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## Invisible Force: Farmers' Mental Models and How They Influence Learning and Actions

### Abstract

The ways in which farmers put their visions into action are indicative of their mental models of farming. This qualitative study explored the nature of mental models of farming and their role in farming practices among a sample of small farm operators. Three themes emerged in the data indicating that farmers' mental models of farming are influenced by prior values and knowledge, serve as guides in learning and decision-making, and are unique to each farmer. Educators who consider the mental models of farmers are more likely to succeed in supporting farmers' development of new knowledge and skills.

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In the last 20 years, farming in the United States has been undergoing accelerated change. Farmland is being lost to development, farmers are going out of business, and more people are leaving than entering the field of farming. In many parts of the country, conventional farm

production and revenue are being consolidated in the hands of a few mega-agribusinesses. Family farming, always precarious, has become an endangered way of life (Dillon, 2003).

At the same time, demand is growing for some products, such as organically grown produce and specialty products. Small farmers who can produce these and other value-added products can maintain and even improve their economic well-being (Burros, 2002; Greene, 2000). Farmers can develop small farming operations that will succeed and endure in this era of polarization. They can do this by recognizing and taking advantage of niches within the food market, especially niches that may see sudden, explosive growth.

Agricultural educators appreciate that individual ingenuity is often the key to success among operators of small farms. Ingenuity enables farmers to see possibilities, take advantage of market niches, and anticipate and solve problems. Indeed, the ways in which farmers put their visions into practice are indicative of their mental models of farming. Mental models are defined as "inventions of the mind that represent, organize, and restructure domain-specific knowledge" (Seel, 2001, p. 408).

Individuals have mental models for different aspects, or domains, of their lives. For example, an individual can have a mental model about family or politics or about his or her profession. A mental model for a particular domain includes related values and beliefs. It includes conceptions of knowledge and skills, and how to use them. Mental models create perspectives and points of view; they serve as both a filter and a guide for information, learning experiences, and problem solving. Often, mental models overlap. For example, for some of the farmers in this study, their mental model of farming and their mental model of family had many components in common.

Agricultural educators who seek to promote the success of small farm operators need to understand the mental models of farming held by farmers with whom they work. In her study of the role of transformative learning in successful Extension partnerships, Franz (2003) highlighted the importance of recognizing and understanding different "world views" (p. 7). Though Franz focused on the educational relationship between campus researchers and county practitioners, the applications to relationships with farmers are equally relevant.

By understanding the ways that individual farmers perceive their world, educators can help small farm operators to think and act in ways that enable them to overcome the many barriers to success. The purpose of this qualitative study was to explore the nature of mental models of farming and their role in farming practice among a sample of small farm operators in the northeastern United States, where pressures on small family farms are especially intense.

## Methods

The researchers tape-recorded and transcribed semi-structured interviews with 10 operators of small farms in the northeastern United States. The interview questions elicited farmers' perceptions of the different types of knowledge they possessed, ways they developed their knowledge, and how they went about solving problems and making decisions. Interviews lasted 60 to 90 minutes each, with two couples interviewed together. The sample included farmers representing a variety of approaches to farming and farm types, including vegetable, dairy, and livestock, and a range of marketing practices, from wholesale to direct marketing and community-supported agriculture (CSA). The researchers identified participants through referrals by providers

of educational and other services to farmers, through referrals by farmers participating in the study, and through Web sites and newspaper profiles of successful farmers.

In addition, the researchers analyzed 17 written profiles of "innovative" operators of small farms--11 from the northeastern U.S. and 6 from other regions--featured in the *New American Farmer: Profiles of Agricultural Innovation* (Berton, 2001). Analysis of the profiles helped to ensure the trustworthiness of the interview data and to extend knowledge of mental models in the domain of farming outside the northeastern United States.

The researchers conducted the interviews over a 6-month period between February and August of 2002. During that period, the interview protocol was revised based on themes and questions that emerged from early data analysis. Data analysis began with transcription of the first interviews and continued throughout the study. The process entailed two alternating strategies (Miles & Huberman, 1994): (a) looking for themes, or patterns, in the data and constructing theoretical explanations for the themes, and (b) using pre-existing theories from the literature on mental models (e.g., Collins & Gentner, 1987; Greeno, 1989; Johnson-Laird, 1983; Seel, 2001) and examining the data for evidence that supported the theories. Relevant information about the interview participants and farmers whose profiles were analyzed is incorporated into the following discussion of the results. (Note that the names of interview participants have been replaced with pseudonyms.)

## Results

The definition of a mental model of farming presented here was constructed through analysis of themes in the data collected from operators of small farms. Three major themes emerged:

1. Prior values, beliefs, and knowledge influence each farmer's mental model.
2. Each farmer's mental model guides his or her actions, decisions, and use of information and feedback.
3. A workable mental model of farming is one that meets the needs of the individual, not necessarily one that conforms to recognized "best practices."

### **Prior Values, Beliefs, and Knowledge Influence Farmers' Mental Models**

A mental model of farming is an individual "mental map" or set of propositions that includes the individual's values and beliefs about the ideal and the actual state of farming. It also includes the role and relative importance of values, beliefs, knowledge, and skills, and ways of processing information and applying skills to learn and solve problems. Every farmer interviewed described his or her practice of farming in ways that reflected an underlying mental model. Kevin, a grass-based livestock farmer, was most explicit, saying:

When you start thinking about it, we've tried to in conventional agriculture apply an industrial model to a biological system, and we just have to keep working harder to make it work . . . We have to keep developing more vaccines, we have to vaccinate more often and treat more often and then it still breaks down.

Both Kevin and another farmer, Mike, talked about farming sustainably in terms of using a model of past farming practices. Their descriptions revealed a respect for tradition and for working with, instead of attempting to overcome, nature. Kevin, referring to current reliance on vaccines and antibiotics, said:

I mean, how did people manage to raise animals years ago, without all that stuff? We make out like there was no life on earth until we developed antibiotics and vaccines and everything else, but there's protective things in nature if you just kind of put the animals in their natural settings.

Mike, an organic vegetable grower, also spoke of his model and practices of farming by referring to past conventions:

. . . You try to be sustainable, like they did in the old days. I mean, there will be some additions, but if you can keep it to a minimum, keep the cost of fuel down, and keep everything in, in one region, that's what we're striving to do . . . Like asking the neighbors to give me their leaves to compost . . .

While Kevin and Mike saw their organic farming practices in the context of tradition, Tom saw his organic farming practices as "cutting edge." He remarked, "I think the organic scene in [names the state], I mean, we are hot! Our biggest challenge every year is keeping up with demand! What other agriculture industry in the state can say that? None!" Tom's view of his farm as cutting edge is congruent with the value he put on innovation and overcoming limitations and barriers. For example, Tom moved his farm to a low-cost plot of land in a depressed urban area when farmland in his rural community experienced the pressures of suburban growth.

For both of the couples interviewed--Carla and Jim and Mike and Cathy--several principles seemed to form the framework upon which their knowledge and practices were built. Their principles served as filters for learning and for knowledge and skill development. These principles, as articulated piecemeal in the course of the interviews, were:

- Being sustainable economically by farming without debt.
- Being sustainable environmentally by farming in a way that enriches rather than depleting or polluting the environment.
- Being sustainable personally and socially by farming in a way that allows adequate family time, does not require prolonged endurance of conditions the individuals find unpleasant or stressful, and fosters a direct connection between the grower and consumer.

This framework of principles based on personal values served to guide these farmers' development and application of knowledge and skills. Carla and Jim and Cathy and Mike shared an organic approach to farming, a Community Supported Agriculture (CSA) approach to marketing, and an emphasis on a diversified operation that was not dependent on the success of any one crop or product.

## **Farmers' Mental Models Guide Their Actions, Decisions, and Use of Information**

The second theme in the data was that farmers use their mental models to guide them in seeking information and deciding what feedback and advice to accept, reject, or adapt, as well as how to act and make decisions. As described above, farmers acted in accordance with mental models based on values, beliefs, and knowledge that were important to them. Especially for non-conventional farmers, this sometimes led them to reject advice and feedback from experts when it was not in accordance with their mental model of farming, or seek to further information that was congruent with their mental model. Carla gave several examples of how their principles served as guides, including the following:

. . . When I called the [names university] guy about the tomatoes that were dropping down dead . . . I explained to him what they looked like, what happens, he started giving me a solution. Well, I'm not gonna spray that . . . I'm not gonna do that . . . Then he remembered who I was. "You wanna go get some Epsom salts and put it in a little sprayer and spray a little bit of Epsom salts on it." . . . It was a magnesium deficiency because the nights had gotten cold and the tomatoes had used up all the available magnesium in the potting soil.

In response to a further question about the Extension expert's first advice being to use a non-organic chemical, Carla answered:

Right. Some chemical that had some other anti-fungal because they were more likely to get a fungus and some other things. But he told me how to cope with that: open a door, air out the greenhouse, don't let the humidity get high in the next couple of days, don't kick the heat up, drop it down a little more so that you're not having those big fluctuations. He gave me some things I could do that worked perfectly fine . . . So there were alternatives. He knew what they were.

In order to elicit non-chemical strategies, Carla had to ask for an alternative to the first advice given by the consultant. The Extension expert's advice was predicated on a mental model that valued efficiency as much as effectiveness, so that the "best" solution was the one that would produce the desired results with the least effort--spraying one product on the tomatoes.

Carla's mental model valued an organic solution even if it required more work--taking steps to regulate temperature and humidity over a period of several days. Her mental model of farming served as a guide so that she did not accept the first advice given, and it served to expose her to more knowledge than she would have been given otherwise. If she had accepted the advice to use the non-organic spray, she would not have heard of the organic alternative.

Another organic farmer, Ellen, described her reaction to expert advice that was not congruent with her mental model:

. . . The year before when we had so much rain, I was very concerned about nitrogen leaching in the field, that with so much rain it just leaches through and then the crops don't have enough nitrogen, and we are a compost farm. So we put compost down and that's it, we don't add fertilizer, we don't have any amendments that we use, so we don't have a quick fix for anything. So if there's low nitrogen, even a lot of organic farms will go to Chilean nitrate or something like that which is a quick fix of nitrogen, it boosts the plants right out of it--I don't believe in that. So, I took some soil samples and sent

them to . . . get it soil tested and see just where we were, and we got a telephone call. This guy was . . . telling me how low our nitrogen level is, and nothing's gonna grow, and you need to, the only thing we could do at that time is put on Chilean nitrate. And I thanked him very much and hung up . . . I don't care what the soil test has to say, I'm not gonna do that. And we were fine, we got plenty of produce through the whole season, because I looked at what was going on in the fields, and yes, maybe the soil test said we're nitrogen poor, he said it was so low it was off the charts, and I'm saying, "Well, okay, but things are growing!" I'm not gonna go and put stuff on my fields that don't fit the problem, it's not good.

## A Workable Mental Model of Farming Meets the Needs of the Individual

The third theme that emerged from the data was that the quality of a mental model is derived from how well it meets the needs of the individual who uses it. "Goodness of fit" of the model to the needs of the individual is more important than goodness of fit between the individual's model and an abstract ideal model described by researchers, policymakers, or advisors. One study participant, Joe, was a conventional dairy farmer whose mental model was compatible with conventional industry standards for quality and growth, as indicated by his use of the Northeast Dairy Business Summary to set benchmarks for his operation. Joe's mental model was in contrast to those of Gordon and Marion Jones, and Mary Doerr, farmers whose profiles were analyzed for this study, as summarized in Table 1.

**Table 1.**  
Comparison of Mental Models Operationalized on Three Dairy Farms

<b>Name</b>	<b>Description of operation</b>	<b>Focal points of mental model</b>	<b>Activities in keeping with mental model</b>
Joe	300-cow dairy herd, goal is to grow to 1000-cows	Success means becoming a "top dairy" by increasing herd size and meeting industry standards.	Developing partnership; evaluating decisions based on evidence; "being involved in the top percentage of the farming community."
Mary Doerr (Berton, 2001, pp. 17-19)	36-goat dairy herd, cheese-making, pasture, "educational retreat" Bed & Breakfast, goal is to stay small and	Success means "creating balance" by running a holistic operation and earning higher prices with a lower	Scaling back dairy and cheese-making operation; retailing instead of wholesaling; diversifying farm

	profitable through diversification	level of production and direct marketing.	activities.
Gordon and Marion Jones (Berton, 2001, pp. 68-70)	65-cow dairy herd, pasture, goal is to stay small and maintain balance in keeping with quality family life	Success means maintaining commitment to quality family life and economic and environmental sustainability.	Developing and refining rotational grazing system; careful financial planning; hiring outside help.

The contrast among the mental models and activities of the dairy farmers above demonstrates that the mental model influences the activities of the farmer. Contrasting the focal points of the mental models makes clear that mental models reflect unique individual values and perceptions of need. They do not necessarily conform to recognized best practices.

For Joe, becoming a "top" dairy farmer by conventional industry standards was of primary importance, while for Gordon and Marion Jones, developing a system of dairy farming that allowed a quality family life was the most important value. Mary Doerr, for example, found a dairy operation that conformed to industry standards and best practices to be stressful and unsatisfying, and the profile of her farming operation demonstrated that a business that is congruent with her mental model of farming is both satisfying and successful. For each farmer, a mental model based on an abstract prototype of an ideal dairy operation would likely have involved a compromise of their unique values and a less-than-satisfying and perhaps less successful operation.

## Conclusions and Recommendations

Though this study was qualitative in nature and the specific mental models held by farmers in the study may not represent those held by other farmers, the study clearly illustrates that farmers can have very different mental models of farming, even among operators of small farms working in similar commodities and geographic regions. The results indicated that the farmers in the study have mental models of farming that are influenced by their values, knowledge, and experiences, and the models play a predominant role in their learning, problem-solving, and decision making.

The results provide empirical support for conceptual researchers like Raedeke and Rikoon (1997), who recognized, particularly in more sustainable forms of agriculture, "the multiplicity of ways in which knowledge is constructed and thus linked to diversity in farmers' perceptions, understandings, and actions" (p. 154). Additionally, the results have implications for agricultural educators in both extension and field research settings.

As illustrated in the comments by Carla and Ellen, farmers are more likely to attend to information and ideas that are congruent with their current mental models of farming, as well as with their current knowledge and skills. When educators consider the mental models, especially the guiding principles, of the farmers with whom they work, their feedback is more likely to be accepted and

applied.

For example, a farmer may seek the advice of an Extension agent about adding an agritourism component, or a value-added product, to diversify her operation. If a basic principle of the farmer's mental model is farming without debt, and the advisor's advice includes financing diversification through a loan, then the farmer is unlikely to accept the advisor's advice. If, however, the advisor probes to learn about the values that inform the farmer's plan, and the advisor tailors his guidance towards managing current assets that enable the farmer to diversify without incurring debt, the farmer will be more likely to apply the advice and maintain what she perceives to be a supportive relationship with the Extension agent.

Agricultural educators can strive to become more aware of the unique mental model underlying each farmer's practice, their own mental model of farming, and the interaction between the two. Becoming more aware of one's own mental model and those held by others requires foregoing assumptions, careful listening and observation, and thoughtful assessment (Eckert, 2003). Educators can ask farmers to articulate the underlying principles and values on which they have based past actions. Often, these principles and values can be revealed through farmers' answers to questions such as "Can you tell me what led you to that idea?" or "What types of things did you consider when you made that decision?"

Agricultural educators can introduce new information and ideas in ways that acknowledge farmers' values, highlight similarities between farmers' principles and those underlying new strategies, and leave open the possibility that each encounter can contribute to the continued development of both the farmers' and the educator's respective mental model of farming. Educators who are more aware of the role that mental models play in farmers' learning, problem-solving, and decision making are more likely to succeed in supporting farmers' application of knowledge and skills, resulting in improvements in farming practices and production.

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