions about how it could work in his location. Mark had concerns about the suitability of red clover for his property, as clover has a relatively narrow grazing window on his farm (December to May); however, he 'talked to him [red clover breeder] later and explained my worries about how narrow the grazing season would be so he told me to sow Balansa clover with it, annual clover to get that earlier production'. Mark also attributes some of his current approaches to utilising or managing herbs to the group, including early weaning of lambs, grazing bull calves on plantain, and use of a particular herbicide for effective transition out of plantain-clover paddocks.

Participation in the group helped Mark to learn in three key ways. The group provided: i) a space to learn through interaction with others, particularly by asking questions and engaging in dialogue; ii) scientific knowledge that met his changing needs, in particular by supplementing his tacit knowledge with concept-based ideas; and iii) experiences that enabled him to grow in confidence and to take action. These findings all emphasise that learning and adaptation happens within group settings that are responsive to individual attributes and needs.

Space to learn through dialogic interaction The group provided a space where Mark could interact with scientists and farmers. Mark used this dialogic space to learn about ways that he could make on-farm changes. When asked to reflect on his experiences in the group, he highlights the value of these group exchanges, as indicated in the following excerpt:

> Well, I'd say that just that interaction… in the field or wherever you are, or just sort of questions and answers sort of flowing, is probably the best way for me and most farmers to learn.

One of the key ways in which Mark interacted with the group was by opening up dialogues through an iterative sequence of questioning. He put questions to guest speakers, visiting scientists, and the regular team. He recognised that a wide range of expertise, including genetics, plant breeding, and chemical use, was represented at these days and he liked to 'head to different ones [people] and find out different aspects'. The workshops were designed to promote this interaction, with opportunities for questions given at each session as well as informally during break times. Members of the science team and guest presenters usually attended the whole workshop, providing opportunities for farmers to put questions to them, which led to an ongoing learning conversation. For Mark, this opportunity to question was the most significant feature of the group, a point he made in the following excerpt:

> To be honest, probably the biggest drawcard [of the group] is just to be able to ask questions directly to scientists…

Not only did Mark ask direct questions, but he also engaged in discussions with people in the group, seeking to work out ideas together with them. These dialogic interchanges explored how good new ideas might be put to work on individual farms and debated the efficacy of certain practices. Within these open-ended dialogues knowledge was often co-constructed between the Mark and those he interacted with. For example, Mark brought observations of the effects of nitrogen use to a scientist in the group in order to get his thoughts on why this was occurring. While he was looking for confirmation and insights, he was willing to engage with the unknown and to collectively think about causes, as the following excerpt indicates:

> I know one time I was talking to [a scientist] about nitrogen use on plantain and how I was getting good production, both plant production and animal production using small amounts of nitrogen often. And he was sort of, it wasn't scientifically proven, but he was saying it was pretty sure it was altering protein levels in plantain and it was having a positive effect. So, that's one thing that I sort of saw but didn't know why and he confirmed, as far as he could.

Access to knowledge that met changing needs The Farmer Learning Group is made up of 38 diverse farmers and 8 agricultural research scientists - mixed membership that provided Mark with wide-ranging views and knowledge that met his changing knowledge needs. While Mark started the project with very little experience using herb-mix crops, other farmers in the group had considerable practical experience. As Mark began to use plantain, he was able to draw on both their technical explicit knowledge, such as seeding rates, as well as their tacit, experience-based knowledge. The following remark illustrates the tacit knowledge that Mark thought the more experienced farmers possessed:

> Because I was new to it, there were some of the guys there that were already doing it…on [a] larger scale and they'd put it into practice and knew the problems, you know, the positives and negatives.

Over the lifespan of the Project, Mark acquired considerable practical knowledge, both from group members and from his own experience as he cultivated plantain, chicory, and lucerne pastures and adapted his farming system to these crops. However, explicit evidence-based knowledge remained harder for him to obtain. As illustrated in the following excerpt, he continued to find value in questioning the scientists:

> Whereas now I've done a lot of it, I'm not learning so much from [the other farmers] … it's probably more the technical stuff that I'm… asking scientists now.

The value he placed in this explicit scientific information meant that Mark emphasised the importance of interacting directly with scientists as the producers and conveyers of this knowledge. When asked what he thought made the Learning Group different from others he had been involved with, he emphasised the opportunity to interact directly with a wide range of scientists, as in the following excerpt:

> I think the access to all the scientists. There's probably a scientist per five farmers almost or something like that, that quite good ratio where you can sort of, yeah, head to different ones and find out different aspects.

Confidence to take action The group contributed significantly not only to Mark's learning but also to his confidence to apply his learning on his own farm. Prior to his involvement with the group, a sales representative had put Mark off using plantain. However, the group gave him the confidence to overcome this setback and start to make practice changes, as the following comment indicates:

> Yeah, yeah no definitely, this group has helped me take that jump. And I don't feel like I'm really jumping into it as much as some people are at the moment.

The group provided a mix of experiences and evidence-based ideas about how these forages could be used and managed, which assisted Mark to develop his farm system that incorporated these crops. New knowledge about weed control was highly valued and these new ideas found their way into this system. The concept of weaning lambs early onto herb and legume pasture was another idea he used and combined with other approaches that had been presented at the group. Mark adapted these ideas to develop his own farm system, as illustrated by the following excerpt:

> After we were looking at [that scientist's] trials on bull calves, I'm now using early weaning the ewes off and filling the space they've created up on the plantain clover with 100kg bull calves to grow on it, which seems to be a really efficient way of doing things.

The group provided opportunities to check and to validate ideas with a range of farmers and scientists, and it supplemented these interpersonal exchanges with regular data reports from the ongoing trials in which the group was participating. Mark valued the ability to compare his experiences with a stream of data that was being scientifically collected at these trials. The following comment illustrates how the trial data provided reinforcement to his existing thoughts about plantain performance:

> The data… just reinforces what you're thinking and, it's sort of black and white then, that it is performing much better than grass.

Discussion

The findings reported above indicate the importance of being part of a learning community. As has been argued in a previous analysis of the Farmer Learning Group (Sewell et al. 2017, pp. 15-16):

> The core values of this learning community were collaboration that opened up dialogic spaces for the collective negotiation of meaning, and that upheld the growth of its individual members and the group as a whole.

In this case study of one farmer, we see again that group experiences upheld his individual growth. The sociocultural factors that work together to promote learning are personal (individual), interpersonal (their participation in the group), and cultural (the values, experiences and traditions of the group). As an individual learner, Mark valued his direct interaction with scientists and participating in the traditions of science trials and the data that ensued. Aarts, Humpheys & Le Gall (2014) argue that such farmer-scientist exchanges improve the effectiveness and impact of research. They identified two projects in north-west Europe in which the close involvement of scientists, farmers and industry people in on-farm research led to a greater rate of on-farm improvements than research that did not involve farmers. Similarly, Mark adapted and implemented multiple aspects of the research that he had learned about through his participation in the group.

The opportunity to ask questions and to engage in the dialogue that this questioning prompted were a key means through which Mark learned. From a sociocultural perspective, dialogue is known to play a key role in learning (Alexander 2008; Brown & Renshaw 2000; Mercer & Littleton 2007). Three different kinds of dialogue are known to exist: disputational, cumulative, and exploratory. Mark's interactions with other workshop attendees showed hallmarks of 'cumulative talk' (sharing of knowledge and uncritical elaboration on each other's ideas), as when during a conversation Mark shared his knowledge with a red clover breeder and built on the breeder's ideas to solve a specific problem on Mark's farm. Mark also was involved in 'exploratory talk' (characterised by active listening, asking questions, giving reasons for responses, and challenging ideas in an atmosphere of trust), a type of dialogue that has been associated with improvements in problem-solving and reasoning capacity (Mercer & Littleton 2007). Such exploratory dialogue was evident when Mark approached a scientist with a question without a clear-cut answer and the scientist formulated a tentative answer to the question, based on his expertise and Mark's experiences. Mark was aware of the tentative nature of this conclusion but still found it helpful for his thinking and practice, reflecting the value he placed on such dialogue.

Of note is the importance of culture in enabling group interactions to be dialogic and productive. As with teachers and students in classrooms, direct interaction can occur between scientists or experts and farmers as a one-way transmission of information. As Sewell (2011) notes, for dialogue to develop in a classroom learning situation, opportunities need to be provided to students, such as shared activities in which power no longer rests solely with the teacher. The sharing of power between farmers and scientists is a key feature of the Farmer Learning Group

(Sewell et al. 2014). The group was set up to incorporate interactive activities and group discussion, making times for socialising between farmers and scientists, and providing opportunities for the farmers to participate in decisions about the group's topics and approach. This context enabled Mark to approach the scientists in the group to discuss questions of relevance to his farm.

The nature of Mark's learning changed over time, with the amount of tacit knowledge he sought decreasing and explicit knowledge becoming relatively more important. This change happened while he was involved with the Farmer Learning Group, which aligns with the observation by Duguid (2005) that communities of practice often play a key role in conveying tacit knowledge, including that required to make sense of and use explicit knowledge. When Mark first joined the group, he was new to herb pastures. Over time, the group, in conjunction with his own experiences, helped him to gain the tacit knowledge needed to successfully grow and utilise these crops. As he obtained this, his need to draw on the tacit knowledge of other farmers was reduced, but it provided him with a sound basis from which to make sense of the explicit knowledge provided by the scientists.

The role of the scientists in making explicit knowledge accessible is also important. While Mark had a sound grasp of growing herb pastures, he acknowledged in the 2014 interview that 'probably if it [data and research findings] were handed to me in a scientific paper I wouldn't necessarily take it all in'. It was access to the scientists themselves that he particularly valued. Through the workshops, they explained and interpreted the data presented, connecting it to practical applications in farm systems. Thus, the scientists made this explicit knowledge accessible through using (and modelling) their tacit knowledge on how to make sense of scientific data. The end result of this was that farmers were able to make connections between this learning and their farm systems, an important factor enabling learning (Sewell et al. 2014). The complexity of Mark's farm system has increased over time, in terms of area and type of herb pastures as well as the stock policies run on these crops. Increasing complexity provides an additional reason why explicit knowledge became progressively more important for Mark. As his farm system's complexity increased, he increasingly valued relevant explicit knowledge to support these changes.

Mark's cultural experiences as he participated in Farmer Learning Group activities helped him to gain the confidence needed to make significant changes to his farm system. He put much of his flat land into herbs and developed a range of stock policies for this pasture. Accompanying such outward changes are discernible inward shifts in his sense of self-efficacy. Mark's personal belief in his ability to achieve goals was enhanced by his participation in the Learning Group. Through this group, he gained vicarious experiences of the scientists' success with the crop as he followed the outcomes of the trials and he also learned from other farmers who were successfully using herb pastures. Complementing his own growing practical experience, these group experiences helped Mark to sustain the self-efficacy beliefs needed to significantly change his farming system.

Mark's on-farm practice changes show the value of learning in group settings based on interactions between individuals with a very diverse mix of skills, knowledge and experience. These differences provide points of interest and motivation that promote individual learning (Sewell et al. 2014). Mark's interactions with the Farmer Learning Group were often highly personal and intensely dialogic, involving him in numerous direct verbal exchanges with other individuals. The Learning Group and its activities had been explicitly set up to provoke questioning and answering. Group meetings included numerous opportunities for talk, many of them highly informal, such as when individuals came together in impromptu small groups at the workshops or held spontaneous one-on-one conversations on the way somewhere else or over a cup of tea (Sewell et al. 2014). These features of the Learning Group's set-up were informed by sociocultural learning theory, which holds that education works best when it takes place through dialogue (Rojas-Drummond & Mercer 2003). Group dialogues engaged with Mark's individuality and in so doing they furthered his learning and practice.

Conclusions

This paper has explored the experience of one farmer in a group made up of fellow farmers and agricultural scientists. We have shown that his participation in this group has supported considerable learning and ongoing practice change. New Zealand sheep and beef farmers are familiar with growing grass to feed animals, but many of the new pasture crops have highly specific requirements and finding out if and how to use them is a significant learning curve. Building a new farm system that incorporates chicory, lucerne and plantain is a complex task. The Farmer Learning Group has helped Mark to begin adapting his farm to these new crops. The learning activities of the group were informed by sociocultural theory and our analysis of Mark's

experience illustrates the value of this theory for agricultural extension. As Mark puts it, 'interaction is probably the best way for me and most farmers to learn', 'just questions and answers flowing'. The value of sociocultural theory lies in its emphasis on individuals learning within a community made up of diverse farmers and scientists. On these terms, agricultural extension works best when it engages with the individuality of farmers in well-designed communities of practice.

We are well aware that our call to personalise agricultural extension may seem idealistic given the scarcity of available resources and the apparent need for frugality. However, the Farmer Learning Group's high level of personal resourcing is something not only recognised but also valued by Mark: 'there's probably a scientist per five farmers', which he describes as a 'quite good ratio'. And with the trials, 'we'd always come back and check what had been happening on them and followed it through a series of years, which doesn't often happen'. While this approach is intensive, it is high impact for the individuals involved. We contend that such intensity may be needed to support significant change.

Our agricultural extension model operates on sociocultural principles. We are not offering a universal template, though we do believe that finding new ways to promote collaboration between farmers and practising scientists is an important task. The high-quality interactions that empower sociocultural learning are inevitably resource intensive. Even though we have shown that the new ideas learned by our farmers have travelled widely in their personal networks (Wood et al. 2014), the level of resourcing required by such interactions means they can never reach all the scales required by agricultural extension. But here the issue is as much about scaling up appropriately as it is about reaching appropriate scale. An emphasis on 'extent' under conditions of limited funding all too easily translates into token efforts to create participation, with the transmission model effectively remaining dominant. Good money continues to follow bad, even though 'cost-cutting does not equal cost-effectiveness; no matter how desirable this might be' (Cornwall, Guijt & Welbourn 1994, p. 49). Sociocultural theories of learning support agricultural innovation and we should search for cost-effective ways to support it. Given the abiding and increasing complexity of farm systems, attempts to reform extension need to focus on building farmers' adaptive capacity, a capacity in which learning plays a central role (Hall & Clark 2010). Extension groups that engage personally and dialogically with the individuality of farmers can deliver the sort of learning these complex adaptive systems require.

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