ADOPTION OF RESIDENTIAL GREEN BUILDING PRACTICES: UNDERSTANDING THE ROLE OF FAMILIARITY

By

Christopher W. Scheuer

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Natural Resources and Environment)
in the University of Michigan
2007

Doctoral Committee:

Professor Rachel Kaplan, Co-Chair
Associate Professor Raymond K. De Young, Co-Chair
Professor Stephen Kaplan
Professor Christopher M. Peterson

DEDICATION

for Jamie

because we are

באַשערט

ACKNOWLEDGMENTS

Many people contributed to this work in large and small ways. Foremost, I am grateful to my committee chairs Rachel Kaplan and Raymond De Young for having faith in my ideas but also the vision to steer me away from distractions and toward my strengths. They taught me how to use and refine my skills. I often did not see where they were guiding me until I realized I had taken my own steps forward. The insights and support of my committee members, Stephen Kaplan and Chris Peterson, were invaluable. It was a pleasure to spend time with such rich and expansive thinkers. My fellow travelers, Christa McDermott and Keith McDade, gave me a friendly place to bounce ideas, fears, and hopes around in. I thank my tireless editor, Esther Brill, for her enthusiasm—and patience—as my thinking and writing evolved. Katy Janda showed me there is a home for work like this and pointed the way forward. Tom Princen shared insights and lent an extra ear as my ideas developed.

I am also extremely grateful for information and support provided by the program coordinators of several green building programs and members of the building industry who looked over my work along the way. I am particularly indebted to several individuals who provided feedback and suggestions on my research ideas: Jason Bing from Recycle Ann Arbor, Sandra Sonkson of the NorthWest Ecobuilding Guild, Ed Hudson of the National Association of Homebuilders Research Group, Jim La Rue of the Cleveland Green Building Coalition, Greg Acker and Mike O'Brian of Portland Oregon's G-rated program, and Peter Reppe at SolArc.

The following organizations provided financial assistance for my education or specific research activities for which I am very grateful: the Alvan Mcauley Scholarship, the Rackham One-term Dissertation Grant and the Rackham Discretionary Fund, the Edna Bailey Sussman Internship Fund, and the SNRE Alumni Incentive Internship fund.

I am, of course, in deepest debt to the builders who I interviewed and surveyed. Their honesty and willingness to share their experiences are what made this work possible.

Finally, I would like to thank my family for making this not only possible, but fun as well. Jamie, Espen, Sadie, and Simon, you are everything.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

BUILDING CHANGE

The construction and operation of homes contribute to many environmental impacts, from the generation of solid waste during construction to the production of carbon dioxide from occupant energy use (Energy Information Agency, 2003; Municipal and Industrial Solid Waste Division, 1999). Improving the environmental performance of buildings is critical to larger sustainability efforts. As a recent United Nation Environment Programme report states, “The building sector contributes up to 40% of greenhouse gas emissions, mostly from energy use during the life time of buildings. Identifying opportunities to reduce these emissions has become a priority in the global effort to reduce climate change” (“Buildings and climate change,” 2007, p80).

There are existent and emerging options for improving the environmental performance of homes; collectively, these options are called green building practices. By using alternative products and systems, green building practices can significantly reduce environmental impacts related to energy consumption, water use, resource use, site practices, and ventilation. In the United States, green building practices are growing, as consumers are more interested in green homes and builders are starting to adopt the practices (Brown, 2007; Power, 2005; “The state of”, 2003). Nonetheless, the vast majority of residential construction has yet to incorporate green building practices (Bernstein, 2006). The number of homes built using conventional, environmentally degrading, practices far exceeds the number of green homes built.

Creating change within the homebuilding industry is challenging. Despite ongoing research, innovation in the construction industry remains elusive (Manseau & Shields, 2005). For a number of reasons, including the number of green product options and the lack of defined green standards, widespread adoption of green building practices may strain the capacity of the industry to innovate. Given existing challenges to construction industry innovation, including those posed by green building, new approaches to understanding and promoting green building practices are called for.

Focus of this work

This dissertation approaches the analysis of changing construction practices by focusing on how homebuilders think about green building. For a homebuilder, building green homes is neither easy nor straightforward. Like other sustainability problems, there is no single approach to using green building practices. Not only is there a constant influx of green building products, but these products are often unfamiliar to builders and potentially unavailable through traditional sources. Additionally, green homes are not as easily standardized as are conventional homes. This lack of standardization requires that builders consider a wider set of options from project to project. These concerns, as well as differences in builders' knowledge of, interest in, and skills with green building suggest that a variety of strategies are needed to gain increased adoption of green building. Builders may need to adapt existing skills, develop new skills, and perhaps abandon skills they once considered essential. Such changes are going to require time and effort, and they will not be undertaken lightly. Mechanisms for facilitating their knowledge and awareness of available products and approaches will be needed.

The studies comprising this dissertation examine these issues from an information-processing perspective. Over the past several decades, researchers have been investigating how people respond to environmental problems (Hines et al., 1986; Vining & Ebreo, 2002). Human information-processing mechanisms have been offered as a tool for studying subjects such as environmental decision making and environmentally responsible behavior (Kaplan, 2000). I build on this work and the framework it has generated to understand homebuilders' perception, evaluation, and eventual adoption of green building practices.

Dissertation purpose and outline

Background research done to assess the state of green building practices in the United States and existing approaches to construction innovation prompted three studies. The overall purpose of this effort is summarized as follows:

1. *Understand opportunities for and challenges of green building practices*
   This dissertation assesses the status of green building practices and seeks to understand the challenges restricting further growth.

2. *Explore the role of information processing in construction innovation*
   Green building falls within the field of construction innovation. While some researchers have examined behavioral factors, the role of human information processing has not been applied to this issue. This dissertation assesses the relevance of information processing to construction innovation generally and green building particularly.

3. *Examine familiarity as a useful information-processing construct*
   Familiarity plays a role in almost every aspect of human behavior. This dissertation expands the empirical account of familiarity, especially its potential relevance to homebuilders' use of green practices.

4. *Identify strategies that facilitate adoption of green building practices*
   Strategies to increase the use of green building practices are needed. This dissertation provides a theoretical and empirical basis for specific communications and education strategies.

Realization of these goals is accomplished through the following three chapters, each exploring homebuilders and green building from separate information-processing angles and using different analytic tools. Drawing on the *Reasonable Person Model* of human behavior (Kaplan & Kaplan, 2006), Chapter 2 lays out a theoretical argument for the role of information processing in construction innovation and green building. Building on the conceptualization developed in Chapter 2, Chapter 3 focuses on a particular information-processing construct, familiarity. Combining theoretical arguments and evidence from interviews with homebuilders in Oregon and Michigan, Chapter 3 outlines why familiarity is an important aspect in the adoption of green homebuilding practices. Chapter 4 uses a survey of U.S. homebuilders to examine the effect of familiarity on builders' use of green practices in comparison to other relevant variables. The findings are then used to develop proposals for facilitating builders' adoption of green practices. The final chapter synthesizes this work by offering recommendations for practitioners and policy makers.

References

Bernstein, H. M. (2006). *Residential Green Building SmartMarket Report*. New York: McGraw Hill.

Brown, M. J. (2007, March/April). A watershed year for green homes. *E: The Environmental Magazine,* 18, 10–11.

"Buildings and climate change." (2007). *Buildings and Climate Change: Status, Challenges and Opportunities* (No. DTI/0916/PA). Paris: United Nations Environment Program.

Energy Information Agency. (2003). Annual Energy Review 2003 (Vol. 2005). Washington, DC: U.S. Department of Energy.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education,* 18 (2), 1–8.

Kaplan, R., & Kaplan, S. (2006). *The Reasonable Person Model: A Brief Description*. Unpublished manuscript. University of Michigan, Ann Arbor.

Kaplan, S. (2000). New ways to promote proenvironmental behavior: Human nature and environmentally responsible behavior. *Journal of Social Issues,* 56 (3), 491–508.

Manseau, A., & Shields, R. (Eds.). (2005). *Building Tomorrow: Innovation in Construction and Engineering*. Hants, UK: Ashgate.

Municipal and Industrial Solid Waste Division. (1999). Characterization of Municipal Solid Wastes in the United States: 1998 Update. In Office of Solid Waste (Ed.) (Vol. 2005). Washington DC: Environmental Protection Agency.

Power, M. (2005). Raising the Bar. *Builder,* 28 (2), 140.

"The state of". (2003). The State of Green Building 2003. Retrieved September 16, 2005, from http://www.housingzone.com/forum-green/.

Vining, J., & Ebreo, A. (2002). Emerging theoretical and methodological perspectives on conservation behavior. In R. B. Bechtel & A. Churchman (Eds.), *The New Handbook of Environmental Psychology* (541–58). New York: John Wiley.

CHAPTER 2

AN INFORMATIONAL NEEDS APPROACH TO THE ADOPTION OF GREEN BUILDING PRACTICES

Green building practices: Status and challenges

During construction, operation, and deconstruction, homes consume large amounts of energy, raw materials, and water (Augenbroe & Pearce, 2000; Hutchings & Christofferson, 2001; Loftness, 2004; Vanegas & Pearce, 2000). Homes are responsible for 20 percent of the energy consumed and carbon dioxide emitted in the United States. Over 50 percent of residential energy consumption is related to construction decisions, such as equipment specification and envelope design (Energy Information Agency, 2003, tables 2.1a, 2.5, 12.2). In addition, a contemporary home may pose health risks to workers and/or occupants from inadequate ventilation or from toxins in carpets, paints, and finishes ("Sustainable construction," 2003).

Green building has emerged as an environmentally beneficial alternative to conventional practices (Cassidy, 2004; Dooley & Rivera, 2004; Nobe & Dunbar, 2004). Innovative technologies and products, along with revived traditional practices, are utilized to create homes that are healthier, longer lasting, and less environmentally destructive than conventional homes. Green building practices are commonly defined by the areas of the environment they affect: energy, water, site, air quality, and materials (Wilson et al., 2001). For example, homes now exist that consume no off-site energy or water. Landscaping practices, such as xeriscaping, which minimizes irrigation, and using native rather than invasive plants, restore rather than deplete local ecologies. The use of indoor air quality systems and low-toxicity materials are creating healthier indoor environments. A variety of finish materials (e.g., siding, flooring, cabinetry) are now available made from recycled, rapidly renewable, or sustainably harvested materials. Use of these materials contributes to the protection of natural resources and fragile habitats.

While many specific environmental building practices or products have existed for decades (or even centuries), since the 1990s green building has become more defined as a distinct system of construction practices. Further, green building has become increasingly viable because of greater product availability and an increase in programs that support green building, such as the USGBC's LEED programs or the Austin Green Building program (Mead, 2001; Smart Communities Network, 2005).

In recent years, green building has experienced rapid growth in the United States. Market share for both commercial and residential green building practices is projected to grow to between 5–10 percent of all construction activity by 2010 (Bernstein, 2006a). The National Association of Home Builders predicts that "by the end of 2007, more than half of NAHB's members, who build more than 80 percent of the homes in this country, will be incorporating green practices into the development, design, and construction of new homes" (NAHB, 2006, p1). Increasingly, local governments, such as Boston, Washington, D.C., and Santa Cruz, California, are modifying their building codes to require green building for new private construction (Miller, 2006; Pal, 2006; Palmer Jr, 2006). Mainstream media coverage has been portraying a highly positive picture of growth in green practices (Cassidy, 2003; Dooley & Rivera, 2004; Fahey, 2005; Paumgartten, 2003; Power, 2005; "The state of," 2003).

Growth projections for green building still project that 90 percent of construction will not be green through 2010 (Bernstein, 2006b). Although substantial, the growth in green practices nonetheless falls short, considering the broad goal of reducing aggregate environmental impacts. Whatever environmental gains are made in green building could be offset by environmentally destructive conventional building practices, such as trends toward larger homes and luxury amenities. For example, installation of just one full-body shower that uses up to 20 gallons per minute undermines the water saving benefits of over 30 water efficient systems (Deneen & Howard, 2007). Existing growth projections are also based on builder self-reports with no established criteria for what defines a green project (Brown, 2007). Such accounting is a limited basis for assessing where green building is growing. Other recent news stories suggest green homebuilding is struggling to gain a foothold among U.S. homebuilders (Tong, 2007; Trotta, 2007). These examples raise concerns that once green building saturates its niche market, growth may level off. If growth in green building does plateau at a low percentage of construction activity, the total contribution to sustainability of the built environment will be seriously limited.

Several factors play into uncertainties about future growth in green building practices. Most environmental impacts remain externalities for construction costs; green products are seen as expensive and technically unreliable by some practitioners; and environmental issues are of varying importance to consumers (Brick, 2003; Cassidy, 2004; Groonroos & Bowyer, 1999; Loftness, 2004; Seiter, 2005). Green building practices are often characterized as "high cost, high risk" (Dewick & Miozzo, 2004, p324). To date, growth in green practices has occurred primarily in areas of the United States that, unsurprisingly, have historically proenvironmental policies and practices (Bernstein, 2006a), while other regions are actively resisting improvements to environmental standards for homes (King, 2005). Lack of standardization is another factor that could affect the growth in green practices. Throughout the country, different programs have different criteria to certify a builder or building, leading to differing implementations of green building practices (Brown, 2007; Tinker & Burt, 2002; Tinker et al., 2004). One potential outcome of the lack of standardization is an inability to realize intended benefits (Scheuer & Keoleian, 2002), which could limit long-term credibility of green building programs. For example, a recent assessment of 11 Leadership in Energy and Environmental Design (LEED) certified buildings show that the designs on which credits were awarded both over- and underestimated actual energy and water consumption (Turner, 2006).

Given the potential environmental contributions of a widespread green building movement and the uncertainties about future growth in green building practices, a deeper analysis of green building adoption is warranted. This paper presents such an analysis. The next section lays the groundwork for this analysis by examining contemporary perspectives on construction innovation and positioning green building as a particularly challenging construction innovation problem. After establishing this groundwork, the latter half of the paper develops an alternative perspective based on a recognition that people's informational needs are central to their behavior, especially in situations involving change. First, an informational needs approach to construction innovation is outlined. Then a model based on informational needs, Kaplan and Kaplan's Reasonable Person Model (RPM), is described. RPM is then used to reinterpret construction innovation. Finally, an RPM-based framework for facilitating the adoption of green building practices is proposed.

Overview of construction innovation

Significant changes to construction practices are neither rapid nor easy. In recent years, literature has emerged that focuses on the challenges of innovation in the construction industry (Bossink, 2004; Harty, 2005; Koskela & Vrijhoef, 2001; Sexton & Barrett, 2003; Slaughter, 2000). Innovation is broadly defined as a change in practices that improves outcomes through cost reductions, process improvements, or performance improvements (Toole, 1998). Construction innovations have also been classified in terms of the degree of change involved; from incremental to radical (Slaughter, 1998). Many innovations are incremental, involving a single product or process that builders can integrate into existing construction practices, for example, steel stud framing or 90 percent–efficient furnaces. Radical innovations involve more complex or comprehensive changes, such as the introduction of CAD/CAM software. Radical innovations can be more challenging to adopt than incremental ones because they can be complex, the benefits can be hard to identify, and adoption may require more stakeholders.

Factors affecting construction innovation

An overview of the literature suggests three broad yet interrelated factors are critical to the adoption process—construction networks, information flows, and social dynamics. These factors reflect a shifting in the literature from a systems and institutions perspective toward a behavioral and social science perspective. Each of the three factors is discussed below.

Construction networks

A construction network is the set of formal and informal relationships, information flows, regulations, and supply chains among consumers, manufacturers, suppliers, regulators, and construction professionals that enable construction projects to function. The literature points to the structure of construction networks, particularly their complexity and fragmentation, as determinative of innovation. For example, the diversity of stakeholders involved, the project-based nature of the work, and the localized structure of the industry can all affect innovation adoption rates. As Lutzenhiser (1994, p871) states, "large scale systems exhibit considerable momentum, but evolve at uneven rates under the influence of contending interests and ways of thinking." Because of the number of interconnected variables in construction networks, how and where innovation occurs has been challenging to pin down (Seaden & Manseau, 2001). However, several scholars point to key issues. Dewick and Miozzo (2004) note that the traditionally firm-centered approach to innovation research has missed the embedded nature of the construction firm within a large network of actors and influences. Harty (2005) emphasizes how collaboration, project-based work, and distributed power all influence innovation adoption. Bossink (2004) attributes innovation to the quality of knowledge networks. The thrust of this work is that the structure of construction networks strongly influences firms' abilities to learn and make informed decisions about innovations. Taken as a whole, construction networks are often slow to integrate new information and resistant to innovation (Koebel, 1999; Seaden & Manseau, 2001).

Information flows

In the effort to understand construction networks, scholars are examining what binds networks together and what moves between the nodes in these networks. From such analysis, information flows have taken on an important role. Innovative firms are found to maintain a greater dedication to research and development, support more communication within and between firms, and have a broader view of risk (Bossink, 2004; Toole, 1998). Factors that inhibit or promote information flows in the construction network are seen as critical to innovation adoption. Constraints on information flows can inhibit stakeholders' abilities to make informed decisions about innovations (Seaden et al., 2003; Slaughter, 2000). For example, Toole (1998) found that homebuilders who utilize more information sources (e.g., other builders, homeowners, or subcontractors) were more likely to adopt innovations (e.g., composite wall beams, insulating concrete wall forms) regardless of whether uncertainties about the innovations were high or low.

Uncertainties about innovations are seen as a product of missing information. Within this perspective, the ability to reduce uncertainty is seen as directly proportional to the ability to increase information flows.

Social dynamics

A construction network is at its heart a group of people working on a shared objective. Without a person to receive information and utilize it in decision making, information is of little use. Work on construction networks and information flows has led some researchers toward a view of innovation as a highly socialized process in which relationships structure the information flows that promote or inhibit innovation ("In this special issue," 2005; Janda, 1998; Koebel, 1999; Lutzenhiser & Janda, 1999). Among the social factors that can stimulate or inhibit innovation are the trust in contractual relationships, comfort with information sharing, and interpersonal dynamics of regulatory, firm, or client interactions. Positive and strong social connections among stakeholders can facilitate innovation because of "lower transaction costs, tacit knowledge sharing and a high level of trust with partners and clients" (Manseau, 2005b, p50). The majority of this work is grounded in organizational behavior, but there are also scholars working from anthropological and sociological perspectives (Guy & Shove, 2000; Rooke & Clark, 2005). Research on social dynamics in construction innovation suggests that although traditional influences on innovations, such as organizational structure, market demand, and regulatory frameworks, do promote innovation, successful implementation of innovations in fact depends on interpersonal relationships.

Green building as a construction innovation problem

Green building poses a particularly challenging innovation problem. Green projects exacerbate the ways that the three factors identified above constrain or promote innovation. Many innovations related to green building, such as flooring materials, new HVAC equipment, and construction waste recycling, are comparable to conventional building practices. As such, existing networks, information flows, and social dynamics may be adequate for adoption of these green practices. Other innovations, however, such as use of passive solar designs, are of a different scale and scope than conventional building construction. These may require modifications to construction networks, access to different information flows, and the development of new relationships with appropriate suppliers and subcontractors, thus slowing the process of innovation.

Adoption of green building is further challenged by the need to provide an integrated construction approach, as opposed to the modular, highly subcontracted approach found in conventional construction (Mead, 2001). While any particular green innovation requires careful evaluation, integrating multiple innovations increases the number of variables that must be considered and managed (Mead, 2001; Riley et al., 2003; Vanegas & Pearce, 2000). For example, as trained installers of some green products are in short supply, homebuilders may have to provide more oversight than usual. To deliver an integrated construction process, homebuilders may need to change the ways they approach projects, the factors they consider in planning and execution, and the selection process for products and systems (Nobe & Dunbar, 2004). Any of these changes can affect network structure, information flows, and social dynamics.

Two additional aspects of green building, valuation and definition, pose challenges to builder innovation. At present, environmental concerns are not valued in the economics of home construction and green buildings are not consistently defined. Both of these issues can constrain green building adoption. “Green building won’t really enter the mainstream until its energy-efficient features, health and productivity benefits and durability are accurately valued in the real-estate market” (“In this special issue,” 2005). Lack of valuation for, and varying definitions of, green building reduces the visibility of green building for the consumer. “If the product is invisible to the consumer and the benefits are not immediately apparent or are uncertain, the builder will most likely reject the innovation” (Koebel, 1999, p80). Such variations make it difficult for builders to evaluate benefits and thus restricts adoption (Tinker & Burt, 2002; Tinker et al., 2004).

Several of these challenges stem from the open-ended nature of green building as a construction practice and how this open-endedness affects problem solving and learning. Adoption of green building practices involves a process of transforming knowledge of conventional building practices into knowledge of green building. This learning process can be thought of as a search for appropriate solutions. In such a search, the commonly assumed process can turn out to be quite different from reality (Figure

2.1). A more rational or linear model of innovation assumes that learning about green building is straightforward and terminal. With such a perspective, once builders know about conventional building, they are assumed to adapt their knowledge to green building, and once they know about green building, they have completed the task. However, as described above, a significant problem with green building is that the starting place and the finish line are largely unknown. As a construction practice that is still very much developing, the endpoint for adoption is a constantly moving target.

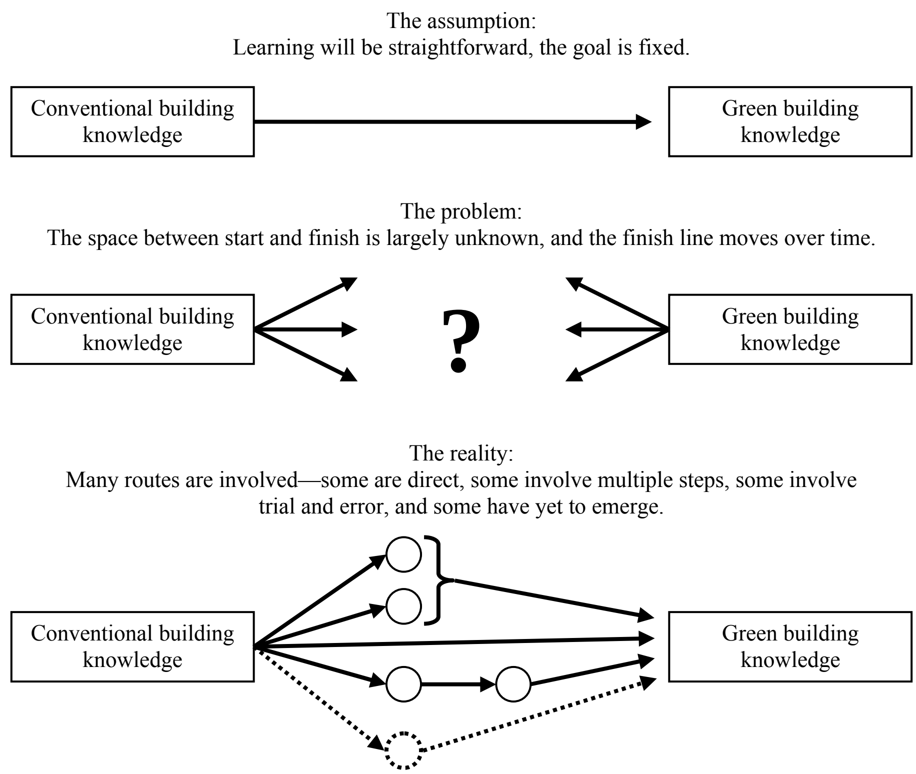


Figure 2.1 Learning about green building is neither straightforward nor terminal

Green building is not one product nor one practice but a suite of practices that are integrated to deliver a final product. Exactly what and how a builder needs to learn about green building is difficult to determine. There are many ways to learn about green building practices, some of which are more straightforward than others. Experience with 2x4 framing is readily adaptable to 2x6 framing. Knowledge of water conservation does not necessarily include a knowledge of xeriscaping, but the two do build on each other. Development of some green building skills will require much trial and error. For example, for passive solar design there are no one-size-fits-all solutions. To be successful, practitioners may have to experiment more than for other green techniques. Finally, some green practices have yet to emerge. What a builder knows today may be relevant to particular tasks, but to keep reducing environmental impacts, they will need to regularly update their knowledge as new practices emerge. As a result of this complicated, layered, and shifting learning process, builders will face repeated challenges in their attempt to get involved with green building, and these challenges may dissuade many from the attempt.

This discussion suggests that for green building to become more widely implemented, new networks will have to be developed, new information must be accessed, and new relationships must be established. The next two sections of the paper tackle this challenge.

An informational needs approach

Information processing and construction innovation

The discussion of construction innovation generally, and the challenges of green building particularly, highlight the importance of information to innovation adoption. Whether fragmented construction networks make information sharing difficult or a high level of trust among stakeholders makes information sharing easier, information is critical to innovation. The literature has explored the mechanisms of information delivery in construction. However, little emphasis has been placed on what happens to that information once it is delivered to construction stakeholders. The implicit assumption is that once people have enough information—or the right information—they will realize the value of a given innovation and adopt it. However, information is not a material good that can be bought, packaged, and delivered ready to be installed. Research has shown in a variety of ways that people's responses to information is complex; relates strongly to their past experiences; and, very often, is not particularly rational (Costanzo et al., 1986; Evans, 2003; Gigarenzer, 1997; Kahneman, 2003; Kaplan, 1991). Criticism of the emphasis on information delivery is not new; however, what criticisms have been put forth are principally grounded in sociology or organizational behavior (Bresnen et al., 2005; Guy & Shove, 2000). Therefore, a discussion based on information-processing theories may prove useful.

Overview of the Reasonable Person Model

To examine the role of information processing in construction innovation, I draw on the conceptual framework developed by Kaplan and Kaplan (Kaplan, 2000; Kaplan & Kaplan, 2003). Their Reasonable Person Model (RPM) looks at human behavior in terms of how well the environment satisfies people's informational needs. Informational needs are not only needs for information per se, but also needs for certain characteristics in the information people are exposed to. People are actively engaged in the acquisition, interpretation, and management of information. People care deeply about where information comes from, how it is delivered, and how it relates to what they already know. RPM proposes that people are more reasonable—cooperative, helpful, constructive—when the environment meets their informational needs. Thus, RPM helps to explain how people understand the world around them and the choices they make. RPM is based on research from many domains, but it has been most directly informed by research on attention restoration (Kaplan & Kaplan, 1995; Kaplan, 2001), cognitive maps (Kaplan, 1973, 1991; Kaplan & Kaplan, 1983), environmental preferences (Kaplan, 1992; Kaplan & Kaplan, 1995), environmental behavior change (De Young, 1996, 2000), and helplessness (Peterson et al., 1993; Seligman, 1998).

Prevalent models of human behavior, especially ones that economics and planning draw on, assume that people are rational actors conducting cost/benefit analyses prior to making their decisions (for a critique of rationality, see Shafir & LeBouf, 2002). If people were rational decision makers, innovation adoption would in fact hinge on information delivery, because people would fully utilize all available information to make decisions. Common sense and abundant research, however, refute this position (Gilovich et al., 2002; Kahneman, 2003; McElroy & Seta, 2003; Simon et al., 2004; Sloman, 2002). When environments support people's informational needs, they can more readily process information they receive. They can focus more of their attention on obtaining new information and figuring out what to do with that information. Broadly stated, satisfying informational needs supports more effective decision making. Rational decision making may be more the exception than the rule (Evans, 2003; Gigarenzer, 1997; Kaplan, 1991; Myers, 2002). Much of what appears to be nonrational decision making is actually quite reasonable when informational needs are considered. People are awash in information, from traffic signals to the internet. Reasonableness is an effective and adaptive response to the flood of information people are exposed to.

RPM categorizes informational needs in three interrelated domains—model building, becoming effective, and meaningful action (Figure 2.2). Each of these domains is described below.

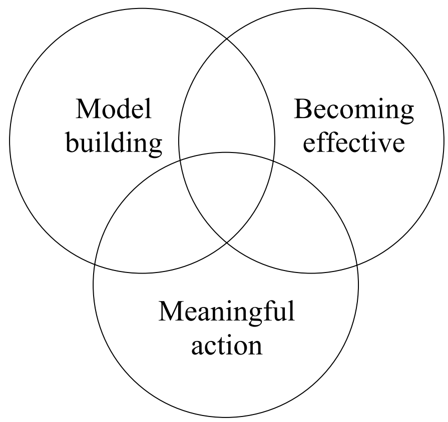


Figure 2.2 The Reasonable Person Model—interrelated domains (Kaplan & Kaplan, 2006)

Model building

People are not empty vessels into which information is poured; rather, people use information to build mental models they can then use to function in the world. "A mental model is a simplified version of reality that we carry around with us to help us make sense of the world, to plan and evaluate possibilities. Mental models reduce confusion and provide a basis for understanding" (Kaplan & Kaplan, 2006, p1). Model building involves both exploring and understanding the world. To develop mental models requires going beyond what is already known as well as connecting new information to existing knowledge. Mental models determine how people see the world, and, as a result, people often try to shape the world to fit their models: A politician sees the political sides of an issue, while a lawyer sees the legal sides. Model building means that while people may enjoy new information and are curious to extend their skills, they simultaneously have a strong bias toward the familiar and toward learning at their own pace. A desire for both exploration and understanding helps balance the acquisition of new information with the integration of that information into existing models.

Becoming effective

People desire information, but they do not just want to possess information, they want to use the information they have to be effective in the world. People often avoid situations where they are unable to be effective with the resources they have. "Becoming effective includes two components: being sufficiently clear-headed to be able to respond appropriately to the abundance of information surrounding us, and a sense of competence that comes from knowing how to do things and what may be possible" (Kaplan & Kaplan, 2006, p1). Being clear-headed requires having enough mental resources to focus one's attention on the tasks at hand. Focusing attention, even on desirable tasks, can be draining. When people's ability to focus their attention is drained, problem solving and creativity decline and information-processing capacity is reduced. For example, restrictions on flying time for commercial pilots recognize that lengthy demands on attention reduce effectiveness. However, being able to focus one's attention is not sufficient to become effective; one has to know what to focus on. Competence is the feeling that comes from knowing what to do with information, realizing how information relates to knowledge one already has, and recognizing the circumstances appropriate to a particular body of knowledge. Competence is valuable in guiding people toward information that matters to them. Conversely, feeling incompetent is a powerful warning that to continue forward (into an environment or in seeking out additional information) will not help one to become more effective.

Meaningful action

People want to make a difference in the world around them. As such, building models and maintaining effectiveness is not enough. "Meaningful action concerns the need to participate, to be an active part of the information-rich world around us" (Kaplan & Kaplan, 2006, p1). While some information is empowering, much information is not. Many environments and much information offer little opportunity for engagement, implicitly telling people there is not much they can do to make a difference. Mainstream news outlets are full of horror stories from around the globe about which one can do little, while offering few stories about local problems with which a person might get involved (Postman, 1986). Information that provides no outlet for action can contribute to feelings of helplessness. Feeling helpless can contribute to a reduced ability to solve problems or to attend to issues of concern. “People strive to appreciate what they can and cannot control. Whatever they learn is registered deeply and profoundly, influencing everything from physiological processes to world politics” (Peterson et al., 1993, p305). Being told what to do or what to think reinforces feelings of helplessness. Conversely, participatory experiences tell people their involvement is useful and their contribution is valued, all of which build people’s sense that their efforts are meaningful.

Interrelationships among domains

Although described in terms of three domains, the RPM framework is highly interrelated. Feeling competent and extending our models of the world can provide a strong sense of meaningful action. Creating participatory experiences supports understanding at the same time as it provides a chance to develop competences. Working in an environment where the gap between exploration and understanding is too great, where mental models are insufficient, can be mentally draining and can lead to feelings of helplessness. Because people have multiple informational needs, it makes sense that the domains of RPM overlap. This framework recognizes that people’s relationship to information is complex and multidimensional. When environments and information support exploration and understanding, enable meaningful action, and facilitate competence and a clear head, people are more likely to act reasonably. Under such situations, people can be more creative and constructive in their efforts. Thus, reasonableness is a cornerstone of problem solving, particularly in contexts that are full of complexity and uncertainty, such as those that call for innovative solutions.

Role of RPM in facilitating adoption of green building practices

There are a number of ways that RPM can help us understand the conditions supporting homebuilders’ adoption of green practices. The number of potential adjustments required by green projects and the changes in familiar products, tasks, and relationships might combine to make model building difficult, challenge the builder’s sense of effectiveness, and fail to provide clear pathways for builders to take meaningful action. For example, a client might ask the contractor about using several green products, such as low-VOC paints, a salvaged wood flooring product, and an on-demand hot-water system. The contractor may be interested but is concerned that he[1] will get in over his head. He may not know how the use of particular products will affect other parts of the construction process or who can perform a quality installation. He has no way to try the products, and the available information may be hard to find or insufficient to address all his concerns. These unknowns pose a large threat to understanding, because the builder has no working models. On the other hand, his model of conventional construction is very well developed and he can resolve questions that come up intuitively. As a result, the builder may avoid green building altogether because it is too threatening and/or confusing. Builders' reluctance to try green building—their uncertainty about the outcomes and pessimism about the value of green building—may not be rational, but may in fact be reasonable and understandable.

Revisiting construction innovation factors from an RPM perspective

The three factors discussed earlier—construction networks, information flows, and social dynamics—all have facets of RPM. Using RPM to understand the three innovation factors helps to explain how informational needs play a role in construction innovation generally and adoption of green building practices specifically.

Construction networks

A well-functioning network is likely to reinforce competence, support model building, and provide meaning. For example, a builder may want to explore green building, but the structure of his network may inhibit the ability to transform that interest into action. Because of how homes are built and the expenses involved, experimenting with new practices is likely to require coordination among actors in the network, such as subcontractors, regulators, or even the client. In a less networked industry, there might be more freedom to explore innovations, but home construction has a high threshold for experimentation, which restricts exploration and thus innovation.

Construction networks are often described as fragmented both in terms of relationships to the wider construction industry and of how information is shared within specific networks (Harty, 2005; Koebel, 1999; Lutzenhiser & Janda, 1999). Because

[1] For simplicity, and because homebuilders are still primarily men, male pronouns will be used in this dissertation.

fragmentation can isolate individual networks from each other, definitions of competence may be more internally defined than if networks were less fragmented. As a result, doing things differently may be less valued, and fragmentation may contribute to competence being related to maintaining status quo practices. A fragmented or local construction network can also make sources of meaningful action harder to modify because a given network may not attach meaningfulness to environmental issues generally or green building practices specifically.

A well-functioning construction network can greatly extend the scope of individual effectiveness. However, the same network structure might limit an individual's ability to change. Once a builder's effectiveness is tied to a particular network, changes to the network, such as using a different subcontractor, may cause delays, errors, and complications, all of which undermine the builder's effectiveness.

Information flows

While scholars often relate the flow of information in construction networks to uncertainty management (Dewick & Miozzo, 2004; Groverse et al., 2001; Lutzenhiser, 1994; Toole, 1998), from an informational needs perspective, the effects of uncertainty can be better understood through an assessment of how different courses of action affect the three RPM domains. What information sources builders utilize are critical to the models they build of their construction practices. What information builders utilize in their work both reflects their current understanding and shapes their future exploration. Constraints on information might limit builders' abilities to extend their models or steer their exploration in particular directions. For example, if builders rely exclusively on their local suppliers for information about new products, their models of viable products can only include those products the supplier informs them about. This may preclude green building products that are not widely available.

Information flows are also important to builders' sense of effectiveness and meaning. For example, builders who read the *Journal of Light Construction* are exposed to a different community of builders than the builders who read *Environmental Building News.* The communities a builder spends time reading about, in part, become the ones they associate themselves with, which in turn contributes to the sense of meaning they attach to different practices.

The structure of information is also likely to play an important role in builders' innovation behavior. Information is structured in many different ways, and this structure affects how people respond to it. For example, a brochure that uses headings and bullet points is easier to digest than one with undifferentiated paragraphs of text. When people become familiar with the structure of information they use regularly, it is easier to use. For example, builders become familiar with common regulatory procedures, such as minimum R-value for the building envelope, as well as standards used to evaluate products, such as SEER ratings for air conditioners. In these cases, the familiarity of structure in these standards and procedures goes a long way to facilitating effectiveness. Because builders know what to expect and when to expect it, they do not spend time figuring out how to proceed. With innovative products, the structure of information may be largely unknown, standards may need more interpretation, regulations may have to be followed in a different way. Information that is not structured in a way builders can easily use can lead to confusion and undermine effectiveness.

Social dynamics

Relationships between actors play a role in innovation, in part, because trust affects information sharing; well-established relationships can in fact hinder introduction of new practices (Bon & Hutchinson, 2000; Dewick & Miozzo, 2004; Lutzenhiser & Janda, 1999). However, relationships also serve informational needs. Social dynamics can play an important role in satisfying people's need to build models, become effective, and take meaningful action. A builder's sense of how to take meaningful action is influenced by relationships with other construction professionals. Strong social connections among builders lead to shared values, which affect the paths a builder sees as meaningful. If well-known suppliers or subcontractors agree that green building is important, a builder's sense that green building is meaningful is reinforced. Over time, the degrees to which a builder's colleagues reject or endorse green building practices will affect his overall outlook.

Because of how new construction products are developed, innovations are more likely to come from sources outside the builder's community (Seaden & Manseau, 2001). Therefore, introducing innovations can require changes in existing relationships that will affect the satisfaction of informational needs. For example, people often place greater trust in the quality of information when it comes from a well-known source. Trust facilitates competence and reduces demands for attention because incoming information is seen as more credible and thus less effort is needed for evaluation. When establishing new relationships, builders have to be vigilant about the quality of the information they are receiving. This can drain mental resources and undermine effectiveness.

Because construction projects often involve collaborative relationships, control over decision making may be distributed among stakeholders. Social dynamics often mediate collaborative decision making. If project participants know each other well, they are likely to know what to expect from each other (Lutzenhiser, 1994) These long-term relationships tend to "foster trust, stability and economies of learning and experience" (Dewick & Miozzo, 2004, p329), all of which help to build shared models, extend participants' effectiveness, and contribute to collective achievement of meaningful action. While understandable from an informational needs perspective, the importance of these relationships may create resistance to change, thus inhibiting innovation adoption.

Summary of RPM and Construction Innovation

Informational needs are clearly not the sole force determining innovation adoption; there are many factors, from regulations to economics, that affect innovations. However, these factors themselves introduce informational needs challenges. The preceding analysis outlines how informational needs play a role in construction innovation and suggests that RPM offers a framework for analyzing construction innovation that may create new inroads into this complex domain. Further, existing approaches and RPM go hand in hand in addressing construction innovation. This relationship is illustrated graphically in Table 2.1.

Table 2.1
Examples of how RPM and construction innovation are related

Construction Innovation		Reasonable Person Model: Model building	Reasonable Person Model: Effectiveness	Reasonable Person Model: Meaningful action
	Construction networks	A better functioning network can make experimentation easier, which facilitates model building	Stakeholders who reject innovations can constrain a builders' ability to develop new outlets for competence	Norms and values within a network about valid construction activities can shape meaningful action
	Information flows	Model building requires multiple exposures to information, more information sources increase the chance of this occurring	Constraints in information sources can make new information harder to process, straining attention capacity	Information sources convey biases about meaningful action that builders take in along with the information itself
	Social dynamics	Information from a trusted source registers more deeply that information from less well known sources, this bias for familiar sources shapes how models are built	Working with a familiar colleague reduces the effort required for communication and can extend one's sense of competence	If a builder's peers reject innovations, this will have an effect on the builder's sense of importance for that innovation

An awareness of the innovation factors is critical to developing programs that can address builders' informational needs, just as an awareness of informational needs is beneficial to examining particular factors affecting an innovation. Understanding the particular information flows stakeholders use is critical to developing opportunities for further exploration and understanding. Supporting effectiveness and meaningful action will be easier to the degree that trust and credibility can be established through existing social systems. While the specific ways innovations are adopted (or not) can be described in terms of networks, information flows, and social dynamics, at times these descriptions may overlook why the adoption does or does not happen. The "why" may be rooted in how well the innovation satisfies the informational needs of the person adopting the innovation. Looking more closely at informational needs provides an analytic perspective that enriches understanding of the innovation process.

Using RPM to support innovation

Addressing builders' informational needs could facilitate adoption of green building practices by supporting their efforts to engage in innovative problem solving. From manufacturers who support effectiveness by teaching builders to estimate and install alternative insulation products to clients who facilitate model building by researching information about green roofs, a large number of activities can support builders' informational needs.

Broadly speaking, there are three key strategies for supporting informational needs that relate to the RPM framework—attending to the structure of information, creating opportunities for participation, and taking time for reasonableness. While strategies based on these ideas are not unique to an informational needs perspective, such a perspective may lead to different applications. Following are a number of ideas drawn from these strategies that may be effective at facilitating the adoption of green building practices among homebuilders.

Attend to the structure of information

Too often when new information is made available, it is in a form that recipients cannot use, comes at a time when they cannot use it, or is delivered to the wrong person. For example, much green building information is coming from nonprofits who may not understand the builder's concerns or may be outside the builder's construction network. Below are some guidelines for how to structure information about green building to work with builders' informational needs.

Consider importance from the builders' perspective

If green building information does not quickly and easily tell builders what they can do with this new information, it is likely they will stop listening and move on. The structure of information (e.g., what is emphasized, the order of presentation, etc.) tells recipients what is important and what is not. When communicating about green building practices, it is important to consider structure alongside content. An attempt should be made to consider importance from the recipients' perspective and to use structure to speak to their needs. For example, a builder may care less about the environmental benefits of a flooring material than its durability or installation procedures. Structuring information to put the builders' concerns at the forefront will make it easier for builders to attend to the information and to find ways to apply information to their practices. Further, seeing that their needs are being addressed up front, builders might be more open to information about other issues. Structuring information to address builders' needs could be accomplished through a number of approaches. For example, developing closer relationships between green building programs and trade associations, as well as working with manufacturers and suppliers to develop better communications programs, might produce green building information that was more relevant to builders' needs. Builders in different regions could be surveyed both about aspects of green building they are and are not familiar with and things they would be most interested to learn about. Building educational programs out of such surveys might lead to greater engagement among homebuilders in those regions.

The importance of understanding

People have a great desire to explore, but they are wary of becoming confused. To enable both exploration and understanding, it is important to structure information so that builders can explore at their own pace. Regardless of whether the information comes from a lecture, brochure, workshop, or meeting, the rate and amount of information provided needs to be manageable. This might mean structuring a green building workshop so that knowledge builds slowly, enabling participants to more readily see connections between information and to have chances to apply what they are learning as the workshop proceeds. Staying connected to what has already been covered is just as important as exciting people about where they are going. For example, a workshop on radiant floors could weave together technical information and case studies. Such a structure helps participants to visualize the real-world experience, which may engage their desire for exploration, but also provides the foundation of knowledge that supports understanding.

Respect the resources of the recipient

Builders devote considerable effort to acquire conventional building skills and have limited resources for learning new skills. Therefore, it is important to consider the balance of effort spent on communicating what builders may know well (such as energy efficiency) versus less well-known aspects of green building (such as air quality). If information can clearly demonstrate what knowledge builders can hold on to and what may need to change, builders may have an easier time using green practices. Taking the time to explain critical differences can go a long way toward minimizing the frustration of trying to use conventional building skills to solve green building problems.

In communicating about green building, it is also important to be sensitive to people's capacity to pay attention to new material. Too much information coming too fast can leave people feeling drained. People who feel drained have a harder time being creative and may end up feeling frustrated and incompetent. Much of the information about green building is complex and dense; therefore, it is important either to take breaks more often when presenting information or to structure the material in ways that engage people's attention in less demanding ways, such as using stories or case studies. The material can also be broken into chunks where the builders can choose which one(s) to pursue and when it is best to pursue them.

There is no single mental model of green building

Currently there are many different sources of information about green building available from the internet, from green building programs, and through trade or mainstream press. However, different sources are likely to tell a variety of stories that may implicitly express different models of what green building is. A builder on the receiving end of so many different stories may develop an *ad hoc* mental model of green building. For example, water conservation and material use are both parts of green building, but if builders only read about material use, eventually their model may favor material options over water options. The mental models builders develop will inform their perceptions of what green building is and how viable it is. To support the development of a useful and relevant mental model of green building, it is important to be explicit about what green building is and where it is similar to, or different from, conventional building. When the model of green building becomes explicit and public, it becomes easier for individuals to share their experiences as well as makes assumptions and biases more easily visible. For parties interested in promoting green building practices, making the model explicit helps with educational efforts and can make communicating with builders easier. Green building programs that take time to understand (through surveys, focus groups, and other information-gathering techniques) the discrepancies between the models of green building they are promoting and the models prevalent in their building community may find a more receptive audience to their programs.

Create opportunities for participation

As mentioned above, people have a strong motivation to be heard and to make a difference; participatory experiences often provide a powerful outlet for this desire. By creating opportunities for participation, green building educational and communications programs may foster a sense of engagement with, and ownership of, knowledge that can contribute to adoption of green practices. Even the relatively small step of finding out what aspects of green building the target audience would want to learn about provides an opportunity for participation. Sharing knowledge in a participatory format, where input and feedback are built into the experience, is different from simply delivering information. Participatory experiences enable experimentation, allow for timely feedback, and encourage dialogue. Further, participatory experiences can reinforce content and provide a check that content is actually being taken in by an audience. As a result, participation can support model building, effectiveness, and meaningful action. Below are some guidelines for how participatory opportunities can work with builders' informational needs to support adoption of green building practices.

Create concrete experiences

Homebuilding is a visual and tactile profession. While many homebuilders may be removed from the hands-on aspects of homebuilding, they are focused on a product that is inherently physical. Concrete, as opposed to abstract, learning experiences can help builders not only see how things work but also imagine what is possible. Seminars and workshops that use case studies and simulations help provide contextualized information in ways builders may find more applicable. For example, hands-on workshops can directly support informational needs by providing a place to build new mental models and extend competence in ways that are less risky than trying them out on a real project. Learning environments that allow for experimentation can engage the desire for exploration, but they can also allow the builder to learn at his own pace, thus facilitating understanding. There are certainly limitations to the possible scope for concrete or hands-on activities. Homebuilding is labor and time intensive, so it may be untenable to build an entire home. However, simulations, case studies, and other methods can be very effective at providing concrete experiences because they can provide multiple examples of a problem or enable trial and error and experimentation in ways not possible with a single large-scale project. For example, a green building program could sponsor workshops where multiple wall sections are constructed to illustrate the process of using an alternative framing system. Scale models of building sites with different topographic, vegetative, and climatic conditions could be used to be walk builders through the procedures for analyzing the site, water, and solar resources on a site. Each of these examples gives participants concrete experiences in a rapid, exploratory way that may be particularly effective at satisfying informational needs.

Foster dialogue between conventional and green builders

An important way to help builders change the outlook they have on green building is by sharing experiences among peers. While sharing technical knowledge is certainly important, such content-focused knowledge may do little to satisfy builders' informational needs. For a conventional builder, talking with an experienced green builder may help them visualize what green building offers, such as innovative construction practices, environmental stewardship, and expanded customer value. Such a conversation helps put technical information into a context that may inspire change. A further benefit is an increased sense of competence. Hearing about green building from a city planner or an academic may convey information about green building, but talking with a successful green builder enables the conventional builder to put himself in that person's shoes and imagine that he, too, can be successful with green building practices. The experienced green builder already speaks the language of construction, can provide answers at the level of detail another builder may be interested in, and thus can respond to the audience's questions more directly.

Frame green building as an extension of conventional building

At its core, green building is tackling issues—health, environmental protection, energy security—that are of increasing concern to customers and governments. This importance can motivate builders to explore what green building has to offer. It is critical, however, to present green building as an extension of conventional building, not as a repudiation of it. If green building is seen as a place where builders have enriched opportunities for participation, they may have a compelling motivation for change. If, however, green building is seen as a rejection of conventional building, the strong sense of competence and meaningful action builders already have attached to conventional building is juxtaposed against their weaker sense of competence and meaningful action for green building. If conventional and green building knowledge are positioned antagonistically, RPM issues may work against adoption. Recognizing and validating the inherent meaningfulness of conventional building, while clearly laying out the opportunities for enhanced exploration and meaningful action provided by green building, may be an important strategy for increasing builder interest and acceptance.

Encourage participation throughout the construction network

As mentioned earlier, builders rely on their construction networks to a great degree. All actors in a construction network have their own informational needs. If these other actors perceive green building unreasonably, it may affect the builders' capacity to use green practices. For example, if painting contractors are familiar with low-VOC paints, then the builder and the painter can more easily share information. If inspectors know how a radiant floor works, then the builder does not have to spend mental resources demonstrating the product's safety and reliability to the inspector. To the degree feasible, green building programs could encourage participation among all residential construction stakeholders, especially subcontractors and regulators. The greater the number of stakeholders in homebuilders' construction networks who participate in green building, the easier it becomes for a homebuilder to explore green practices within existing social networks.

Connect to builders' sense of participation with the construction industry

For some time, construction has been seen as a conservative industry uninterested in innovation, in which the labor pool has been shrinking because the industry is not seen as dynamic or modern (Manseau, 2005a). This regressive view of homebuilding diminishes the perception that homebuilding is a profession where one can take meaningful action. Green building gets a lot of media attention and paints a cutting-edge, forward-thinking image of homebuilding. If green building were seen to be contributing to the revitalization of the field as a whole, builders might begin to feel that, aside from any environmental benefits, being a green builder is a way to contribute to the advancement of their profession in new and exciting ways. This image could motivate younger people to enter the field, which could in turn invigorate the industry. This reframing serves informational needs in a number of ways: integrating green and conventional building models; supporting effectiveness; and, most importantly, elevating green building as an outlet for meaningful action.

Take time for reasonableness

The previous two strategies are specific approaches to the development of materials or programs; what they neglect to address is how much time this process takes. No single exposure to a green product or practice is going to lodge very deeply with builders. Developing new mental models, sources of competence, or outlets for meaningful action takes time and repeated experiences. Considering the informational needs of homebuilders requires an awareness of the developmental aspects of reasonableness. Supporting reasonable behavior about green building will involve multiple exposures, preferably in different contexts and in different forms. Structuring one piece of information more appropriately or creating one participatory workshop is not sufficient to change builders' behaviors. For example, if one green building goal is to have builders incorporate water conservation strategies in their projects, this goal needs to be considered and addressed from several angles. How many ways can builders be exposed to water conservation messages? In what settings are builders best able to learn about water saving fixtures? One meeting, brochure, or workshop cannot create the change necessary for builders to adopt green building practices. Recognizing that satisfaction of informational needs occurs over time and multiple experiences suggests that educators and communicators will need to develop longer-term, more multipronged outreach campaigns. The goal of such campaigns is not just to inform builders but also to provide enough experiences with green building so that their mental models, effectiveness, and meaningful action can develop enough to see green building as a reasonable option to pursue.

Conclusions

Adopting innovations can change work routines, alter familiar relationships, and require the development of new skills or technical knowledge. These are all significant challenges, affecting what individuals perceive, how they evaluate options, and ultimately their desire to implement particular innovations. Builders may feel green building is untenable not because of anything inherent to green building but because of how it appears from their current viewpoint. Consideration of the informational needs of builders within the residential construction context could serve two functions. First, such efforts could significantly facilitate increased adoption of green building practices, making important contributions to larger sustainability goals. Second, such work could enrich the understanding of construction innovation as a whole, an outcome that might facilitate advances throughout the industry.

RPM is practical

Compared to tackling structural, institutional, regulatory, or economic barriers directly, strategies based on RPM may be more practical to implement. RPM-based strategies focus on the changes to existing relationships among information, knowledge, and environments. As such, these strategies are often incremental rather than systemic in scope. For example, if suppliers do not carry many green products, a green building program may have little ability to influence suppliers' inventory choices. A local green building program, however, can easily work to provide information that supports builders' effectiveness, so builders may be more open to looking outside their traditional supply sources. In communities with little awareness of green building and conservative regulatory policies, stimulating customer demand directly or reforming building codes may require more resources than are available to many small, nonprofit green building programs. However, identifying ways to help builders develop models of green building, or making sure that communications about green building support builders' effectiveness, can be done incrementally through more common channels, such as trade association seminars, community college programs, and the internet. By addressing informational needs, resistance to green building may be reduced and stakeholders may approach adoption decisions more creatively, offering openings for innovation that they were previously unable to see or appreciate.

By applying RPM to construction innovation, new approaches emerge that policy makers, advocates, and other building industry stakeholders can use to stimulate change. Focusing on how green building information is presented to construction stakeholders, providing participatory ways of gaining experience, and recognizing that adoption of green practices takes time and multiple experiences to take hold may lead to programs that can substantially reduce the burdens associated with learning new skills. Furthermore, obtaining data on what information builders want about green building and addressing their competence and sense of meaning through RPM-based educational programs can energize the learning process. Such programs can draw, rather than push, participants into green building. Supporting the development of builders' mental models can increase engagement by clarifying how green building relates to and extends conventional building skills. With opportunities to explore green building through training and case studies, stakeholders can develop familiarity with green building that will facilitate their evaluations of specific technologies and practices. By attending to the informational needs of construction project stakeholders, the benefits of green building may become more visible, and the barriers may seem less challenging, facilitating greater overall adoption of green construction practices.

References

Augenbroe, G. L. M., & Pearce, A. R. (2000, February 22–25). *Sustainable construction in the USA: A perspective to the year 2010.* Paper presented at the International Conference on World Futures, Sri Lanka, India.

Bernstein, H. M. (2006a). *Green Building SmartMarket Report: Design and Construction Intelligence*. New York: McGraw Hill.

Bernstein, H. M. (2006b). *Residential Green Building SmartMarket Report*. New York: McGraw Hill.

Bon, R., & Hutchinson, K. (2000). Sustainable construction: Some economic challenges. *Building Research and Information,* 28 (5/6), 310–14.

Bossink, B. A. G. (2004). Managing drivers of innovation in construction networks. *Journal of Construction Engineering and Management-Asce,* 130 (3), 337–45.

Bresnen, M., Goussevskaia, A., & Swan, J. (2005). Editorial: Managing projects as complex social settings. *Building Research & Information,* 33 (6), 487–93.

Brick, M. (2003, January 13). Not building green is called a matter of economics. *New York Times,* p. 5.

Brown, M. J. (2007, March/April). A watershed year for green homes. *E: The Environmental Magazine, 18,* 10–11.

Cassidy, R. (2003). White paper on sustainability: A report on the green building movement. *Building Design and Construction.* Retrieved April 11, 2005, from http://www.bdcnetwork.com/contents/pdfs/BDCWhitePaperR2.pdf.

Cassidy, R. (2004). Progress report on sustainability. *Building Design and Construction.* Retrieved October 3, 2005, from http://www.bdcnetwork.com/contents/pdfs/bdc04White_Paper.pdf.

Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist,* 41 (5), 521–28.

De Young, R. (1996). Some psychological aspects of reduced consumption behavior: The Role of intrinsic satisfaction and competence motivation. *Environment and Behavior,* 28 (3), 358–409.

De Young, R. (2000). Expanding and evaluating motives for environmentally responsible behavior. *Journal of Social Issues,* 56 (3), 509–26.

Deneen, S., & Howard, B. (2007). Buildings that breathe: Green construction is coming of age. *E: The Environmental Magazine.* Retrieved March 12, 2007, from http://www.emagazine.com/view/?3525.

Dewick, P., & Miozzo, M. (2004). Networks and innovation: Sustainable technologies in Scottish social housing. *R & D Management,* 34 (3), 323–33.

Dooley, R., & Rivera, J. (2004, March). Green building goes mainstream. *Professional Builder,* 69, 71–72.

Energy Information Agency. (2003). Annual Energy Review 2003 (Vol. 2005). Washington, DC: U.S. Department of Energy.

Evans, J. S. (2003). In two minds: Dual process accounts of reasoning. *Trends in Cognitive Science,* 7 (10), 454–59.

Fahey, V. (2005). Building Green always made sense—now it's beginning to pay off. *San Francisco Chronicle.* Retrieved September 11, 2005, from http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2005/09/11/REG4DEKFQD1.DTL.

Gigarenzer, G. (1997). Bounded rationality: Models of fast and frugal inference. *Swiss Journal of Economics and Statistics,* 133 (2), 201–18.

Gilovich, T., Griffin, D., & Kahneman, D. (Eds.). (2002). *Heuristics and Biases: The Psychology of Intuitive Judgment*. New York: Cambridge University Press.

Groonroos, J. C. M., & Bowyer, J. L. (1999). Assessment of the market potential for environmentally certified wood products in new homes in Minneapolis/St. Paul and Chicago. *Forest Products Journal,* 49 (6), 28–34.

Groverse, T., Hekkert, M. P., Groenewegen, P., Worrell, E., & Smits, R. E. H. M. (2001). Wood innovation in the residential construction sector: Opportunities and constraints. *Resources Conservation and Recycling,* 34, 53–74.

Guy, S., & Shove, E. (Eds.). (2000). *A Sociology of Energy, Buildings and the Environment: Constructing Knowledge, Designing Practice*. London, UK: Routledge.

Harty, C. (2005). Innovation in construction: A sociology of technology approach. *Building Research & Information,* 33 (6), 512–22.

Hutchings, M., & Christofferson, J. (2001). Factors leading to construction company success: Perceptions of small volume residential contractors. *Associated Schools of Construction, ASC Proceedings of the 37th Annual Conference.* Retrieved March 28, 2005, from http://www.asceditor.usm.edu/archives/2001/hutchings01.htm.

"In this special issue." (2005). *Building Research & Information,* 33 (6), 495–97.

Janda, K. B. (1998). Building change: Effects of professional culture and organizational context on energy efficiency adoption in buildings. (PhD, University of California, Berkeley, 1998).

Kahneman, D. (2003). A perspective on judgment and choice—mapping bounded rationality. *American Psychologist,* 58 (9), 697–720.

Kaplan, R., & Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. New York, NY: Cambridge University Press. Republished by Ann Arbor: Ulrich's, 1995.

Kaplan, R., & Kaplan, S. (2006). *The Reasonable Person Model: A Brief Description*. Unpublished manuscript. University of Michigan, Ann Arbor.

Kaplan, S. (1973). Cognitive Maps in Perception and Thought. In R. M. Downs & D. Stea (Eds.), *Image and Environment: Cognitive Mapping and Spatial Behavior* (pp. 63–78). Chicago: Aldine.

Kaplan, S. (1991). Beyond rationality: Clarity-based decision-making. In T. Gärling & G. W. Evans (Eds.), *Environment, Cognition and Action: An Integrated Approach* (pp. 171–90). New York: Oxford University Press.

Kaplan, S. (1992). Environmental preference in a knowledge-seeking, knowledge-using organism. In J. H. Barkow, L. Cosmides & J. Tooby (Eds.), *The Adapted Mind* (pp. 581–83, 595–96). New York: Oxford University Press.

Kaplan, S. (2000). New ways to promote proenvironmental behavior: Human nature and environmentally responsible behavior. *Journal of Social Issues,* 56 (3), 491–508.

Kaplan, S. (2001). Meditation, restoration, and the management of mental fatigue. *Environment and Behavior,* 33 (4), 480–506.

Kaplan, S., & Kaplan, R. (1982). *Cognition and Environment: Functioning in an Uncertain World.* New York: Praeger. Republished by Ann Arbor: Ulrich's, 1989.

Kaplan, S., & Kaplan, R. (2003). Health, supportive environments, and the Reasonable Person Model. *American Journal of Public Health,* 93 (9), 1484–89.

King, R. J. (2005). Home builders sue state on code: More stringent energy rules would boost cost of homes, association says. *Detroit News,* February 6, 2005. Retrieved April 11, 2005, from http://www.detnews.com/2005/business/0502/06/B01-80540.htm.

Koebel, C. T. (1999). Sustaining sustainability: Innovation in housing and the built environment. *Journal of Urban Technology,* 6 (3), 75–94.

Koskela, L., & Vrijhoef, R. (2001). Is the current theory of construction a hindrance to innovation? *Building Research and Information,* 29 (3), 197–207.

Loftness, V. (2004). Improving building energy efficiency in the U.S: Technologies and policies for 2010 to 2050. *U.S. Congress House Committee on Science.* Retrieved June 22, 2005, from http://www.house.gov/science/hearings/energy04/may19/loftness.pdf.

Lutzenhiser, L. (1994). Innovation and organizational networks: Barriers to energy efficiency in the US housing industry. *Energy Policy,* 22 (10), 867–76.

Lutzenhiser, L., & Janda, K. B. (1999). *Residential New Construction: Market Transformation Research Needs*. Davis, CA: California Institute for Energy Efficiency.

Manseau, A. (2005a). Construction—a changing industry challenging current innovation models. In A. Manseau & R. Shields (Eds.), *Building Tomorrow: Innovation in Construction and Engineering* (pp. 23–42). Hants, UK: Ashgate.

Manseau, A. (2005b). Redefining innovation. In A. Manseau & R. Shields (Eds.), *Building Tomorrow: Innovation in Construction and Engineering* (pp. 43–55). Hants, UK: Ashgate.

McElroy, T., & Seta, J. J. (2003). Framing effects: An analytic-holistic perspective. *Journal of Experimental Social Psychology,* 39 (6), 610–17.

Mead, S. P. (2001). Green building: Current status and implications for construction education. *Associated Schools of Construction, ASC Proceedings of the 37th Annual Conference*. Retrieved April 11, 2005, from http://asceditor.unl.edu/archives/2001/mead01.htm.

Miller, T. (2006). Green buildings take root in cities, schools. *PBS Newshour with Jim Lehrer*. Retrieved December 27, 2006, from http://www.pbs.org/newshour/extra/features/july-dec06/green_12-26.html.

Myers, D. G. (2002). *Intuition: Its Powers and Perils*. New Haven: Yale University Press.

NAHB. (2006). Introduction to NAHB voluntary green building guidelines. *National Association of Home Builders.* Retrieved December 27, 2006, from http://www.nahb.org/publication_details.aspx?publicationID=1994&sectionID=155.

Nobe, M. C., & Dunbar, B. (2004). Sustainable development trends in construction. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.ascproceedings.org/ASC%202004%20CD/2004pro/2003/MaNobe04.htm.

Pal, M. (2006). Cities strike pledge to build green power. *Contra Costa Times.* Retrieved December 27, 2006, from http://www.contracostatimes.com/mld/cctimes/news/local/states/california/16326740.htm.

Palmer Jr, T. C. (2006). Boston expects to be first big US city to require "green" building for large projects. *Boston Globe.* Retrieved December 27, 2006, from http://www.boston.com/business/ticker/2006/12/boston_expect_t.html.

Paumgartten, V. (2003). The business case for high-performance green buildings: Sustainability and its financial impact. *Journal of Facilities Management,* 2 (1), 26–34.

Peterson, C., Maier, S. F., & Seligman, M. E. P. (1993). *Learned Helplessness: A Theory for the Age of Personal Control*. New York: Oxford University Press.

Postman, N. (1986). *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*. New York: Penguin Books.

Power, M. (2005). Raising the bar. *Builder,* 28 (2), 140.

Riley, D., Pexton, K., & Drilling, J. (2003). The procurement of sustainable construction services in the U.S.: The role of the contractor on green building projects. *Industry and Environment: A Quarterly Review,* 26 (2–3), 66–69. Retrieved April 11, 2005, from http://www.uneptie.org/media/review/vol26no2-3/005-098.pdf.

Rooke, J., & Clark, L. (2005). Learning, knowledge and authority on site: A case study of safety practice. *Building Research & Information,* 33 (6), 561–70.

Scheuer, C. W., & Keoleian, G. A. (2002). *Evaluation of LEED Using Life Cycle Assessment Methods* (No. GCR 02-836). Gaithersburg, MD: National Institute of Standards and Technology.

Seaden, G., Guolla, M., Doutriaux, J., & Nash, J. (2003). Strategic decisions and innovation in construction firms. *Construction Management and Economics,* 21, 603–12.

Seaden, G., & Manseau, A. (2001). Public policy and construction innovation. *Building Research and Information,* 29 (3), 182–96.

Seiter, D. (2005). Top five bogus reasons not to build green. *Built Green Colorado.* Retrieved October 6, 2005, from http://www.builtgreen.org/homebuilders/bogus.htm.

Seligman, M. E. P. (1998). *Learned Optimism: How to Change Your Mind and Your Life,* 2nd ed. New York: Free Press.

Sexton, M., & Barrett, P. (2003). A literature synthesis of innovation in small construction firms: Insights, ambiguities and questions. *Construction Management and Economics,* 21, 613–22.

Shafir, E., & LeBouf, R. A. (2002). Rationality. *Annual Review of Psychology,* 53, 491–517.

Simon, A. F., Fagley, N. S., & Halleran, J. G. (2004). Decision framing: Moderating effects of individual differences and cognitive processing. *Journal of Behavioral Decision Making,* 17 (2), 77–93.

Slaughter, E. S. (1998). Models of construction innovation. *Journal of Construction Engineering and Management,* 124 (3), 226–31.

Slaughter, E. S. (2000). Implementation of construction innovations. *Building Research and Information,* 28 (1), 2–17.

Sloman, S. A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment* (pp. 379–96). Cambridge, U.K.: Cambridge University Press.

Smart Communities Network. (2005). Green Building Success Stories (Vol. 2005). Washington, DC: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.

"Sustainable construction." (2003). Sustainable construction: Facts and figures. *Industry and Environment Review,* 26 (2–3), 5–8.

"The state of." (2003). The state of green building 2003. *HousingZone.com.* Retrieved September 16, 2005, from http://www.housingzone.com/forum-green.

Tinker, A., & Burt, R. (2002). Characterizing green residential construction for green builder programs and construction education. *Associated Schools of Construction, ASC Proceedings of the 38th Annual Conference.* Retrieved June 2, 2005, from http://www.asceditor.usm.edu/archives/2002/Tinker02b.htm.

Tinker, A., Burt, R., Bame, S., & Speed, M. (2004). Austin Green Building Program analysis: The effects of water-related green building features on residential water consumption. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.asceditor.usm.edu/archives/2004/Tinker04b.htm.

Tong, V. (2007). Big homebuilders lag on green building. *Associated Press.* Retrieved March 7, 2007, from http://www.businessweek.com/financialnews/D8NNG87O0.htm.

Toole, T. M. (1998). Uncertainty and home builders' adoption of technological innovations. *Journal of Construction Engineering and Management,* 124 (4), 323–32.

Trotta, D. (2007). U.S. struggles to build green homes. *Reuters.* Retrieved March 10, 2007, from http://www.alertnet.org/thenews/newsdesk/N07377514.htm.

Turner, C. (2006). A post-occupancy look at LEED building performance. *HPAC Engineering.* Retrieved March 1, 2007, from http://www.hpac.com/GlobalSearch/Article/32116.

Vanegas, J. A., & Pearce, A. R. (2000, February 20-22). Drivers for change: An organizational perspective on sustainable construction. Paper presented at the Construction Congress VI, Orlando, FL.

Wilson, A., Malin, N., & Yost, P. (2001). EBN's priority list for sustainable building. *Environmental Building News.* Retrieved April 11, 2005, from http://www.fypower.org/pdf/EBN_GrnBuild_Priorities.pdf.

CHAPTER 3

VARIATIONS IN FAMILIARITY AMONG CONVENTIONAL AND GREEN BUILDERS

Green building is an emerging solution with an uncertain trajectory

The environmental effects of homes are significant (Augenbroe & Pearce, 2000; "Intro to USGBC," 2004; Loftness, 2004; Municipal and Industrial Solid Waste Division, 1999; Vanegas & Pearce, 2000). Compared to manufacturing, commercial construction, and transportation, however, the environmental impacts from homes are often overlooked. Yet just the operation of homes in the United States consumes over 20 percent of total primary energy. (Energy Information Agency, 2003, tables 2.1a, 2.5, 12.2). A recent UNEP report cited the particular importance of buildings, including residential structures, in combating climate change. Many of the impacts from home construction and operation also can pose direct health risks to construction workers and occupants ("Sustainable construction," 2003).

Green building practices—those designed to minimize environmental impacts through design, material use, and operations—have emerged in both the commercial and residential sectors as more environmentally appropriate alternatives to conventional building practices (Cassidy, 2004; Dooley & Rivera, 2004; Nobe & Dunbar, 2004). In the residential sector, innovative technologies and products along with revived traditional practices are being utilized to create homes that are healthier, longer lasting, and less environmentally destructive than conventionally built homes. Advocates describe green building as a holistic way of approaching construction (Van der Ryn & Cowan, 1996), an "integrated whole building approach" as opposed to the "modular" approach of conventional building (Mead, 2001, p8).

As detailed in the previous chapter, green building is experiencing rapid growth in the United States (Cassidy, 2003; Dooley & Rivera, 2004; Fahey, 2005; "Intro to USGBC," 2004; Paumgartten, 2003; Power, 2005; "The state of," 2003). But it is uncertain what the long-term trajectory might be. There is some perception that green building may remain a niche market because the environment is still a cost externality in construction, because green products are prohibitively expensive and technically unreliable, or because environmental issues are unimportant to most consumers (Brick, 2003; Cassidy, 2004; Groonroos & Bowyer, 1999; Loftness, 2004; Seiter, 2005). Growth in green practices may also be constrained by a lack of standardized benefits. At present, green building practices, while intended to be "integrated," are by no means uniform. Different programs throughout the country have different criteria by which they certify a builder or building, leading to differing implementations of green building practices (Tinker & Burt, 2002; Tinker et al., 2004). Thus, the trajectory for green building is uncertain. One experienced green building advocate recently wondered why green building has not become more commonplace.

> Green building was supposed to be the road to the promised land, where good design meshed with stewardship for the benefit of all, while the bottom line remained intact. But if Moses were an architect, he would have come back from the mountain with 10 tablets of screw-ups and cover-ups (Schendler, 2006, p2).

If the outlook on green building is promising, but by no means certain, how are construction professionals likely to respond to green building? In an environment lacking regulatory compulsion and with conflicting market pressures, construction professionals are likely to perceive the relevance of green building in widely different ways, and these perceptions are going to affect their adoption of green building practices. The research presented here is an effort to more closely examine some of these perceptual factors. More specifically, it focuses on the role of familiarity in the perceptual process. How does familiarity with green building relate to builders' evaluation and adoption of green building practices? Before presenting the research, however, these links between adoption of green building practices and familiarity need to be explained.

The role of familiarity in builder behavior

Knowledge is an essential component of behavior. At the same time, however, knowledge can be an impediment. The knowledge an experienced conventional builder has is vital to his practice, yet may not serve him well for a green building project. In fact, such knowledge may lead to false expectations. For example, a builder may expect bamboo flooring to perform like other flooring materials only to find installation and performance differences. On the other hand, lack of knowledge may lead to avoiding practices that would be advantageous.

Familiarity draws on knowledge as well as experience and goes beyond these to include a sense of comfort. It is reasonable to expect that as one acquires knowledge and gains experience, comfort will increase as well. In an area such as green building, where the materials and approaches are changing constantly, acquiring such comfort can be a major challenge. Yet gaining such familiarity is important in builders' decision making.

The conceptual model of familiarity in this article is drawn from cognitive map theory (Kaplan, 1973, 1991; Kaplan & Kaplan, 1983). Cognitive map theory proposes that humans' adaptive success is due, in part, to their ability to create and manipulate cognitive maps of objects and concepts. Cognitive maps are composed of internal representations (cognitive units representing concepts and objects) and the associations among them. With substantial experience, the internal representations become richly associated and the cognitive map becomes more compact, requiring less effort to put to use. The ease of cognitive activity with familiar information often contributes comfort or confidence.

While familiarity relates to knowledge, it is distinct in important ways. Knowledge has specific content, but familiarity also includes the estimation of one's knowledge or the estimation of match between new information and existing knowledge. For example, a new city may feel familiar based on similarities to one's hometown, even though one has no direct knowledge of it.

Particularly relevant to this paper is the important role familiarity plays in cognitive functioning. Topics, concepts, and places that are familiar are easier to think about, navigate and manage. In other words, using a well-formed cognitive map can facilitate cognitive functioning (Irvine & Kaplan, 2001; Kaplan & Kaplan, 2003). Familiar topics require less attention and leave more mental resources for other tasks. Consider a highly familiar activity such as driving. Familiarity enables people to calmly maneuver a three-ton car through dense traffic at high speeds, while thinking about other things.

Given the greater ease of functioning, it is not surprising that familiarity is often a desirable state. Conversely, unfamiliarity is an undesirable state because the lack of relevant knowledge can impair cognitive functioning. At the same time, however, the familiar may be less preferred because it no longer holds one's attention. The comfort and predictability of the familiar can also mislead. Habits, routines, and assumptions arise out of familiarity. Thus, familiarity may allow us to overlook changed conditions or exceptions and resist areas that lack familiarity. Research has shown that the degree of match between what people are familiar with and what they are confronted with plays a critical role in their problem solving (Evans, 2003; A.W. Kaplan, 1999; Myers, 2002; Rogers, 2003; Sloman, 2002; Todd & Gigarenzer, 2000). Such research has demonstrated that problem solving is more often than not a constrained process in which the solution space—the dominant options a person will pursue—are bounded by what they are familiar with.

Because of the ways familiarity develops and relates to cognitive functioning, familiarity is likely to play an important role in builders' perceptions of green practices. Builders with substantial experience, comfort, and facility with conventional construction have strong reasons to rely on their knowledge. Changing practices is likely to reduce their efficiency and add complications. Adoption of green practices, however, requires venturing into this zone of less comfort. The lack of familiarity with green practices and a bias for familiar information serve as disincentives to change and may result in overestimations of the risks of green alternatives. Obstacles related to green building may seem intractable not because the problems themselves are too complex but because builders lack the familiarity to confidently or flexibly address them. While lack of familiarity may inhibit builders' engagement with green building, increasing familiarity may be a useful route for stimulating change. Addressing builders' familiarity with green building may alleviate negative perceptions. Once builders become familiar with green practices, previously overwhelming challenges may take their place alongside other complex but common problems they feel comfortable managing.

Research questions

The issues discussed above suggest that research on builders' familiarity with green building practices could provide insights into current practices and approaches to enhancing adoption of green building practices. Further, understanding how experience with green building relates to familiarity can provide information about builders' perceptions of what they would need to know about green building before trying it out.

This research is thus located at the crossroads of studies of green building practices and research on cognitive maps in environmental problem solving. With respect to the first of these, the surveys of homebuilder attitudes and knowledge about green building (Bernstein, 2006; Roberts, 2001; "The state of," 2003; Zweigart, 2007) have focused on green building practices but have not analyzed how builders' knowledge might relate to practices. Work on the role of cognitive maps in environmental problem solving, the second topic related to the current research, has demonstrated that systematic analysis of stakeholders' perceptions has value in understanding how experience and environmental cues affect problem solving (Austin, 1994; Kearney & Kaplan, 1997; Wells, 2000). Generally, this work has focused on how the structure of knowledge among oppositional stakeholders affects collective problem solving. The studies reported here differ by looking at how differences in familiarity among otherwise comparable individuals (conventional and green builders) might reflect changes in knowledge as one gains experience with a new subject and at how these differences might relate to individual problem solving.

Study 1: Familiarity with green building

Study 1 addresses what green building means to builders. This study is intended to provide a broad outline of builders' familiarity with green building by documenting the concepts they feel represent the topic of green building. The study also examines how familiarity with green building affects the selection of these concepts. While one might expect certain concepts to be widely shared as key elements of green building, less clear is the range of concepts builders would include in their description of green building. Further, it is not clear that builders with different amounts of green building experience are familiar with green building in the same ways.

Sample

Nineteen builders from Southeastern Michigan were recruited for this study. These participants ranged widely in terms of experience with green building; some had no experience, while some had substantial experience. Ten of the builders are considered conventional builders and were recruited from personal contacts, the Home Builders Association of Washtenaw County, or EPA's EnergyStar home certification program. These builders were considered conventional because of their limited experience with green building practices. At the time of data collection (summer 2005), the Home Builders Association of Washtenaw County had done very little to support or advance green building practices. Although EPA's EnergyStar Program is focused on energy efficiency, which is important to green building, the EnergyStar participants recruited in this study had limited experience with green practices as a whole. Nine of the builders are considered green builders and were recruited from green building sources, principally the Detroit's WARM training program and Recycle Ann Arbor's Environmental House. The sources that provided contact information for the green builders recommended these individuals specifically because of their experience or interest in green practices. Although where participants are sampled from is not an ideal measure of green building experience, these sources did provide a basic filter and the sample source serves as a proxy measure of green building experience in this study.

A profile of the participants' gross sales, building experience (in years), and age is provided in Table 3.1. It is noteworthy that these two groups are quite distinct in terms of annual gross sales. The green builders in this sample run substantially smaller companies than the conventional builders. In terms of building experience and age, the two sample groups were quite similar.

Table 3.1
Sample demographics

	Median	Min	Max
Conventional (n=10)			
Gross sales	$7,000,000	$275,000	$125,000,000
building experience (years)	28	21	38
age	54.5	37	66
Green (n=9)			
Gross sales	$237,500	$100,000	$2,000,000
building experience (years)	12	4	30
age	44.5	36	55

Method

This study employed the open-ended Conceptual Content Cognitive Map (Open-3CM) method as a means to document builders' familiarity with green building (Kearney & Kaplan, 1997). 3CM enables participants to freely describe their knowledge in a way that permits the researcher to record both the content and the structure of their knowledge of a given topic. The 3CM method consists of several steps. First, the researcher poses a question about a given topic, asking participants to think about how they would explain their response to someone unfamiliar with the topic. In this case, participants were asked, "Imagine someone who knows a little bit about building asks you, 'What is green building to you?' What are all of the things you would want to tell them about?" Explaining their response in this manner helps participants organize their thoughts more than they might in an open-ended question. As the participant offers answers, the researcher writes their comments down on a card. Participants' comments are assumed to represent concepts from their cognitive map of the topic (Kaplan & Kaplan, 1983). When participants finish responding, they are asked to review the concepts and group them to reflect what they feel belongs together. Finally, they label each group with a word or short phrase that describes what the group has in common. By reflecting on how concepts go together and what they have in common, the grouping and naming helps participants to describe their cognitive maps. Concepts that are grouped together are assumed to represent associated internal representations. The participants can add concepts at any time and are free to organize their concepts and groups in any way they see fit. Taken as a whole, the results provide a picture of what aspects of a given topic participants are familiar with.

Results

Concept generation

The concepts generated by all participants covered a broad range of issues, from specific practices to personal philosophies about building, as seen in the following examples, one from each of the participant groups (Table 3.2).

Table 3.2
Examples of participant maps

Conventional Builder Map
Land[1]
protection of natural features[2]
conservation of land
Safety of workers
conserve building material resources
conserve energy resources
consideration of toxic substances during construction
Unnecessary waste of existing infrastructure
loss of materials in teardown
[teardown] rather than trying to adapt a building
don't have programs for recycling waste material
number of people who buy knowing they will teardown
Ongoing impact of the building
energy consumption post-occupancy

Green Builder Map
Economic viability
performance and design in a holistic fashion
think about what they do for their own business
most builders stuck on first costs
it's not just about supply and demand
long-term / short-term mind set
Environmental stewardship
everything effects everything else
think about what your actions impact environment
holistic building design
take a walk in the redwoods sail on Lake Michigan
Sustainability as triple bottom line
social responsibility
economic viability
environmental stewardship
triple bottom line
Social responsibility
take yourself out of the silo mind set
building life span ~ 40 years --> impacts
think longer term
breaking the mold of traditional building mind set

[1] bolded and framed phrases are group names
[2] items below group names are group concepts

The 19 participants generated 370 concepts within 78 groups. Participants averaged 20 concepts and 4 groups for an average of 5 concepts per group (Table 3.3) This volume and distribution of concepts and groups is similar to that found in other 3CM studies (Austin, 1994; Kearney, 1997; Wells, 2000).

Table 3.3
Summary of numbers of concepts and groups generated

	total	max	min	average
Concepts	370	42	10	20
groups	78	7	1	4

Category definition

Data analysis consisted of examination of both the concepts and groups to identify coherent categories and then assigning all the concepts to particular categories. Categories of recurring ideas and themes were defined by assessing common words among concepts, by identifying common themes in concepts being raised, and by examining group names. For example, in the concept "market doesn't bear the cost of extras," the words *market* and *cost* stand out. The implication of this concept is that green building costs more than conventional building. Further, the participant placed the concept in a group named "costs." Other participants also included market-related concepts leading to identifying *market incentives* as a recurring category. Three other categories also emerged from this analysis: *products and practices, environmental outcomes,* and *the green difference*. A final category, *unknown or personal,* consists of the 10 concepts (out of 370) that were not related to the four categories. After defining the categories, each of the concepts was assigned to a particular category by the researcher.

Table 3.4 provides examples of concepts included in each of these four categories and the total number of concepts assigned by the researcher to each category. To validate the assignment of concepts to categories, an independent rater was given a coding sheet with descriptions of the category definitions and instructions on how to code the concepts. On the sheet were 50 randomly selected concepts from each of four researcher-defined categories and the 10 unknown or personal concepts. The concepts were randomly distributed on the sheet and the rater was asked to code each concept in one of the five categories. For this subsample of total concepts, the rater and researcher had an 85 percent average match across the categories. See Appendix A for coding instructions and a complete list of concepts arranged by category.

Table 3.4
Categories, total number of concepts assigned to each category, and examples of concepts

Categories	Participant concepts	
Products and practices concepts = 133	> natural ventilation	> no processed finishes, plastics or polyurethanes
	> downsize furnace	> energy framing—no cold corners
Environmental outcomes concepts = 68	> healthy home	> there will be a time when there won't be more land to build on
	> conserve energy	> we use a lot of poison [in building]
Market incentives concepts = 68	> create jobs through recycling	> liability issues today in building
	> there are cost effective energy efficiencies	> green is not a concern unless [it] saves money
The green difference concepts = 104	> integrated design	> try to convince owner to build better but smaller
	> breaking the mold of traditional building mindset	> passive solar requires attention dedication and thoughtfulness
Unknown or personal concepts = 10	> spent a lot of time in the woods [as a child]	> [conventional building is] What I don't want to do

Products and practices

The *products and practices* category comprises concepts that describe technical details of green building. This category is made up of specific products or practices that builders might utilize in a building. *Products and practices* were the most frequently mentioned concepts among participants (133). Among the green building products and practices mentioned, those referring to energy efficiency were by far the most commonly discussed. Air quality, toxicity, site, and material practices or products were often brought up, but jobsite and water were only infrequently discussed. Sometimes participants talked about a new practice specifically, such as “cellulose insulation”; other times, they spoke of practices to be changed, such as “downsize furnace.”

Environmental outcomes

The *environmental outcomes* category comprises concepts related to the environmental benefits or effects from construction practices. This category comprises the why of green building, the larger reasons builders might be motivated to do green building. Occupant health issues were the dominant outcome discussed, followed by resource scarcity and habitat/land preservation issues. Energy consumption was infrequently discussed as an outcome despite the emphasis on energy in the *products and practices* category.

Market incentives

The *market incentives* category comprises participants' comments on both positive and negative drivers of the market for green building. Participants spoke of costs, market demand, financial opportunities, and uncertainties related to green building. These concepts appear to capture builders' awareness of a variety of factors that can positively or negatively influence their capacity to do green building. Concern over the increased costs related to green building was a very commonly mentioned concept in this category, although a number of participants also spoke about financial opportunities. There were relatively few comments on market demand or consumer factors. Some of the general uncertainties that may act as drivers for green building are liabilities, resistance among tradespeople, and uncertainty about the benefits given the "hassles."

The green difference

The green difference category comprises concepts that express the many ways green building differs from conventional building. *The green difference* category is not about the technical or product differences but the ways in which green building involves more fundamental changes over conventional building practices. Concepts in this category include ideas about changing the building process as a whole, perspectives on the builders' role, and ideas about changes for homeowners' expectations. Several participants spoke about the need for integrated or holistic design practices with green building as well as the need to be "more conscious" or "intentional" about the building process and the factors they consider in their practices. A number of participants pointed to the variability or subjective nature of green building compared with conventional building, highlighting the need for interpretation and greater attention to dynamic conditions for the builder. Builders also described an opportunity through green building to expand homeowners' expectations of what a home can mean emotionally, environmentally, and physically. Builders also expressed a feeling that green buildings might be a valuable way to teach people about sustainability in general.

Comparing familiarity with green building

Figure 3.1 shows the frequency of participant concepts in each of the four categories for the conventional and green builders. Frequency was determined by looking at the number of concepts for each participant that were assigned to each category as a percentage of their total comments (excluding the *unknown or personal category*) and then averaging each of these percentages for the two participant groups.

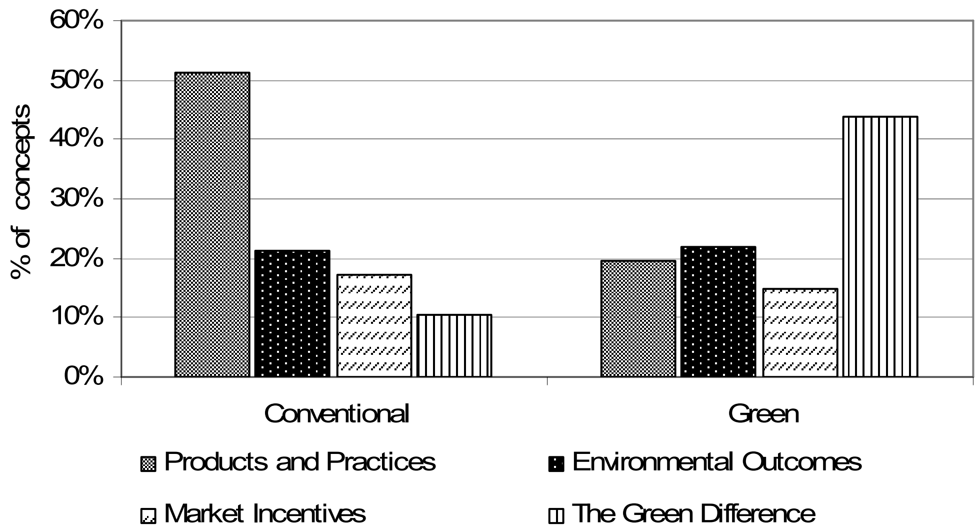


Figure 3.1 Frequency of concepts among categories for participant groups

A pairwise comparison of the frequency of each category for each of the participant groups was conducted (Table 3.5). For both the conventional and green builders, one category is mentioned significantly more frequently. As can be seen in Figure 3.1, however, the dominant category differs in the two cases. For the conventional builders, *products and practices* is significantly different from the other categories ($p<0.05$). Over 50 percent of conventional builders' concepts were assigned to this category. By contrast, for the green builders, the primary focus was on *the green difference,* which was the only category with a statistically significant difference from the others ($p<0.05$, except for with environmental outcomes $p<0.10$). Over 40 percent of green builders' concepts were assigned to *the green difference* category. Both the conventional and green builder participants had approximately the same percentages of concepts for *environmental outcomes* and *market incentives*. Despite the attention market issues receive in the press (Brick, 2003; Fahey, 2005; Sullivan, 2002), *market incentives* is not a dominant component of either the conventional or the green builders' familiarity with green building.

Table 3.5
Pairwise comparisons of category frequencies for each participant group

	Conventional (n=9) Paired differences			Green (n=10) Paired differences		
Pairs	Mean	SD	Sig.	Mean	SD	Sig.
products and practices — environmental outcomes	30%	32%	*	-4%	19%	
products and practices — market incentives	34%	35%	*	4%	16%	
products and practices — the green difference	41%	25%	**	-26%	33%	*
environmental outcomes — market incentives	4%	30%		7%	29%	
environmental outcomes — the green difference	11%	26%		-23%	36%	
market incentives — the green difference	7%	27%		-30%	30%	*

* p<0.05
**p<0.01

Study 1 discussion

This study provides insight into builders' concept of green building. Their descriptions of green building are the result of differing experiences with green building, ranging from little if any direct experience to substantial familiarity with the underlying intentions as well as practices. Based on the 370 concepts generated by the 3CM procedure, four major categories were identified, reflecting recurring themes from responses by both conventional and green builders.

Three of these categories—*products and practices*, *environmental outcomes,* and *market incentives*—are the more concrete dimensions of green building. These three categories cover much of what one would expect builders to be thinking about green building: what it is, why do it, and how much it costs.

The fourth category—*the green difference*—illustrates that some builders do not think about green building strictly in concrete terms but are interested in understanding how green building relates to their understanding of conventional building practices at a broader or more abstract level. This category suggests that some builders' cognitive maps include both a concrete set of concepts about what green building is and a set of more abstract, relational concepts about how it differs from conventional building.

Both conventional and green builders had some concepts in all four categories, but the two groups showed significant differences in emphasis across the four categories. Both participant groups had approximately equal emphasis on the *environmental* *outcomes* and *market incentives* categories, suggesting that these are definitely part of familiarity with green building. However, builders are more focused on two other categories that are part of the experience of green building from a builder's perspective. The conventional builder participants were strongly focused on the *products and practices* category, suggesting that their familiarity with green building is anchored at the building level. The *products and practices* category appears to encompass the nuts and bolts of green building at a project level. In contrast, the green builders are more focused on how green building differs from conventional building in broad, even philosophical, ways. These differences represent a significant difference in perspective.

Builders' awareness of differences may be a key piece to the adoption problem. If builders do not understand the ways that green building is different from conventional building, they may apply conventional building approaches to green projects. However, if builders have a strong sense of where conventional and green building overlap and where they diverge, they may have an easier time selecting the appropriate skills for a particular problem or seeking out more training where they identify gaps. A related issue is the time frame for developing a coherent sense of *the green difference*. While information about the environmental, financial, and technical aspects of green building may be conveyed or picked up in straightforward manner, developing a strong sense for differences may take longer and require more diverse experience. Yet, if these results hold and *the green difference* category is important to builders' success with green building, it is essential that builders' develop an understanding of the green difference early on in their experience with green building.

It is unclear from this study whether *the green difference* category is related to green building experience or to individual attributes these participants share. While a shift in emphasis from *products and practices* to *the green difference* could reflect the kind of shift from concrete to abstract that one might expect as familiarity develops, the data in this study are too limited to make such a conclusion. However, shifting from conventional to green building practices will change builders' cognitive maps over time, so this study offers hints of the direction in which these changes might occur.

Study 1 explores how familiarity with green building practices might be structured or distributed. If results of the distribution of categories among participants are representative of how familiarity differs between conventional and green builders, then these results raise questions about transition from one kind of construction practice to another. Perhaps, as builders gain experience with green practices, their knowledge spreads out, encompassing more issues while the balance of their cognitive maps shifts from the practical to the conceptual. Such a perspective provides insights that could be applied to learning opportunities and help promote the adoption of green practices. Such a conclusion is not tenable from this study alone. Given the sample size and the type of measure of green building experience, it is important to consider the possibility that observed variations in category emphasis are a poor indication of the participants' building experiences. Some of the conventional builders interviewed had done some green projects, and some of the green builders were just getting started. Participants had a range of building experience overall, which might account for some of the differences, perhaps more than their affiliation with a green or conventional organization. However, Study 1 does illustrate some of the properties of builders' familiarity. Further, familiarity with green practices appears to be distributed among coherent categories that are likely relevant to builders' choices about green practices.

Study 2: Familiarity with differences

Study 2 was designed to gain a deeper understanding of differences between conventional and green builders in their understanding of green building. More specifically, builders with differing amounts and kinds of experience with respect to green construction were asked to reflect on the differences between the two approaches.

In Study 1, the green builders placed the most emphasis on *the green difference,* which was defined as ways building practices might need to change in a more fundamental way to accommodate green building. *The green difference* focused not only on different approaches, such as the use of integrated design, but also on the different roles and expectations builders see for themselves within green building. This emphasis on differences serves as a useful way to understand familiarity. For example, conventional and natural carpets have similarities, but knowledge of their differences is also essential. On the other hand, the emphasis on differences may make builders wary of trying to change. However, if builders are familiar with the similarities as well the differences between conventional and green practices, then they may feel the unknowns are balanced out by the knowns. Thus, an examination of the perceived differences between the two kinds of building should help to clarify how builders' familiarity affects their decision making about green building.

Sample

Twenty six homebuilders from Portland, Oregon, were interviewed in the summer of 2005. Participants were recruited from a variety of organizations to reflect different kinds of experience. The conventional builders consisted of seven participants from the Multnomah County Home Builders Association (MHBA) and two from the EnergyStar (ES) program. Similar to Study 1, MHBA and ES participants had minimal explicit connections to or experience with green building practices. The remaining 21 participants were green builders, but because of potential differences in familiarity arising from the sources they were recruited from, they were separated into a "Green1" and a "Green2" group. Green1 consisted of the eight participants from the Earth Advantage (EA) program, a voluntary green building certification program. Earth Advantage uses a formal checklist approach to certifying green buildings, which may lead to a more formal and concrete familiarity with green building. Green2 includes four participants who were recruited from the Northwest Eco-Building Guild (NWEBG) and nine from the Portland Office of Sustainable Development (OSD). Both of these organizations have a broader green building advocacy mission, and the participants from these groups were recommended because of their explicit commitment to green building practices. Compared to the EA participants, the NWEBG and OSD participants are likely to have a less formal, but perhaps more intimate, familiarity with green building. Four of the initial sample were removed from analysis. Two participants did not respond to the original question and two responded that there was no difference between green and conventional building (see results below)

Demographics for each participant group in terms of annual gross sales, building experience and age are presented in Table 3.6. As shown in the table, as a group the

Green2 participants were younger and had far lower median gross sales than the other two groups. While the conventional and Green1 participants were relatively similar, the Green1 group did include two participants with over $100,000,000 in annual gross sales.

Table 3.6
Sample demographics by participant groups

	median	min	max
Conventional (n=7)			
gross sales	$4,000,000	$800,000	$14,000,000
building experience (yrs)	27	15	35
age	47	35	61
Green1 (n=8)			
gross sales	$5,500,000	$700,000	$170,000,000
building experience (yrs)	27	10	35
age	52.5	32	59
Green2 (n=11)			
gross sales	$350,000	$28,000	$3,000,000
building experience (yrs)	17.5	5.5	35
age	43.5	29	63

Method

As part of a longer interview, study participants were asked the open-ended question: “If at all, how do you think green building is different from conventional building?” Participants were instructed that the question was focused not on technical issues but on the potential differences in how green building might require builders to approach building. Participants’ responses were audio recorded and later transcribed. Transcribed responses were coded for themes, and from these themes, categories and subtopics within the categories were identified.

Results

Participants responded to the open-ended question in a variety of ways. In addition to addressing the topic of how green building is different, participants often addressed their motivations for adopting green building practices, what they see as the benefits or outcomes of adopting green building practices, and barriers to adoption. Two of the 30 participants stated in some way that green building is not different from conventional building. One participant was emphatic about the lack of fundamental differences: “You use different products a lot of recycled materials—so what? That should not lead to a different mind-set in construction.” And one felt the differences are not significant, just a “variation on what we already do.” Two further participants’ answers were also not recorded because of technical errors.

Category and topic definition

For the 26 participants who did address how green building differs from conventional building, the transcribed responses were coded for phrases such as “it takes more . . .,” “you have to be willing to . . .,” “you can’t just . . .,” “it takes . . .,” etc. Ninety response segments were identified, ranging from very brief (3 words) expressions to longer descriptions (48 words). Participants had from one to nine relevant segments in their responses. All response segments were reviewed, and recurring phrases or subjects were highlighted. Comparison and analysis of recurring phrases led to identification of broad categories and related topics. Two categories of ways green building is different from conventional building were identified: in terms of *project changes* (67 segments) and *builder changes* (70 segments). Each of these subsumed three topics. For *project changes,* the topics are *plan ahead, communication,* and *variability*. For builder changes, the topics are r*esearch/learning, commitment,* and *attention/awareness*. The categories and topics are discussed in the following section.

After determining the categories and related topics, participants’ response segments were assigned to one or more of the topics. Because of the relatively open-ended nature of the responses, segments were not restricted to only one topic. Table 3.7 presents the percentage of participants, by group, who had segments in a given topic. While most of the topics were represented with some frequency (i.e., 40 percent or more of the group members), two topics (*plan ahead* and *commitment*) were not mentioned at all by the Green1 and conventional builders, respectively.

Table 3.7

Group patterns for mentioning categories of differences between conventional and green building

		Conventional (n=7)	Green1 (n=8)	Green2 (n=11)
Project changes	plan ahead	43%		33%
	communication	57%	25%	58%
	variability	57%	63%	75%
Builder changes	research / learning	29%	50%	67%
	commitment		50%	33%
	attention / awareness	43%	50%	58%

To validate the assignment of segments to topics, an independent rater was given a coding sheet with descriptions of the topic definitions and instructions on how to code the segments. The segments were randomly distributed on the sheet, and the rater was asked to code each segment in one of the six topics. The rater and researcher had an 84 percent average match across the six topics. See Appendix B for coding instructions and complete list of segments arranged by topic.

Project changes

Sixty-seven segments were assigned to the *project change* category. Table 3.8 provides a listing of *project change* topics, the number and frequency of segments assigned to each topic, and examples from participants' response segments. Because green building introduces many new products and practices, there are ripple effects throughout the construction process that affect the timing of project activities, the information that is communicated among participants, and the number of considerations that have to be addressed on any particular jobs. The project-related changes that participants spoke of encompassed three distinct themes: *plan ahead, communication,* and *variability*. Each of these is discussed next.

Table 3.8
Project change topics and examples of participants' responses

Topics # of segments (% of category)	Examples
Plan ahead 14 (10%)	> You gotta call them 2 months in advance tell em what you want so they can, when it gets in you can get that stuff. > It's just not click and go. It's more "now who do I got to call" > Part of taking more time would involve more planning more scheduling > You have to essentially train subcontractors how to deal and work around some different technology or different material.
Communications 25 (18%)	> It takes a little more oversight with subcontractors and employees on construction methods > More showing people what you've done and explaining why > You've got to do a little bit more networking with either your suppliers, your distributor or whatever > It involves more education, constantly to convince the client
Variability 28 (42%)	> You have to be oriented toward the environment to a much larger degree that the project is in. > Being aware of the site, my clients needs and the resources that are available > Things are more tied together than you might think when you first look at the project > There's a lot of information that is hard for most builders to grasp on to, especially since it is changing so rapidly

Plan ahead

Seven (27 percent) participants spoke of a need to do more advance planning with green projects to juggle scheduling variability or to find sources for unusual materials. Some participants mentioned that in order to avoid delays they have to anticipate supply availabilities and to train subcontractors for jobs before they start working. Using an integrated construction approach appears to require significantly greater degree of planning to effectively coordinate a project. The requirement to plan ahead may lead to a basic reorganization of job structure and work flow. Conventional building projects are structured around a presumption of constant material and labor availability, from the way jobs are bid to the way subcontractors are hired. Scheduling is dictated by the builder's, subcontractor's, or client's needs, not by site conditions or product availability.

Communication

Thirteen participants (50 percent) spoke of how green projects require more communication—particularly with their subcontractors, but also with their clients and suppliers. If all goes well on a conventional project, the builder may have limited need for communication with subcontractors in the field. In a green project, because there may be new products or new systems, more communication is involved in training or supervising subcontractors. For example, when a builder specifies a standard furnace, he can simply order the product from the supplier, tell the subcontractor what is being used, and possibly not even tell the client about what decisions were made. However, specifying a new heating system, such as a geothermal one, can involve many layers of additional communication. The builder has to explain to the client the benefits of the heating system, find a qualified supplier, and possibly interview subcontractors who can install the system. Furthermore, if the subcontractor is unfamiliar with the system, the builder could end up needing to supervise the installation. If a builder does not communicate how a green project is different, subcontractors may, as one participant said, "just go back and do it the same old way." Participants also spoke about a need to participate more actively in fostering consumer awareness of and interest in green building. Participants felt there was a need to go beyond just developing their business by participating in community events that could stimulate general interest in green practices. With conventional construction, where there is no need to educate the public about what a home is, such effort is unnecessary.

Variability

Eighteen participants (69 percent) spoke of how green projects utilize a wider variety of products and practices than conventional projects. At the same time, environmental issues represent a constraint on options. This simultaneous increase and constraint on choices creates greater variability for the builder. Environmental constraints can limit the customer base for a green builder. For example, an unwillingness to use certain paints may cause customers to choose another builder. More effort is required to evaluate particular sites to identify sun paths, solar gain, and drainage patterns. A concern for the particular site conditions means that a builder cannot use as many stock designs. Because of variability in products, consumer interests, and site conditions, green projects involve much greater variation from project to project. While there are certainly many variables in conventional building projects, participants report that green practices greatly expand on conventional variation, creating, as one participant noted, an "open-ended evolving thing."

Builder changes

Seventy segments were assigned to the *builder change* category. Table 3.9 provides a listing of *builder change* topics, the number and frequency of segments assigned to each topic, and examples from participants' response segments. Participants spoke of individual changes they had undertaken since getting involved in green building or changes they anticipated being required of them if they did get involved in green building. The changes reflected perceptions that green building requires the builder to take on new roles, implement different learning processes, and even adopt a different mind-set. While changes to how construction projects are administered are to be expected with the introduction of new products and practices, the abundance of comments about changes for the builders themselves was a surprising outcome. The builder-related changes that participants spoke of encompass three distinct themes: *research/learning, commitment,* and *attention/awareness*. Each of these is discussed next.

Table 3.9
Builder change topics and examples of participants' responses

Topics **# of segments** **(% of category)**	**Examples**
Research / Learning 25 (18%)	> A true green builder really knows his stuff. He knows his suppliers, he knows the consequences of what his materials are. > When you get into green you got to do a lot more research. > Know the alternatives to conventional building. > You have to research and find new things.
Commitment 12 (9%)	> The green builder it really necessitates that kind of vision and that kind of commitment. > It takes some dedication to something against the grain. > Accountability is getting everyone to be accountable, even if they don't feel the same way or they aren't as emotionally attached to it as you are. > So you have to have more patience and integrity around this is what you want to be doing.
Attention / Awareness 33 (24%)	> You have to think a lot more about it because you want to make sure you get all the everything that meets green. > You just need to look at everything and take a step back. > There's a fundamental shift in how you approach it. > Takes a lot more thought process to stay on top of it and ahead of it and keeping that in mind as you're building.

Research/learning

Fourteen participants (54 percent) spoke of ways that green building required a thorough knowledge of both green and conventional practices. The comments in the research/learning topic suggested that green building requires a richer knowledge of building science and building practices than conventional builders currently possess. Participants mentioned that while there is an abundance of information about green building, much it is sometimes conflicting. Participants felt that they have to spend more time researching options from a wider variety of sources. However, strictly conducting research is insufficient to effective green building. To be successful, participants suggested builders need to find hands-on opportunities to try out their developing knowledge. Because of the increased number of options and configurations that a green project may involve, builders need information and experience to evaluate these options and apply them in their work.

Commitment

Eight participants (31 percent) made statements about how being a green builder requires a different level of commitment to building practices, whether in the form of greater integrity, greater perseverance, or greater willingness to do the work required. Builders spoke of principles, emotional attachment, and dedication. These affective and passionate comments seem to express the notion that green building requires an emotional or personal commitment beyond what is required for conventional building practices. There is also a sense that greater commitment is necessary because green building is riskier. One participant commented on the need to be more "accountable" when using new products or unfamiliar techniques.

Although conventional builders are also likely to say they are committed to their work, these participants seem to feel the commitment involved in green building is somehow greater or more intense. Because green building is still out of the mainstream of construction practices, these participants possibly feel that they have to assume greater responsibilities than with conventional construction. This broader responsibility appears to be tinged with a moral dimension (protecting the environment) and a sense of doing what's right, which participants noted is not supported by the building profession nor compensated financially. Therefore, participants may feel this deeper commitment is part of what makes green building different.

Attention/awareness

Thirteen participants (50 percent) spoke of ways that builders need a different mental outlook going into green projects. Participants used words such as “mind-set,” “vision,” and “concern” to express this difference. Looking broadly at these comments, it seems that participants are talking about an increase in attention to the building process and a greater awareness of impacts from decisions made in construction. These comments speak about a need for a greater ability to synthesize information in real time. It would seem that, accompanying the need for more research and experience, these participants are commenting on how green building involves a heightened level of attention and awareness throughout their work. There is also a sense in some comments that green jobs require greater awareness of the multiple layers on which a construction project affects the environment. These comments seem to reflect a sense that green builders cannot offload work to subcontractors or other participants, resulting in a greater need for attention on the part of the homebuilder.

Comparing familiarity with differences

Figure 3.2 shows the frequency of participant segments in each of the two categories for the conventional and the two green builder groups. Frequency was determined by looking the number of segments for each participant that were assigned to each category as a percentage of their total segments and then averaging each of these percentages for the three participant groups. A means comparison of the frequency of each category for each of the participant groups was also conducted (the small sample size precludes making these comparisons at the topic level). While none of these results reaches significance (at $p<.05$), there are several noteworthy observations. For the conventional builders in the sample, over 70 percent of the comments reflected project changes. Although not statistically significant, ($p<0.065$)[2], the conventional builders had the greatest disparity between the two categories. Green1 and Green2 were more similar in their distribution of comments across the two categories. Despite the large

[2] Likely due to the small sample size (n=7)

demographic differences in the two green samples, there were no measurable differences in how the green builder comments were allocated between the *builder changes* and *project changes* categories.

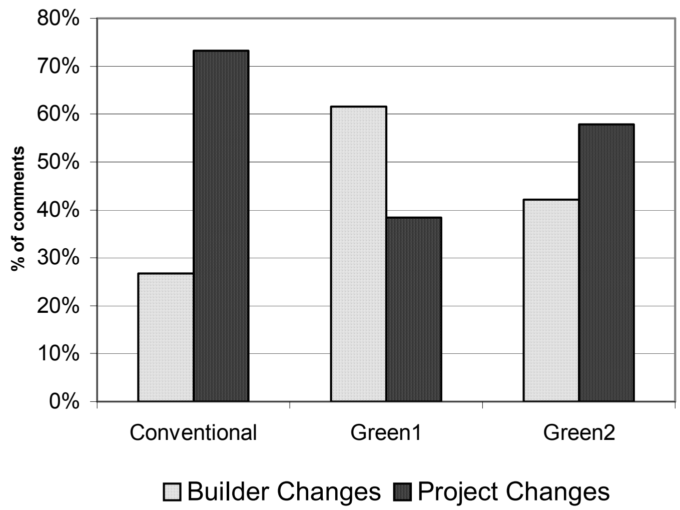


Figure 3.2 Frequency of comments among categories for participant groups

Study 2 discussion

Participants in this study identified two broad ways that green building is different than conventional building—in terms of changes to the construction project itself and in terms of changes builders themselves might need to take on. Identification of these two categories is useful in itself as a way to address the adoption of green building by current and future builders. Furthermore, the topics identified within each of these categories provide further insight into the multiplicity of issues embedded in green building.

The topics included in the project change category, *plan ahead*, *communication*, and *variability,*) provide a picture how green building projects are different from conventional ones. These topics provide a basis for examining how well builders are prepared for green projects or what tools they may need to be better prepared. For example, although some builders may recognize that green projects require more time on the phone with clients and subcontractors, they may not see that their particular experience is part of a more general requirement for more communication.

The topics included in the *builder change* category, *research/learning, commitment,* and *attention/awareness,* provide a picture of the green residential builder as one who may have important differences from conventional builders. While these changes may make green building seem out of the mainstream for many conventional builders, identifying these changes can help reduce the perceived gap between green building and conventional building. For example, being a green builder may require greater knowledge of both building science and hands-on experience with that science. Yet it is unclear if current educational opportunities provide sufficient experience for builders to feel comfortable with that material. Recognizing a need for *research/learning* creates a starting place to assess the state of builder education.

Understanding that there are common features to builders' experience of green building and that there are topics with which they may be more or less familiar creates a vocabulary for talking about builders' experience that is not currently available. Builders who do not see their particular experience as part of a larger pattern may be less equipped to manage challenges they encounter. By identifying and documenting the difference between green and conventional building at both a project and a builder level, efforts can be made to facilitate builders' skills in managing these differences.

Like the conventional builders from Study 1 who were more focused on the products and practices, the conventional builders in Study 2 were primarily focused on the ways green projects are different from conventional building. By contrast, the participants with more experience as green builders showed a more balanced perspective between the major categories, reflecting that green building entails project changes as well as commitment, attention, and research.

Examining builders' familiarity with differences in terms of these two broad categories helps to identify the scope of ways green building is different and thus makes more explicit where builders might expect challenges if they are not sensitive to these differences. Although identification of the *project changes* category is somewhat intuitive given the topic, the identification of the substantial *builder changes* category is an unanticipated outcome of this study. It is noteworthy that the builder change category has strong parallels with the Green Difference category identified in Study 1. In both instances, the differences builders are aware of are not only focused on the jobsite but also encompass builders' attitudes and approach to construction. By naming the major categories *builder changes* and *project changes,* even in a tentative way, a vocabulary of green building as a distinct construction practice begins to emerge that may help inform the development of educational programs. This will discussed further in the final section.

General discussion

These two studies of builders' familiarity with green practices have identified several categories and topics that, taken together, provide insights into builders' perceptions of green building practices. While exploratory and based on small samples, this research nonetheless enhances our understanding of factors that distinguish green building from the perspective of homebuilders. The systematic variations in conventional versus green builder descriptions of what green building is and how it differs from conventional building strongly suggest that familiarity is playing a role in builders' understanding of, and thus decision making about, green building practices.

Green building has an irregular learning curve

The results of both studies suggest an irregular learning curve for homebuilders adopting a green building approach. Acquisition of new knowledge with respect to products and practices can lead to different perspectives on *the green difference;* gaining perspective on *the green difference,* in turn, can lead to different approaches to green practices. In other words, these issues can be iterative and interactive and do not follow a single sequence. Similarly, the two categories of differences identified in Study 2—*builder changes* and *project changes*—also contribute to this irregular learning curve. Although the topics in both *project changes* and *builder changes* may be equally important to learn, the ease of acquiring the knowledge and the accessibility of pertinent information may not be equivalent. For example, the need for *communication* skills is hardly surprising, but the *attention/awareness* demands of green building are far less obvious. How explicitly topics are attached to definitions of green building will affect what builders learn and the kinds of programs developed to promote green practices.

Additionally there may be interactions between topics or categories that enhance or undermine the learning process. For example, greater experience with *research/ learning* may make *plan ahead* easier to manage. What participants describe is not just the addition of new units of knowledge but a fundamental shift in understanding about the purposes and processes of home construction. This shift may be broadly distributed among several topics that are not necessarily learned together. For example, becoming familiar with the *variability* of green construction practices may contribute to a builder's familiarity with *communication* strategies but may do less to enhance the builder's understanding of how *commitment* plays a role in green building. As a result, builders may acquire pieces of understanding about green building in small doses, with little coordination, which may exacerbate an already challenging learning process and limit builders' desire to get involved with green building.

Green building may create new roles with new responsibilities

The results provide a much richer understanding of the wide range of roles and responsibilities required of the green homebuilder. Regulations and established practices in conventional homebuilding facilitate communication among stakeholders. In a conventional project, the builder doesn't spend time convincing his clients they want drywall or a furnace, the builder just helps them pick from a few options and has their subcontractors install them. By contrast, when a builder is working with earthen plasters or solar hot water systems, he takes on the role of educator, advocate, and expert, assuming both more oversight and more risk for the outcome.

It is unclear how readily conventional builders can adapt to such new roles and responsibilities. As some researchers have noted, the construction industry has a difficult time with changes to the structure of compensation, risk, and responsibility (Lutzenhiser, 1994). The effort a builder puts into researching new products, training subcontractors, and doing outreach to clients has costs associated with it. A builder who factors in the additional costs may look overpriced compared to one who has a stock set of plans, uses the same materials on each job, and works with conventional subcontractors. If builders do not factor in the additional costs, they risk profitability, which can undermine their efforts to develop a green practice.

There also may be tensions among stakeholders as general contractors extend their oversight into subcontractors' domains. Conventional practices are structured to distribute roles among many participants—the drywall contractor handles the drywall, the painter the paint, etc. Green building asks the general contractor to participate more actively in each of these fields, making the responsibility more ambiguous. If changing roles is too challenging, builders may try to maintain their traditional roles only to face problems because the conventional role does not provide room for them to address topics such as *variability, communication, research, plan ahead,* etc. Defining and implementing new roles and responsibilities may thus presents a major challenge to builders' engagement with green practices.

Conclusions: The dilemma of change

Getting builders to change how they work—what they attend to, the ways they communicate, the flow of project tasks—takes a significant amount of time and effort. Moving into green building practices will likely slow builders' performance as they adjust to both new information and new ways of working. In a competitive environment, slowing down is not an option builders are likely to embrace. The alternative to slowing down is trying to utilize familiar approaches while moving into unfamiliar territory, basically by attempting to do green building as though it were conventional building. The participants in this study suggest that this latter approach is unlikely to yield successful outcomes for the builder or his projects. Doing a green building in a conventional way may lead to negative experiences, which will discourage builders and create a backlash among frustrated consumers, thereby increasing the perception that green building is not a viable option. Builders interested in green building face a dilemma: whether to use conventional practices on a green project or to take time out to learn a new way of building. By some measure, either option poses more risks than just maintaining the status quo. Understandably, staying with their familiar patterns is a more comfortable path. The dilemma of change is how to make the unfamiliar path more comfortable.

Recommendations

An underlying assumption of these recommendations is that some of the challenges to adoption of green practices, while related to familiarity, can also be mitigated through familiarity. Admittedly, attending to builders' familiarity is not the only way to advance green building practices; there are other stakeholders (such as consumers or regulators) and other approaches (such as policy or market interventions) that need to be part of any well-planned effort to promote green building practices. However, familiarity-based strategies that target builders directly have a place in initiating and sustaining change. Presented below are three interrelated concepts that explore how to use familiarity to develop green building programs that might overcome these problems and better engage homebuilders.

Identify opportunities for using familiarity

Although familiarity can present barriers to change, familiarity also offers opportunities for change. Builders are not going to abandon hard-earned knowledge they are very comfortable with for something completely new. If green building continues to be seen as new and thus remains unfamiliar, many builders will steer clear. However, highlighting builders' existing familiarity, such as with energy efficiency, could be used to engage them with less familiar concepts, such as passive solar design. Additionally, there are opportunities to use familiarity by looking at other stakeholders. For example, steps taken to manage *variability* do not have to focus only on builders. Effort can be made to educate other stakeholders, such as subcontractors. By increasing subcontractors' understanding of variability with green products, builders' emerging familiarity will be reinforced. Further, there are opportunities to be found by examining the sources of information that are familiar to builders, such as local homebuilder associations, public agencies, and building suppliers. These sources both convey information about green building and contribute to builders' familiarity, for example, by the degree to which *project* or *builder change* issues are covered. Without assessing the role of familiarity in builders' behaviors, there is less basis to assess their information sources. With such an assessment, it is possible to use information sources to support builders' developing skills.

Make the unfamiliar familiar

By addressing familiarity, efforts to promote green practices could move beyond "How can builders adopt something new?" to "How can something unfamiliar to builders be made familiar?" Whereas the first approach puts the onus of responsibility on the adopter, the second approach seeks to identify the interactions among the adopters, their environment, and the thing they are adopting—in this case, green building practices. To help builders bridge their familiarity with conventional building and their unfamiliarity with green building, it is important to speak the builders' language, use their existing familiarity whenever possible, and provide support for what is truly unfamiliar.

Builders generally have a high level of tactile and visual skills. Green building programs can draw on these skills to create experiences that are as real as practically possible, so that the lessons are readily apparent and directly applicable. Making clear to builders where their existing knowledge and skills can carry over into their developing knowledge of green building can go a long way to reducing the perceived and real costs of change. For example, some builders may already possess skills in some areas, such as with *communication* or *plan ahead*, but conventional building practices may have made these skills less of a priority than other skills. A green building program can emphasize skills builders already possess that may play a more prominent role with green building. Another way to make the unfamiliar familiar is by carefully describing where green building is truly unfamiliar. Such an explanation can help builders more easily see where they really need to expend effort to be effective with green building. For example, if a green building program can provide clear, contextually appropriate examples of how green building requires a different kind of *attention/awareness,* builders may have an easier time recognizing this issue when confronted by it on a project. Finally, where educational programs can identify the conventional building assumptions most likely to be ineffective with green building, builders may have an easier time making adjustments.

At present, familiarity-based strategies have not been emphasized. It may be useful to look to research in other fields to see how a sense of familiarity can be accelerated or enhanced. Kaplan and Kaplan outline an approach based on *prefamiliarization:* " If people were to become thoroughly familiar with alternative futures and their implications, then the terror of the unknown would play less of a role in the process of making necessary adjustments" (Kaplan & Kaplan, 1983, p162). Some useful examples of how to apply such strategies are found in work on stories, case studies, and simulations (De Young & Monroe, 1996; Monroe, 2003; Shanahan et al., 1999), small experiments (Irvine & Kaplan, 2001; Kaplan, 1996), and adaptive management and muddling (De Young & Kaplan, 1988; Edney, 1980). These approaches can enhance or accelerate familiarity by offering opportunities for incremental change involving participatory and experiential methods.

Coordinate the development of familiarity

The descriptions of what green building is and how it is different provided by the study participants point to a number of distinct knowledge domains—technical, personal, strategic, communications—that all are involved in a comprehensive familiarity with green building. No single course or program can possibly familiarize builders with each of these domains. Green building is going to be an irregular learning process that could leave builders with a very fragmented understanding. Green building programs could take on a coordinating role in their communities, seeking out ways to connect the diverse knowledge builders are accumulating so that they eventually acquire a more holistic understanding. Green building programs could provide information to help builders relate unfamiliar skills to familiar ones, highlighting areas where they overlap and diverge. For example, a workshop series could provide local suppliers, regulators, subcontractors, and other stakeholders a chance to articulate the ways they can support green building practices, and the green building program could identify how these different stakeholders' offerings can work together. Such a coordinating role could help to nurture the richer familiarity with green building this study suggests may be important.

Creating change

These two studies have identified important dimensions for familiarity within homebuilders' understanding and use of green building practices. If builders and green building programs focus only on the concrete dimensions of green building and the project-related differences, at the expense of an understanding of the more abstract issues and builder-related changes, the development of familiarity this study suggests is important may be critically limited. The results of this study illustrate several ways familiarity relates to builders' ability to successfully implement green practices. A new "mind-set," as one participant called it, may be needed because the problem-solving skills builders are familiar with are inadequate for green practices. Commitment is called for to break out of familiar routines and to introduce unfamiliar patterns into a well-established system. Research/learning is about obtaining both the knowledge of new products and practices and the experiential familiarity so the products can be deployed effectively. Developing familiarity with each of these topics requires effort and care. Although builders can become more familiar with green practices on their own, without support or guidance the process may be frustrating, the costs may be too high, and the risks may be too great. Providing that support through further research on familiarity among residential homebuilders could be a powerful means of creating change in the industry, which would prove of great benefit to society at large.

Acknowledgments

Data collection for Study 1 and Study 2 was financed in part through a Rackham Discretionary Fund, the School of Natural Resources and Environment Alumni Incentive Fund, and the School of Natural Resources and Environment Professional Development Fund.

The author would also like to thank contacts within the Portland Office of Sustainable Development, the NorthWest EcoBuilding Guild, and Jason Bing of Recycle Ann Arbor for putting me in touch with many of the green builders who participated in this study.

References

Augenbroe, G. L. M., & Pearce, A. R. (2000, February 22–25). *Sustainable Construction in the USA: A Perspective to the Year 2010.* Paper presented at the International Conference on World Futures, Sri Lanka, India.

Austin, D. E. (1994). Exploring Perceptions of Hazardous Waste Facility Proposals in Indian Country: An Application of the Active Symbol Cognitive Map Model. (PhD, University of Michigan, 1994). *Dissertation Abstracts International,* 55, 1012.

Bernstein, H. M. (2006). *Residential Green Building SmartMarket Report*. New York: McGraw Hill.

Brick, M. (2003). Not building green is called a matter of economics. *New York Times,* p. 5.

Cassidy, R. (2003). White paper on sustainability: A report on the Green Building Movement. *Building Design and Construction.* Retrieved April 11, 2005, from http://www.bdcnetwork.com/contents/pdfs/BDCWhitePaperR2.pdf.

Cassidy, R. (2004). Progress report on sustainability. *Building Design and Construction.* Retrieved October 3, 2005, from http://www.bdcnetwork.com/contents/pdfs/bdc04White_Paper.pdf.

De Young, R., & Kaplan, S. (1988). On averting the tragedy of the commons. *Environmental Management,* 12 (3), 273–83.

De Young, R., & Monroe, M. C. (1996). Some fundamentals of engaging stories. *Environmental Education Research,* 2 (2), 171–87.

Dooley, R., & Rivera, J. (2004, March). Green building goes mainstream. *Professional Builder,* 69, 71–72.

Edney, J. J. (1980). The commons problem: Alternative perspectives. *American Psychologist,* 35 (2), 131–50.

Energy Information Agency. (2003). Annual Energy Review 2003 (Vol. 2005). Washington, DC: U.S. Department of Energy.

Evans, J. S. (2003). In two minds: Dual process accounts of reasoning. *Trends in Cognitive Science,* 7 (10), 454–59.

Fahey, V. (2005). Building green always made sense—now it's beginning to pay off. *San Francisco Chronicle.* Retrieved September 11, 2005, from http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2005/09/11/REG4DEKFQD1.DTL.

Groonroos, J. C. M., & Bowyer, J. L. (1999). Assessment of the market potential for environmentally certified wood products in new homes in Minneapolis/St. Paul and Chicago. *Forest Products Journal,* 49 (6), 28–34.

"Intro to USGBC." (2004). An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System®. *U.S. Green Building Council.* Retrieved February 26, 2005, from https://www.usgbc.org/Docs/Resources/usgbc_intro.ppt.

Irvine, K. N., & Kaplan, S. (2001). Human ingenuity and environmental problems. *Environmental Management,* 12 (3), 273–83.

Kaplan, A. W. (1999). From passive to active about solar electricity: Innovation decision process and photovoltaic interest generation. *Technovation,* 19, 467–81.

Kaplan, R. (1996). The small experiment: Achieving more with less. In J. L. Nasar & B. B. Brown (Eds.), *Public and Private Places* (pp. 170–74). Edmond, OK: Environmental Design Research Association.

Kaplan, S. (1973). Cognitive maps in perception and thought. In R. M. Downs & D. Stea (Eds.), *Image and Environment: Cognitive Mapping and Spatial Behavior* (pp. 63–78). Chicago: Aldine.

Kaplan, S. (1991). Beyond rationality: Clarity-based decision-making. In T. Gärling & G. W. Evans (Eds.), *Environment, Cognition and Action: An Integrated Approach* (pp. 171–90). New York: Oxford University Press.

Kaplan, S., & Kaplan, R. (1983). *Cognition and Environment: Functioning in an Uncertain World.* New York: Praeger. Republished by Ann Arbor: Ulrich's, 1989.

Kaplan, S., & Kaplan, R. (2003). Health, supportive environments, and the Reasonable Person Model. *American Journal of Public Health,* 93 (9), 1484–89.

Kearney, A. R. (1997). Some Implications of Cognitive Map Theory for Environmental Problem Solving and Decision Making. (PhD, University of Michigan, 1997). *Dissertation Abstracts International,* 58, 615.

Kearney, A. R., & Kaplan, S. (1997). Toward a methodology for the measurement of knowledge structures of ordinary people: The Conceptual Content Cognitive Map. *Environment and Behavior,* 29 (5), 579.

Loftness, V. (2004). Improving Building Energy Efficiency in the U.S: Technologies and Policies for 2010 to 2050. *U.S. Congress House Committee on Science.* Retrieved June 22, 2005, from http://www.house.gov/science/hearings/energy04/may19/loftness.pdf.

Lutzenhiser, L. (1994). Innovation and organizational networks: Barriers to energy efficiency in the U.S. housing industry. *Energy Policy,* 22 (10), 867–76.

Mead, S. P. (2001). Green building: Current status and implications for construction education. *Associated Schools of Construction, ASC Proceedings of the 37th Annual Conference.* Retrieved April 11, 2005, from http://asceditor.unl.edu/archives/2001/mead01.htm.

Monroe, M. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review,* 10 (2), 113–25.

Municipal and Industrial Solid Waste Division. (1999). Characterization of Municipal Solid Wastes in the United States: 1998 Update. In Office of Solid Waste (Ed.) (Vol. 2005). Washington DC: Environmental Protection Agency.

Myers, D. G. (2002). *Intuition: Its Powers and Perils*. New Haven: Yale University Press.

Nobe, M. C., & Dunbar, B. (2004). Sustainable development trends in construction. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.ascproceedings.org/ASC%202004%20CD/2004pro/2003/MaNobe04.htm.

Paumgartten, V. (2003). The business case for high-performance green buildings: Sustainability and its financial impact. *Journal of Facilities Management,* 2 (1), 26–34.

Power, M. (2005). Raising the bar. *Builder,* 28 (2), 140.

Roberts, J. (2001). The state of green building. *Housing Zone.* Retrieved February 26, 2005, from http://www.housingzone.com/green/index.asp.

Rogers, E. M. (2003). *Diffusion of Innovations,* 5th ed. New York: Free Press.

Schendler, A. (2006). Raise high the green beam, carpenter: Why is green building still so hard? *Grist Magazine.* Retrieved June 9, 2006, from http://www.grist.org/comments/soapbox/2006/06/08/green-building.

Seiter, D. (2005). Top five bogus reasons not to build green. *Built Green Colorado.* Retrieved October 6, 2005, from http://www.builtgreen.org/homebuilders/bogus.htm.

Shanahan, J., Pelstring, L., & McComas, K. (1999). Using narratives to think about environmental attitude and behavior: An exploratory study. *Society and Natural Resources,* 12, 405–19.

Sloman, S. A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment* (pp. 379–96). Cambridge, UK: Cambridge University Press.

Sullivan, C. C. (2002). New rules, tax breaks boost green building. *Architecture,* 91 (12), 14.

"Sustainable construction." (2003). Sustainable construction: Facts and figures. *Industry and Environment Review,* 26 (2–3), 5–8.

"The state of." (2003). The state of green building 2003. *HousingZone.com.* Retrieved September 16, 2005, from http://www.housingzone.com/forum-green.

Tinker, A., & Burt, R. (2002). Characterizing green residential construction for green builder programs and construction education. *Associated Schools of Construction, ASC Proceedings of the 38th Annual Conference.* Retrieved June 2, 2005, from http://www.asceditor.usm.edu/archives/2002/Tinker02b.htm.

Tinker, A., Burt, R., Bame, S., & Speed, M. (2004). Austin Green Building Program analysis: The effects of water-related green building features on residential water consumption. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.asceditor.usm.edu/archives/2004/Tinker04b.htm.

Todd, P., & Gigarenzer, G. (2000). Precis of simple heuristics that make us smart. *Behavioral and Brain Sciences,* 23, 727–80.

Van der Ryn, S., & Cowan, S. (1996). *Ecological Design*. Washington DC: Island Press.

Vanegas, J. A., & Pearce, A. R. (2000, February 20-22). Drivers for change: An organizational perspective on sustainable construction. Paper presented at the Construction Congress VI, Orlando, FL.

Wells, N. M. (2000). Housing and well-being: A longitudinal investigation of low-income families transitioning to new dwellings. (PhD, University of Michigan, 2000).

Zweigart, W. (2007). Green building survey. *IMRE Communications.* Retrieved February 2, 2007, from http://www.imrecommunications.com/GreenBuilding.pdf.

CHAPTER 4

DEFINING THE ROLE OF FAMILIARITY IN GREEN BUILDING PRACTICES

Toward a new understanding of green building

Homebuilding is one of the biggest segments of most national economies (Hutchings & Christofferson, 2001; Loftness, 2004), yet other sectors (e.g., manufacturing, utilities, transportation, commercial buildings) receive more attention for their environmental impacts. During construction, operation, and deconstruction, homes consume large amounts of energy, raw materials, and water (Augenbroe & Pearce, 2000; "Intro to USGBC," 2004; Loftness, 2004; Municipal and Industrial Solid Waste Division, 1999; Vanegas & Pearce, 2000). Homes built with conventional building practices pose health risks to workers and occupants from inadequate ventilation or from the release of toxins from carpets, paints, and finishes ("Sustainable construction," 2003; Wilson, 2006).

Over the last decade, green building practices—those designed to minimize environmental impacts through design, material use, and operations—have become more common in both the commercial and residential sectors (Cassidy, 2004; Dooley & Rivera, 2004; Nobe & Dunbar, 2004). As detailed in Chapters 2 and 3, green building has experienced a rapid growth in the United States, yet it still accounts for only a small percentage of total construction (Bernstein, 2006). Further, green building is evolving throughout the United States with regional programs implementing green building practices differently (Brown, 2007; Tinker & Burt, 2002; Tinker et al., 2004). Even within one program, outcomes can vary substantially. A recent assessment of 11 LEED certified buildings found that the designs on which specific credits were awarded both over- and underestimated actual energy and water consumption (Turner, 2006).

Reflecting on the more developed history of research on energy efficiency in the built environment raises questions about green building's trajectory. For some time, researchers have struggled to understand the persistence of the "efficiency gap," the gap between what gets built and what is economically and environmentally justifiable (Guy & Shove, 2000; Janda, 1998; Sanstad & Koomey, 2007). Despite significant effort, many feasible energy efficiency practices have yet to be adopted in the building sector. This suggests that adoption of innovative, environmentally beneficial building practices is not straightforward. To modify Guy and Shove's comments on the trajectory of insulation practices in the United Kingdom: "Although appealing and although extremely influential, the vision of linear progress toward [greener building practices] and so more sustainable future simply does not square with the realities and practicalities of the [construction industry] (Guy & Shove, 2000, p91)."

Realization of sustainability goals for the built environment will not happen through a focus on individual buildings alone. To achieve these goals requires widespread adoption of innovative building practices. However, history and current trends suggest that adoption of green practices, while gaining momentum, is unlikely to be linear or continual; therefore, it is useful to explore conditions that can better support such adoption.

Current perspectives: Construction innovation

Stimulating the adoption of green practices is a challenging objective that requires an understanding of the complexities of innovation in the construction sector as well as the particular challenges related to green building. This section briefly reviews the research on innovation in the construction industry as it relates to green building practices. A more detailed discussion of this material is found in Chapter 2.

Research on construction innovations began within the broader field of innovation research, but over time it has developed theories and empirical work that specifically address innovation in the construction sector (Shields, 2005). The earlier emphasis saw the firm as the center for innovation, focusing on issues such as research intensity or customer service (Manseau, 2005). More recent research examines the forces behind innovation, in particular, issues such as network structure, information flows, and social dynamics (Andersen et al., 2004; Bossink, 2004; Janda, 1998). For example, the diversity of stakeholders involved, the project-based nature of the work, and the localized structure of the industry make construction networks highly complex and fragmented. This complexity and fragmentation can make adoption of innovations difficult to implement (Lutzenhiser, 1994). Additionally, constraints on the flow of information can inhibit the ability of stakeholders to make informed decisions about innovations (Seaden et al., 2003; Slaughter, 2000). Some researchers have also moved toward a view of construction innovation as primarily a social process in which relationships among stakeholders structure decision making about innovation (Harty, 2005; "In this special issue," 2005; Koebel, 1999; Lutzenhiser & Janda, 1999). For example, social issues, such as trust in contractual relationships or comfort with information sharing, are found to affect innovation.

While not described as such in the literature, these innovation factors can be cast in terms of sources of information and communication patterns. As such, they offer important recognition of the ways in which the dynamics between information sources and information recipients are vital to the innovation process.

Green building as an innovation problem

In the United States, adoption of green homebuilding practices presents a particularly challenging construction innovation problem. Ideally, green buildings utilize an integrated, whole-building approach as opposed to the modular and highly subcontracted approach common in conventional construction (Mead, 2001). Green building projects often involve a number of new products (e.g., flooring materials, HVAC technologies, envelope systems) as well as the establishment of new working relationships to implement the new features. While a green innovation requires careful evaluation, integrating multiple innovations increases the number of variables that must be considered and managed (Mead, 2001; Riley et al., 2003; Vanegas & Pearce, 2000). For example, with some green products, trained installers are in short supply, so the general contractor typically provides more oversight than on a conventional construction project. To build green homes using integrated practices, homebuilders may need to change the ways they approach projects, the factors they consider in planning and execution, and the selection process for products and systems (Nobe & Dunbar, 2004).

A new perspective: Information processing and innovation

The construction innovation literature focuses much attention on the role of information delivery. The implicit assumption in this work is that once builders have enough information or the right information, they will realize the value of a given innovation and adopt it. Information, however, is not a material good that is bought, packaged, and delivered, ready to use. As discussed in Chapters 2 and 3, time and practice are required to turn information into usable skills. The ways people accumulate, integrate, and apply information are, in part, a result of their information-processing capacities. There is ample empirical evidence that information-processing influences what people perceive, how they make decisions, and ultimately how they change their behavior (Costanzo et al., 1986; Evans, 2003; Gigarenzer, 1997; Kahneman, 2003; Kaplan, 1991).

Information delivery in the construction innovation literature has been critically examined, principally from a sociological and organizational behavior perspective (Bresnen et al., 2005; Guy & Shove, 2000). However, information processing has received scant attention in the construction literature. In his dissertation research, Bueche (2005) included personality trait measures such as dogmatism, fatalism, and rationality that are related to information processing. A number of authors recognize the role of information processing through their emphasis on information transfer and education (Hassell et al., 2003; Holman Enterprises Ltd., 2001). Existing approaches, however, utilize relatively static models of mental processes: Beuche's personality traits are fixed characteristics, and the information transfer approaches cited above assume that people absorb information in a complete and rational fashion. A few scholars are more sensitive to the fluid nature of information processing. Martin and Bernstein (2006) note, "In order to knock down barriers to innovation it becomes essential to understand the different learning processes of consumers, builders, manufacturers and others" (p18). The one information-processing construct that does appear in the construction innovation literature is attitude. For example, a positive attitude about innovation or an interest in innovation have been linked to increased adoption (Koebel & Cavell, 2006; Martin & Bernstein, 2006; Toole, 1998).

This chapter adds to the available work by examining information processing as a tool for understanding construction innovation. More specifically, familiarity is presented as a central concept, useful for understanding and facilitating builders' use of green practices.

Familiarity

Familiarity refers to a facility with knowledge applied to the current situation. Being familiar suggests confidence in one's grasp of a topic or in one's ability to apply current knowledge to new problems. How much familiarity affects decision making is dependent on the presence (and strength) of relevant knowledge and the degree to which environments support decision making (Atran et al., 1999; De Young & Kaplan, 1988; Kaplan & Kaplan, 1983; Kaplan & Peterson, 1992).

Research suggests that the match between what people are familiar with and what they are confronted with plays a critical role in their problem solving (Evans, 2003; A.W. Kaplan, 1999; Myers, 2002; Rogers, 2003; Sloman, 2002; Todd & Gigarenzer, 2000). There is a common tendency for people to overestimate the value of familiar information and underestimate or disregard unfamiliar information (Kaplan, 2000). Familiarity is relevant to several research topics, such as expertise, cognitive clarity, explanatory styles, judgment, media effects, and intuition (Kaplan, 1991; Austin, 1994; McCombs & Estrada, 1997; Kearney & Kaplan, 1997; Seligman, 1998; Kaplan, 2000; Myers, 2002; Kahneman, 2003). Research in these domains demonstrates that problem solving is often a constrained process in which the solution space—the dominant options people pursue—are bounded by familiarity. As familiarity expands in one domain, people's capacity to see outside that domain can be compromised. People may leap to conclusions, be unable to adapt their problem solving to new requirements, or be unable to understand others' confusion about topics that they perceive as straightforward.

Despite the importance of familiarity in decision making and behavior, there is relatively little work on how familiarity relates to innovation. Although citing familiarity in the context of diffusion of innovation, Wejnert (2002) uses familiarity as a proxy for knowledge, not as the information processing construct described above. When discussing how a proinnovation bias in diffusion research has resulted in a failure to examine nondiffusion cases, Rogers (2003) implicitly acknowledges the undeveloped state of familiarity when he says, “if only the diffusion scholar could adequately understand the individual’s perceptions of the innovation and of the individual’s situation” (Rogers, 2003, p114). To my knowledge, research by Kaplan (1999) and the research discussed here are among the few studies considering familiarity as an information-processing construct in the context of innovation. Kaplan found that familiarity, measured as confidence in knowledge, was a significant predictor of utility managers’ innovation decisions. He concludes, “Familiarity is an important variant on the conventional knowledge-based decision model that has framed innovation research” (A.W. Kaplan, 1999, p479). The qualitative interviews with residential builders presented in Chapter 3 documented systematic variation in familiarity based on participants’ green building experience, which suggest ways that familiarity might relate to innovation decisions.

While each person’s familiarity is idiosyncratic, familiarity has general characteristics. For groups of people with similar backgrounds, familiarity can be structured and activated in similar ways (Bardwell, 1991; Kaplan & Kaplan, 1983; McCombs & Estrada, 1997; Myers, 2002; Peterson et al., 1993). Identifying general characteristics of familiarity among groups of people provides insight on how they respond to change and has the potential to generate strategies for using familiarity to facilitate change.

Familiarity is likely to play a role in homebuilders’ innovation decisions. In construction, familiarity is readily visible, distinguishing the well-schooled but inept novice from the wizened journeyman. Being effective with materials and tools requires more than mere possession of information, it requires familiarity. However, familiarity may also bias builders, especially when it comes to new practices. Experienced builders have a wide array of skills they know well. In comparison, new practices may appear to require giving up hard-earned skills to take on something with vaguely defined benefits and many risks. Confusion stemming from a lack of familiarity may dissuade builders from recognizing the viability of alternatives.

Toward a model

The study presented here explores the role of familiarity as a potential link—or mediating variable—in explaining the likelihood of adopting green practices. The issues previously studied in the innovation literature are included here as both formal and informal information sources as well as in terms of characteristics of builders or firms. In addition, the study incorporates builders' attitudes about the importance of green building issues as a further link between the information-based sources and the likelihood of adopting green practices.

For purposes of this study, the issues addressed by the prior work on innovation in the construction industry are represented by three information source constructs. *Formal* information comes from sources such as trade magazines, suppliers, building associations, conferences, and the internet. *Informal* information sources, by contrast, rely on social networks, organizational structure, and more indirect patterns of communication. The third construct, *builder/firm characteristics,* includes a variety of background issues (e.g., age, education, construction type) that have been related to innovation (Blackley & Shepard, 1996; Holman Enterprises Ltd., 2001; Toole, 1998). Such background characteristics represent a source of information that is particular to the builder or the firm.

Formal information about innovations comes from a variety of sources builders are likely to access. Many builders belong to trade associations, read magazines, and attend conferences. These sources often provide explicit information about particular innovations. While formal information sources address innovations specifically, they may not convey the same information. Different sources offer different perspectives on any given innovation. For example, trade magazines are likely to provide information about green building that is very different from that available through the internet or at a conference. Which and how many formal information sources builders utilize are often related to innovation behaviors (Hassell et al., 2003; Toole, 1998). Martin and Bernstein point to the importance of formal information: "The homebuilding industry and consumers are reluctant to embrace innovation due to the little objective public information documenting the full benefits of an innovation" (Martin & Bernstein, 2006, p12).

Informal information is an important input to builders' knowledge. For example, personal experience can tell a builder much about the viability of new practices in ways that a manufacturer's pamphlet cannot. Formal information sources are less likely to provide useful information to a builder about how local codes affect the use of an innovation. However, informal experiences with the local code officials may offer critical information to a builder about what can work in their community. Such informal information is essential to making decisions about the viability of particular innovations. Informal information is often described in the literature in terms of the organizational, regulatory, or market "barriers" that builders face (Blackley & Shepard, 1996; Building Technology Inc., 2005). Koebel highlights the importance of informal information when stating, "production builders are more prone than small builders to think that building codes impede innovation, that new building products increase the risk of call-backs and that their own construction workers are resistant to innovation" (Koebel et al., 2006, p*x*).

The information-processing component of the study includes both *familiarity* and *attitude*. While familiarity would appear to provide a useful framework for understanding builders' decision making about green building, evidence for this framework has yet to be developed. Because information processing is central to how people respond to information, builders' familiarity should theoretically mediate the information sources described above. If builders lack the familiarity to confidently address green building problems, they are likely to treat green building information differently than conventional building information. Given the documented role for attitudes in the construction innovation literature, it provides an important alternative mediator for information sources.

In light of the literature on innovation and these theoretical considerations, a research model is proposed to explore familiarity (Figure 4.1). In addition to a familiarity construct, the model includes attitude as potential mediating constructs to account for green practices. The issues addressed by the prior innovation work are shown on the left: builder/firm characteristics and formal/informal information.

This model addresses two questions that collectively assess the role of familiarity in green building practices:

- To what degree do the information-processing constructs predict green practices and mediate information sources?
- Is familiarity more significant than attitude, either directly or as a mediator?

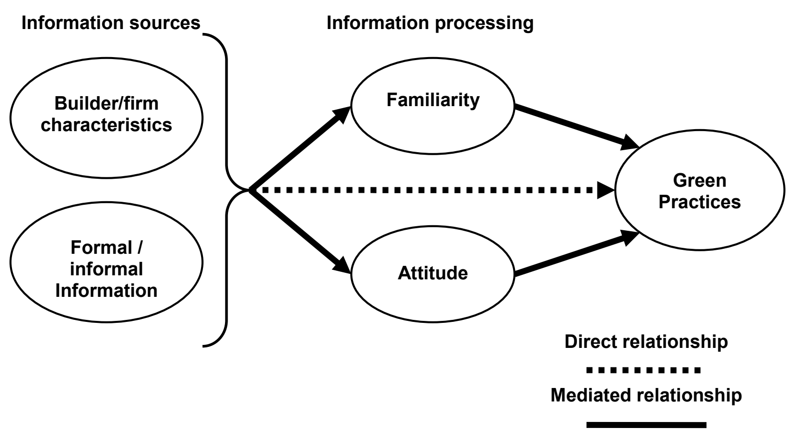


Figure 4.1 Construct diagram with lines showing theoretical relationships

Methods

Instrument

Development of questions for each of the model constructs was based on literature reviews, analysis of websites and mainstream media articles on green building, and the research from Chapter 2. Details of these factors and criteria for scale construction are presented in the next section. (See Appendix C for survey questions.)

In the spring of 2006, a five-page survey was sent to builders with a cover letter explaining that this research is “about how residential builders view ‘green’ or environmental building practices and is part of dissertation research at the University of Michigan.” Three weeks after the original survey, a reminder card was sent out with a link to an online version of the survey.

Sample

In order to sample builders with a wide range of green building experience, participants were recruited from directories of green building organizations and local homebuilder organizations. Where possible, participants were recruited from regions with both an active residential green building program and a local homebuilder association (Table 4.1). While membership in an organization provides no assurance of green building experience, and experienced green builders may not belong to these organizations, using these organizations made it possible to specifically target builders likely to have green building experience.

Table 4.1
Sample profile

Program name	State	response	sample	response rate
City of Scottsdale Green Building Program	AZ	3	61	4.9%
BuiltGreen	CO	19	124	15.3%
Greater Atlanta HBA[1]	GA	16	251	6.4%
Earthcraft House	GA	18	145	12.4%
Washtenaw County HBA	MI	22	203	10.8%
Livingston County HBA	MI	9	181	5.0%
NorthWest EcoBuilding Guild	OR, WA, ID	19	87	21.8%
Greater Austin HBA	TX	18	314	5.7%
Austin Energy Green Building Program	TX	19	45	42.2%
Greater Dallas HBA	TX	5	76	6.6%
Wisconsin Builders Association	WI	7	136	5.1%
Green Built Home	WI	13	49	26.5%
unknown[2]		3	~	~
Total		*171*	*1672*	*13.6%*

[1]HBA=HomeBuilder Association

[2]Online response that did not indicate source

Of the 1672 surveys that were distributed, 171 were returned, including 8 online. The response rate, approximately 14 percent, is close to what Bueche (2005) considers typical. However, according to Ed Hudson, NAHB's Manager of Builder and Consumer Practices (personal communication, October 25, 2006) this figure is at the high end of response rates for the residential building industry. Conventional builder organizations were oversampled relative to green builder organizations because the number of green building organizations in the United States is still relatively small. However, response rates for these groups were far lower (7 percent) than for participants from green builder organizations (20 percent). In absolute numbers, however, just over half of the sample (53 percent) came from green sources.

Results

Analysis consisted of three stages; identification of construct measures, prediction of use of green practices, and modeling of relationships.

Identification of constructs

For the builder/firm characteristics, construct variables were taken directly from the survey (see Appendix C). For the remaining constructs (e.g., formal/informal information, familiarity, attitude, green practices), exploratory factor analyses were conducted to identify latent constructs and produce scale scores using principle components analysis with varimax rotation. Criteria for factors included: eigenvalues greater than 1.0, factor loadings greater than 0.5, exclusion of items that loaded on multiple factors above 0.4, no less than 3 items per factor, absolute skew or kurtosis < 2.0, and alpha reliability greater than 0.7. Scale scores are the mean of items comprising the factor.

Information sources

Builder/firm characteristics

Respondents are predominantly owners of their companies, with a mixture of on-the-job and management experience and a median of 19–24 years of building experience. Almost half of respondents have a bachelor's degree; the median age range is 45 to 54 years. Respondents' building practices are a mixture of remodeling, spec., and custom homebuilding. The majority of respondents' homes sell for between $250,000 and $800,000, with median annual gross sales of $1,500,000. Almost half of the respondents are developers as well as homebuilders. Overall, respondents' practices and backgrounds suggest a sample with similar background and company structure to homebuilders in the United States. However, respondents' median annual gross sales are less than half the weighted average of gross sales for residential construction from the 2002 census, approximately $3,400,000 (Census Bureau, 2005). For a complete list of the builder/firm characteristics, see Appendix D.

Formal/informal information

To assess the role of formal information in builders' use of green building practices, participants were asked, "How much do you rely on these information sources to learn about new techniques and practices (for either conventional or green building information)?" Responses went from *not at all* (1) to *all the time* (5). Participants were asked about their use of such information sources as magazines, conferences, manufacturers, and suppliers. Some sources were labeled as either conventional or green with examples provided. Additionally, items asked about participants' use of formal information from other sources, such as other builders, the internet, or clients.

Factor analysis yielded one factor, labeled *green information sources* (Table 4.2), which combines a variety of sources of information about green building, such as seminars, conferences, organizations, and magazines. Participants rated their frequency of relying on green information sources slightly less often than "sometimes" (mean = 2.80).

Table 4.2
Sources of formal information about green building

Factor name and items included	mean	SD	alpha
Green information sources	2.80	1.12	0.85
Green local seminars or workshops			
Green conferences			
Green building organizations			
Green trade magazines			

To assess the role of informal information in builders' use of green building practices, participants were asked, "Currently for you, how much of a barrier to doing green building are the following?" Responses ranged from *not at all a barrier* (1) to *very much a barrier* (5). Items were included that addressed a range of barriers found through the interviews from Chapter 3 and the literature. Items addressed informal information such as building codes, product reliability, costs for green features, and customer demand.

Factor analysis yielded one factor labeled *the construction network* (Table 4.3) because, in previous studies, the structure of local networks of suppliers, products, and subcontractors are linked to builders' capacity to adopt innovative practices (Bossink, 2004). The degree to which a builders' construction network is a barrier to green building provides important information to builders that does not come from formal sources. In this study, participants rated their construction networks slightly more than "somewhat" of a barrier to the use of green practices (mean = 3.27).

Table 4.3
Sources of informal information about green building

Factor name and items included	mean	SD	alpha
The construction network	3.27	0.94	0.81
Suppliers' knowledge of green products			
Availability of products			
Trades / subcontractors' familiarity with green practices			

Information Processing

Familiarity

Drawing on A. W. Kaplan's (1999) work on familiarity and innovation among utility managers, familiarity is measured as confidence with knowledge. To measure familiarity, participants were asked, "How confident are you in your current knowledge of green building techniques and issues?" Responses ranged from *not at all confident* (1) to *very confident* (5). Twenty-five questions were included in the measure; 16 address specific green building practices, such as passive heating, storm water management, and recycled materials; 3 relate to broader environmental impacts on the climate, air quality, and water; and 6 relate to financial or implementation issues, such as liability risks or product reliability.

Factor analysis yielded two factors, labeled *familiarity with green techniques* and *familiarity with green systems* (Table 4.4). Although the correlation between the two factors is relatively high (r = .68), both are included because of their relatively high internal consistency and their emphasis on contrasting elements of familiarity.

Table 4.4
Familiarity with green building

Factor names and items included	mean*	SD	alpha
Familiarity with green techniques	3.45	0.91	0.82
Ventilation systems for improving indoor air quality			
Health effects from mold and moisture			
Equipment and appliance efficiency			
Climate change from energy consumption			
Familiarity with green systems	3.04	0.99	0.90
Suppliers of green building products and equipment			
Costs for green building features			
Reliability of green products			
Availability of trades / subcontractors with green experience			
Customer demand for green features			

*means have a significant pairwise t-test comparison at p<.001

Familiarity with green techniques is composed of four items focused on specific techniques that might be used on green projects. The items in this factor address topics that are commonly associated with the performance of the building itself. Specification of energy efficiency or air quality equipment requires a familiarity with technical details and the mechanics of installing the equipment that delivers that performance. Overall, participants rated themselves more than "somewhat" familiar (mean = 3.45) with green building techniques.

Familiarity with green systems is composed of five items that reflect builders' familiarity with the larger systems in which green building practices occur. In contrast to the technical knowledge emphasized in the first familiarity factor, the items in the systems factor incorporate knowledge of economic, behavioral, and social aspects of green building practices. For example, understanding customer demand involves an appreciation of both market conditions and buyer behavior. Evaluating green products can involve life-cycle costing and an ability to seek out information from a diverse set of suppliers. The included items suggest this factor is measuring familiarity with a broader set of issues than are involved in the technical side of green building. Overall, participants rated themselves as "somewhat" familiar (mean = 3.04) with green systems.

Attitude

To measure participants' attitudes toward green building, participants were asked, "How important to you is improving the environmental performance of buildings?" Responses ranged from *not at all important* (1) to *very important* (5). Items were included that addressed the major environmental impact areas that green building practices often target. Factor analysis extracted one component labeled *environmental performance attitude* (Table 4.5). Despite large differences in how a builder might have to deal with environmental impacts, such as energy consumption or material resource use, builders' attitudes about the importance of addressing these impacts emerged as a single factor. Overall, participants rated *environmental performance attitude* close to "very important" (mean = 4.34).

Table 4.5
Attitude factor

Factor name and included items	mean	SD	alpha
Environmental performance attitude	4.34	0.68	0.81
Water resource use			
Material resource use			
Plant and animal habitat impacts			
Energy consumption			
Indoor air quality			

These participants reported that improving environmental performance is very important. These results suggest that a positive attitude toward the idea of green building may be well established in the building community. Further, this positive attitude encompasses the broad range of issues green building practices are intended to address.

Green practices

To measure builders' use of green practices, participants were asked, "How often are you using green practices in your construction work?" Responses ranged from *never* (1) to *all the time* (5).The items in this measure include techniques that represent the major impact areas defined by many green building programs (e.g., energy, site, air, water, materials) (Wilson, 2006). An additional item in this set asked about use of green building certification programs. Factor analysis yielded two factors, labeled *more common green practices* and *less common green practices* (Table 4.6). Although the correlation between these factors is relatively high (r = 0.53), both are included because of their relatively high internal consistency and their emphasis on contrasting elements of green building practices. Both skew and kurtosis of *more common green practices* exceed the predetermined cutoff value of 2.0, indicating a deviation from normal distribution. However, this variable is retained because of its important conceptual relationship to *less common green practices*.

Table 4.6
Green practices factors

Factor name and included items	mean*	SD	alpha
More common green practices	4.30	0.75	0.73
High performance envelopes			
High-efficiency energy systems			
Protection of trees and natural features on site			
Less common green practices	3.06	1.00	0.83
Natural or renewable materials			
Construction waste minimization			
Passive solar designs			
Green building certification programs			
Low-toxicity materials			
Low-consumption water systems			

*means have a significant pair-wise t-test comparison at p<0.001

In this study, the use of green practices does not break down by the kind of building practices (e.g., energy systems, finishes) but by how commonly the practices are being used. The *more common green practices* factor includes items that address energy, envelope, and site practices. In many regions, local building codes regulate these practices (e.g., minimum HVAC performance, envelope R-values, site disturbance practices). Further, the benefits of these practices (e.g., energy efficiency, thermal comfort, landscaping) are better established and integrated into the building industry. By contrast, the *less common green practices* factor includes the use of natural materials, passive solar designs, and green certification programs. These practices are not well established in the industry. Building codes rarely tackle environmental impacts through overall building design (e.g., passive solar) or interior material selection (e.g., natural materials). Increasingly, water conservation and construction waste are regulated but not as often as are envelope and energy performance. Most green building certification programs are voluntary and are still uncommon in the United States. In line with these conceptual definitions, mean ratings for the two factors indicate that respondents are using *more common green practices* almost “all the time” (mean = 4.30) and significantly more often than they are using the *less common green practices* (mean = 3.06).

Correlations among factors

Table 4.7 reports the correlations among the factors used in this study, indicating which are statistically significant. As noted above, the pairs of familiarity and green practices factors are moderately correlated ($r = 0.68$ and $r = 0.53$, respectively). The other correlations that are above .40 are between the *less common green practices* and *green information sources* ($r = 0.49$) and between *less common green practices* and *familiarity with systems* ($r = 0.58$).

Table 4.7
Correlations among factors

	1	2	3	4	5	6	7
1. Green Information sources	*1.00*						
2. Environmental performance attitude	0.36 *	*1.00*					
3. The production network	-0.14	0.01	*1.00*				
4. Familiarity with systems	0.40 *	0.07	-0.36 *	*1.00*			
5. Familiarity with techniques	0.32 *	0.07	-0.11	0.68 *	*1.00*		
6. More common green practices	0.24 *	0.24 *	-0.01	0.27 *	0.39 *	*1.00*	
7. Less common green practices	0.49 *	0.35 *	-0.13	0.58 *	0.39 *	0.53 *	*1.00*

* significant at the 0.01 level (2-tailed).

Predicting use of green practices

The theoretical model described in Figure 4.1 has each of the included constructs affecting builders’ use of green practices. To test these individual relationships, separate linear regressions were performed on both green practices factors using the factors from each of the other domains (i.e., builder/firm characteristics, formal/informal information, information processing).

Builder/firm characteristics

Table 4.8 shows the results of the regression analyses with builder/firm characteristics predicting each green practices factor. *Price range of houses built* is the only significant predictor of *more common green practices*, indicating that firms that build houses that are more expensive are more likely to use these practices. *Gross sales* are the only significant predictor for *less common green practices; the negative* *relationship* indicates that smaller firms are more likely to use these practices. The total amount of variance explained by builder/firm characteristics is modest in both cases (R^2 = 0.15 and 0.13, respectively). It is notable that despite the use of builder/firm characteristics in many innovation studies, in this study, most of these variables are not significant predictors of use of green practices.

Table 4.8
Linear regression with builder/firm characteristics

Builder/firm characteristics variables	More common green practices *B*	Less common green practices *B*
Builder		
Owner	-0.10	-0.06
Age	0.03	0.04
Education	-0.08	-0.09
Majority of experience is on the job	-0.04	-0.08
Majority of experience is management	0.01	-0.13
# of years in building trades	-0.02	-0.08
Firm		
Gross Sales	-0.05	-0.40 ***
Developer	0.03	0.16
Price range of houses built	0.19 *	0.17
Majority of work is remodeling	-0.17	-0.14
Majority of work is spec.	-0.18	-0.14
Majority of work is custom	0.18	0.09
R^2	*0.15*	*0.13*
F	*3.04* ***	*2.83* **

*p<.05. **p<.01. ***p<.001

Formal/informal information

Table 4.9 shows the results of regression analyses with the formal/informal information factors predicting each green practices factor. The two analyses show a similar pattern, with *the construction network* not being a significant predictor and *green information sources* being a significant positive predictor. Although the *green information sources* factor accounts for relatively little variance in *more common green practices* (R^2 = 0.05), it is a stronger predictor of *less common green practices* (R^2 = 0.24).

Table 4.9
Linear regression with formal/informal information

Formal/informal information sources	More common green practices *B*	Less common green practices *B*
The construction network	0.02	-0.07
Green information sources	0.24 **	0.43 ***
R^2	*0.05*	*0.24*
F	*4.94* **	*26.15* ***

*p<.05. **p<.01. ***p<.001

It is noteworthy that there was no significant relationship between the construction network and either green practices factor. If builders' informal information about barriers to green practices was affecting their use of those practices, one might expect to see a strong negative correlation between *the construction network* and use of green practices. The lack of such a relationship suggests that for these participants, the informal information about barriers they are exposed to may not be critical to their ability to do green projects.

Information processing

Table 4.10 shows the results of the regression analyses with the information-processing factors predicting each green practices factor. Information processing factors explain some of the variance in *more common green practices* (R^2=0.17) and a substantial amount of the variance in *less common green practices* (R^2=0.45). *Environmental performance attitude* is a significant positive predictor of both green practices factors. In each analysis, one familiarity factor is a significant predictor, but not the same one. *Familiarity with techniques* is the significant predictor of *more common green practices,* whereas *familiarity with green systems* is the significant predictor of *less common green practices*.

Table 4.10
Linear regression with information-processing factors

Information processing factors	More common green practices *B*	Less common green practices *B*
Familiarity with green techniques	0.33 ***	-0.11
Familiarity with green systems	0.05	0.65 ***
Environmental performance attitude	0.22 **	0.30 ***
R^2	*0.17*	*0.45*
F	*12.69* ***	*46.05* ***

*p<.05. **p<.01. ***p<.001

The positive relationship between *environmental performance attitude* and both green practices factors suggests that a positive attitude toward green building does matter to builders' use of both *more* and *less common green practices*. The finding that *familiarity with green systems* strongly relates to the use of *less common practices* suggests that system-level familiarity is important to the kinds of practices that are less mainstream, which are also the ones that are less well adopted.

Modeling relationships

The final analytic step involves using structural equation modeling (AMOS 6.0; Arbuckle, 2005) to test the theoretical model outlined in Figure 4.1. Based on the earlier theoretical explanation, information processing is a mechanism that helps to explain how information sources affect green practices. Therefore, information-processing variables are theoretically mediators or process variables and are modeled as such. With this mediation model, the interest lies in determining the degree to which information processing accounts for the relationships between information sources and green practices. The amount of mediation, the indirect effect, is the reduction in effect from information sources on green practices when controlling for information processing. Complete mediation would be where information sources no longer relates to use of green practices after controlling for information processing. Partial mediation is where paths from the information sources to green practices are reduced in absolute size but are still different from zero when controlling for information processing. Although mediation models do reflect causal hypotheses, the outcomes are still correlational in nature.

Rules of thumb from the SEM literature indicate this study (n=171) is of moderate sample size (Kline, 2005), which effectively restricts the number of parameters that can be modeled. Therefore, to minimize the number of parameters, latent factors were modeled using a single variable (the average of factor items) rather than modeling the full factor structure. Factor reliability is accounted for by adjusting the latent construct regression weight[3] and the variance of the factor variable error term.[4] This approach replicates effects of modeling the full factor structure but reduces the total number of parameters in the model (Laura Klem, Center for Statistical Consulting and Research, personal communication, September 8, 2006).

Model estimation occurred in two stages. First, a saturated, or overidentified, model including all paths from the theoretical model was created. Next, a parsimonious model was identified by iteratively deleting nonsignificant paths with the highest p-values until the change in chi-square became nonsignificant (Kline, 2005; Wells, 2006). Model fit was assessed using standard measures of model fit: a nonsignificant chi-square statistic (p>0.05), a comparative fit index and a non-normed fit index close to one (CFI and NNFI >0.90), a significant root-mean-squared error of approximation (RMSEA p<0.05) and a nonsignificant close fit statistic (PCLOSE >0.05). Unlike other analyses, with SEM a nonsignificant chi-square statistic is an indication of good fit. Nonsignificance is important because, in this case, chi-square results reflect the difference between the model and the data, and the desired outcome is a nonsignificant difference. In addition to indices familiar to other statistical methods (chi-square and RMSEA), with SEM, other indices specific to the domain are used (CFI, NNFI, PCLOSE). The CFI compares the covariance matrix of the existing model with that of a null model in which the latent variables in the model are uncorrelated.[5] The NNFI is an alternative to the CFI that does not make chi-square assumptions and is based on the Normed Fit Index (NFI), but, unlike NFI, it accounts for model complexity and thus is

---

[3] Calculated as the square root of the alpha reliability for the factor items times the variance of the factor measure ($\sqrt{\alpha * s^2}$).

[4] Calculated as the variance in the factor measure times the sum of one minus the alpha reliability for the factor items ($s^2 * (1-\alpha)$).

[5] CFI = $\frac{\text{Null model}(\chi^2 - df) - \text{proposed model}\,(\chi^2 - df)}{\text{Null model}\,(\chi^2 - df)}$

less sensitive to sample size.[6] The PCLOSE statistic tests the null hypothesis that RMSEA 0.05 or less and examines the alternative hypothesis that RMSEA is greater than .05. If the PCLOSE statistic is nonsignificant, the fit of the model is considered close. Taken together, these criteria provide a broad assessment of the fit of each model to the data (Kline, 2005). See Appendix E for the full table of parameter estimates.

Table 4.11 illustrates the fit statistics for the saturated and parsimonious models. With both the *more common green practices* and the *less common green practices,* the parsimonious models show good fit to the data, are significantly improved over the saturated models, and explain the data as well as the fully developed models. In all instances, the chi-square p-value is not significant and NNFI and CFI values are above .90 and .95 respectively. The RMSEA statistic is significant for *more common green practices* but just misses being significant for *less common green practices.* The latter was nevertheless considered a close fit based on the other fit indices.

Table 4.11
SEM fit statistics

		df	N	χ^2	p	NNFI	CFI	RMSEA	PCLOSE
More common green practices	Saturated	2	171	0.74	0.69	1.00	1.00	0.00	0.78
	Parsimonious	5	171	5.25	0.39	0.99	1.00	0.02	0.61
	change in χ^2			4.51	0.21				
Less common green practices	Saturated	2	171	5.18	0.08	0.86	0.98	0.10	0.16
	Parsimonious	4	171	7.41	0.12	0.93	0.98	0.07	0.27
	change in χ^2			2.23	0.33				

More common green practices

Figure 4.2 illustrates the structural model for *more common green practices.* In this model, *price range* was the only significant builder/firm characteristics variable in the regression analysis, and *familiarity with techniques* was the only significant familiarity factor. In identifying a parsimonious model, the paths from *price range* both to *environmental performance attitude* and to *more common green practices,* as well as the path from *green information sources* to *more common green practices* were deleted.

[6] $\text{NNFI} = \dfrac{\text{Null model}(\chi^2/df) - \text{proposed model}(\chi^2/df)}{\text{Null model}(\chi^2/df) - 1}$

As a whole, this model explains 35 percent of the variance in *more common green practices*. *Price range* and *green information sources* explain 21 percent of the variance in *familiarity with techniques*. *Green information sources* explain 18 percent of the variance in *building performance attitude*. *Price range* has a positive relationship with *familiarity with techniques,* suggesting that working on more expensive homes may provide builders with more experience of these techniques. The lack of significant path coefficients between information sources and green practices, in conjunction with the significant path coefficients between information sources and information processing and between information processing and green practices, support a mediating relationship for this model. Indirect effects are calculated by multiplying the path coefficients from information sources to information processing by the path coefficients from information processing to green practices. The allocation of indirect effect between familiarity and attitude is calculated by looking at the ratio of indirect effect through familiarity or attitude over the total indirect effect. The relative significance of mediator effects is calculated using by comparing results of Sobel tests (Sobel, 1982) for the significance of mediators (see Appendix E for results of Sobel tests). Specifically, the effects of both *price range* and *green information sources* on *more common green practices* are fully mediated by the information-processing factors. The indirect effect of *green information sources* on *more common green practices* is mediated by both *environmental performance attitude* and *familiarity with techniques* and is divided approximately 40 percent through attitude and 60 percent through familiarity, with familiarity being a more significant mediator than attitude ($p<0.001$ versus $p<0.05$). The indirect effect of *price range* is mediated by *familiarity with techniques* alone. These results indicate that neither *price range* nor *green information sources* have any direct effect on *more common green practices* after controlling for the information-processing factors. The significant effects described in regression results appear to be a result of their effect on the information-processing constructs and then the effect of information processing on green practices.

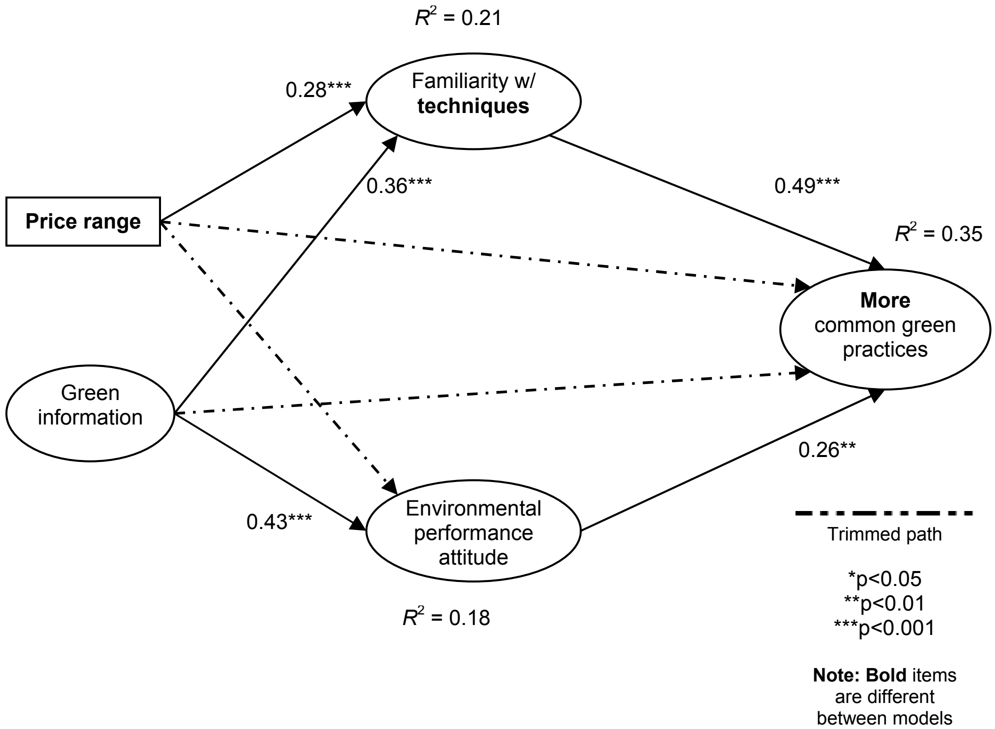


Figure 4.2 Parsimonious model for more common green practices

Less common green practices

Figure 4.3 illustrates the structural model for *less common green practices*. With this model, *gross sales* is the only significant builder/firm characteristics variable, and *familiarity with green systems* is the only significant familiarity factor. In identifying a parsimonious model, the paths from *gross sales* to *familiarity with green systems* and *less common green practices* were deleted. In this model, *green information sources* is partially mediated by the information-processing factors. Although controlling for information processing does reduce the effect of *green information sources* on *less common green practices*, the effect is still greater than zero. As a whole, this model explains 62 percent of the variance in *less common green practices*. *Green information sources* explain 21 percent of the variance in *familiarity with green systems*. *Gross sales* and *green information sources* explain 28 percent of the variance in *environmental performance attitude*.The relationship of *gross sales* to *environmental performance attitude* is negative, suggesting that larger building companies are more likely to have negative attitudes towards green building. The effect of *green information sources* on *less common green practices* is partially mediated (30 percent direct effect and 70 percent indirect effect) by both *familiarity with green systems* and *environmental performance attitude.* Of the indirect effect, 30 percent is through attitude and 70 percent is through familiarity. As with the model for *less common green practices*, familiarity is a more significant mediator than attitude (p<0.0005 versus p<0.005)

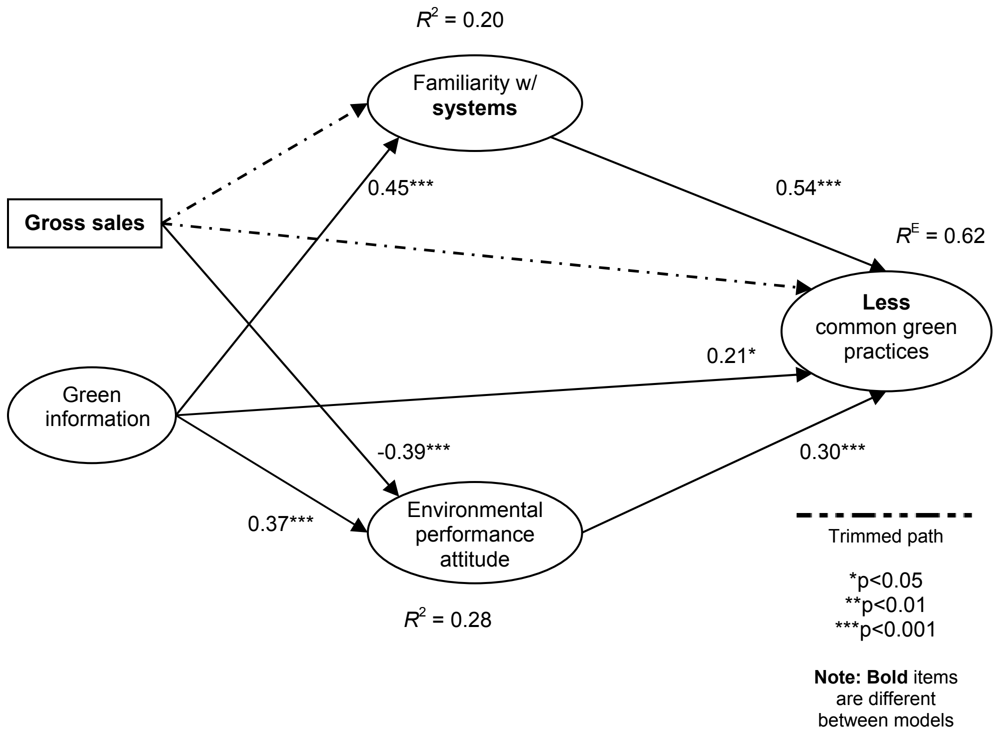


Figure 4.3 Parsimonious model for *less common green practices*

Comparison of models

In both cases, inclusion of information-processing constructs provides a richer account of builders' use of green practices than is provided through the use of information sources alone. The first structural model accounts for a modest amount of the variance in *more common green practices* ($R^2 = 0.35$), and information processing fully mediates information sources. The second model accounts for a much greater amount of the variance in *less common green practices* ($R^2 = 0.62$), but information processing has a more mixed relationship with information sources. Overall, the constructs used in this study provide a better explanation of *less common green practices* than of *more common green practices*.

The variations in model structure are also noteworthy. The two builder/firm characteristics variables have markedly different relationships with information processing. *Price range* has a positive relationship with familiarity, while *gross sales* has a negative relationship with attitude. Although different aspects of familiarity were related to different kinds of green practices, attitude has a consistent relationship to both kinds of green practices. Additionally, *green information sources* are fully mediated in one case, but only partially so in the other. Finally, in both models, familiarity is found to be a more significant mediator than attitude.

With SEM, it is important to note that these results do not confirm the theoretical model, they just do not reject it. There are many possible alternative models that could be explored and might also explain these data. For example, reversing the role of the mediators (information sources mediating information processing) may also fit the data. However, such models do not assess the theoretical approach this chapter is examining, and therefore are not explored here.

Discussion

Addressing research questions

To what degree do the information-processing constructs predict green practices and mediate information sources?

The information-processing constructs are more significant direct predictors of green practices than the information sources constructs. For *more common green practices,* builder/firm characteristics and formal/informal information sources accounted for 15 and 5 percent of the variance, respectively, whereas familiarity and attitude together accounted for 17 percent. With *less common green practices,* builder/firm characteristics and formal/informal information sources accounted for 13 and 24 percent of the variance, respectively, whereas familiarity and attitude together accounted for 45 percent.

Both models support a mediating role for the information-processing constructs with respect to the information sources constructs (i.e., builder/firm characteristics, formal/informal information sources). Although familiarity and attitudes were potent mediators for both kinds of green practices, the mediating role was not consistent across the two models. The balance between familiarity and attitude varied across the two models, and information sources had a statistically significant, albeit limited, direct effect on less common green practices. These results suggest that there are important variations in how and where information processing affects the use of green practices worthy of further exploration.

Is familiarity more significant than attitude?

Although it is difficult to isolate the direct contributions of familiarity and attitude, comparing the correlation coefficients from the regression analysis does give some indication (see Table 4.10). For *more common green practices, familiarity with techniques* and *environmental performance attitude* had coefficients of 0.33 and 0.22, respectively, suggesting roughly comparable direct effects. However, with *less common green practices, familiarity with systems* had a coefficient of 0.65, while the coefficient of *environmental performance attitude* was only 0.30, suggesting that familiarity is a much more powerful predictor than is attitude for the *less common green practices.* As mediators, familiarity plays a stronger role than attitude. For *more common green practices,* familiarity accounted for somewhat more of the mediational effect than attitude (60 versus 40 percent) and had a more significant Sobel test result ($p<0.001$ versus $p<0.05$). With *less common green practices,* however, familiarity played a substantially stronger role than attitudes (70 versus 30 percent) and had an even more significant Sobel test result ($p<0.0005$ versus $p<0.005$).

These results make a solid case for the role of information processing in builders' use of green practices and, in particular, for the role of familiarity as a relevant information-processing construct. The variations in results across the two models highlight the complex relationship among builders' information-processing capacities, their information sources, and their use of green practices. Such variations are consistent with the theoretical background for this study. Familiarity and attitude are mechanisms for processing information and making decisions, so one does not expect them to behave identically with respect to different green practices.

Implications and recommendations

This study expands our current understanding and suggests directions for future research and program development. The results reported here suggest new directions to pursue in part because the relationships identified have not been described previously, nor have they been used as a means to promote green building. There are four broad implications that arise from this study. Each implication is discussed along with some associated recommendations.

Information processing enriches the picture of builder behavior

While the emphasis in the literature has been on the direct relationships between information sources and new building practices, this study provides evidence that what individuals do with information once they possesses it is an important aspect of their adoption of innovative construction practices. Considering information processing as a mediator helps to explain why particular information sources might affect the adoption process. For example, knowing only that *green information sources* relates to the use of green practices gives little insight into what about that information is relevant to builders. However, knowing that for *less common green practices, familiarity with green systems* and a positive *environmental performance attitude* mediates reliance on *green information sources* provides much more description of what kinds of information are of use for builders. Adding an information-processing perspective sheds light on how builders use information to make decisions.

The addition of information processing to the vocabulary of construction innovation suggests new ways to design programs for increasing builder interest in green practices. Identifying information-processing aspects of stakeholder behaviors provides insights about why particular groups are reluctant to innovate. Such an understanding can then be used to better develop outreach efforts. For example, if one only considers that *gross sales* was negatively correlated with use of *less common green practices,* then one might conclude that educational programs that target small companies are more likely to be successful. However, knowing that larger companies are more likely to have a negative attitude toward green building, and that this negative attitude affects their use of green practices, leads to a very different conclusion; targeting large builders with programs to encourage more positive attitudes might also be successful.

Different practices relate to different familiarities

This study was able to define two coherent dimensions to both familiarity and green practices. Identification of the *less common green practices* and *more common green practices* factors suggests that builders' adoption of green practices may occur in stages. These stages may not be defined by the kind of practice or the environmental effect of the practice (e.g., energy efficiency, water conservation) but instead by the level of proliferation of a given practice within the industry. Further, this study identified two dimensions to familiarity with green building. Differentiating *familiarity with green techniques* from *familiarity with green systems* suggests that builders' knowledge may be organized in ways that reflect builders' perspective on what green building is and how it works.

The ways the two familiarity factors are paired with the two green practice factors suggests an approach to supporting builders' adoption of green practices. Efforts to promote green building might be more effective to the degree that they take into account these two dimensions of familiarity. For example, *familiarity with techniques* may already be more closely associated with conventional building practices. For builders who are familiar with an array of conventional techniques, becoming familiar with green techniques may be a relatively straightforward process. However, *familiarity with techniques* is only related to the use of *more common green practices*. Increasing this kind of familiarity, although perhaps straightforward, may be better suited to modifying existing practices, not to encouraging the adoption of more innovative practices. In contrast, *familiarity with systems* is related to a broader understanding of more abstract concepts of green building (e.g., markets, consumer interests, suppliers). Knowledge of green building systems is perhaps quite different from knowledge of conventional building systems. Developing familiarity with green systems may prove more challenging to accomplish; however, since it relates to adoption of *less common green practices*, development of this kind of familiarity may be more effective at encouraging the use of innovative practices.

Familiarity may be a key at the leading edge

Although a number of the constructs had significant relationships to the use of green practices, the results suggest that *familiarity with green systems* is particularly relevant to builders' adoption of innovative green building practices (e.g., natural materials, passive solar design, low-toxicity materials). It is arguable that among green building programs and policy makers, much of the emphasis is on communicating the technical aspects of green building to builders. People are naturally concerned about the concrete details of what a green building is, so this focus is understandable. The results reported here, however, suggest that builders who are more comfortable with broader issues related to green building may be more willing to adopt innovative green practices.

The relevance of *familiarity with green systems* on the use *of less common green practices* suggests a number of recommendations. First, developing a better understanding of what this system-level knowledge comprises would generate a more specific set of topics to share with builders. This information could be collected through interviews with builders about what their systems look like, what features work well, and how they set up and maintain their own systems. Second, understanding more about how builders become familiar with green systems would provide a basis for supporting changes in their practices. While processes and methods for teaching specific construction methods are well established, the tools for teaching system-level topics to residential builders are not. It is unclear how builders can best learn green systems topics, such as integrating performance criteria, building a new network of subcontractors, or conducting green market analyses. One could develop such tools by looking at other fields that either are systems focused or have recently undergone changes in their system structure. Identifying the best practices for teaching in these fields may generate new techniques applicable for the building community. Finally, there is a need to document the best sources for learning about green systems (e.g., from well-known sources, through hands-on experience, with repeated experiences) and what kinds of programs, formats, and activities (e.g., case studies, workshops, narratives, peer-to-peer communications) would help builders to develop this kind of familiarity most effectively.

More understanding of influences on information processing is needed

The limited amount of variance in familiarity and attitude accounted for by *green information, gross sales,* and *price range* raises two important questions. First, how well does the information builders are exposed to contribute to their familiarity or attitude? However, the low variance explained by the information sources measures raises a more important question. How else do builders' familiarity and attitudes develop, and how might other influences on this development be relevant to the use of green practices? While these results clearly show that there is value in better understanding the relationships between information sources and information processing, other options may ultimately prove more valuable. From this study, it is unclear whether the variance explained in familiarity would increase with an improvement in the quality of green information sources or whether additional measures are required. The theoretical explanations of information processing and familiarity in Chapters 2 and 3 suggest that people develop familiarity through exploration of topics over time. Multiple exposures to concepts are needed to develop the kind of familiarity that is used in decision making. Theoretically, information sources are but one influence among many, and more or better information may have limited effect on overall familiarity. It is thus important to resolve how much effort needs to be spent on addressing the content of green building workshops, magazines, and organizations versus identifying what else influences builders' information processing and how to incorporate green building concepts into those influences.

A first step in answering these questions would be to refine the research procedures used in this study. Several of the survey measures for formal/informal information sources were eliminated, not because they were not relevant, but because of a lack of internal consistency. Studies that incorporate better and more diverse measures of information sources could help resolve how information sources contribute to builders' information processing. A more important step would be to conduct experiments on how familiarity and attitude develop among builders. For example, familiarity and attitude could be surveyed before and after a green building training program to assess how much the design of a particular program influences information processing. If participants' commitment to green building were correlated with changes in information processing, then it might become clearer what influences builders' information processing. Such studies could provide guidance for the kinds of experiences that are most suitable for the development of builders' information-processing capacities. Further, longitudinal studies could look specifically at how issues such as formal and informal educational experiences or peer group communications contribute to the development of familiarity. Such research could identify effective means to facilitate builders' successful adoption of green practices.

Conclusions

There are risks involved in innovation, and there are important institutional, policy, and market forces that can support or undermine the adoption of new building practices. Adding an information-processing perspective to construction innovation problems identifies factors that may prove valuable in reframing these risks and forces to foster change in the residential building industry. By addressing information processing, this study shifts the focus away from any particular innovation and toward the informational needs of adopters.

By shifting the focus from innovations to adopters, this study helps to explain how builders respond to the challenge of green building. As such, these findings contribute to a more general understanding of construction innovation. Much of what makes a particular construction innovation successful is specific to the innovation and the context in which it is implemented. However, by modeling innovators as decision makers with information-processing needs, parts of the adoption process become generalizable. This study documents that one category of generalizable components—the information-processing constructs—are both measurable and significantly related to use of green practices. For example, knowing that information use relates to innovation is rather obvious and does not provide insight into how information guides decision making. However, knowing how information relates to attitudes and familiarity, which in turn relate to the use of innovations, combines the particular with the general to better describe the decision-making process. Because the strategies outlined here build on the information-processing aspects of participants, recommendations are not constrained to any one stakeholder and can be applied in a wider variety of circumstances. Therefore, the generality of this approach can help researchers, policy makers, and educators to develop the array of approaches to promoting green practices that are critical to creating a sustainable future.

References

Andersen, P. H., Cook, N., & Marceau, J. (2004). Dynamic innovation strategies and stable networks in the construction industry: Implanting solar energy projects in the Sydney Olympic Village. *Journal of Business Research,* 57, 351–60.

Arbuckle, J. L. (2005). Amos (Version 6.0) [computer software]. Spring House, PA: Amos Development Corporation.

Atran, S., Medin, D. L., Ross, N., Lynch, E. B., Coley, J., Ucan Ek', E., et al. (1999). *Folkecology and commons management in the Maya Lowlands.* Paper presented at the National Academy of Sciences U.S.A.

Augenbroe, G. L. M., & Pearce, A. R. (2000, February 22–25). *Sustainable construction in the USA: A perspective to the year 2010.* Paper presented at the International Conference on World Futures, Sri Lanka, India.

Austin, D. E. (1994). Exploring perceptions of hazardous waste facility proposals in Indian country: An application of the active symbol cognitive map model. (PhD, University of Michigan, 1994). *Dissertation Abstracts International,* 55, 1012.

Bardwell, L. V. (1991). Problem-framing: A perspective on environmental problem Solving. *Environmental Management,* 15 (5), 603–12.

Bernstein, H. M. (2006). *Green Building SmartMarket Report: Design and Construction Intelligence*. New York: McGraw Hill.

Blackley, D. M., & Shepard, E. M. (1996). The diffusion of innovation in home building. *Journal of Housing Economics,* 5, 303–322.

Bossink, B. A. G. (2004). Managing drivers of innovation in construction networks. *Journal of Construction Engineering and Management-ASCE,* 130 (3), 337–45.

Bresnen, M., Goussevskaia, A., & Swan, J. (2005). Editorial: Managing projects as complex social settings. *Building Research & Information,* 33 (6), 487–93.

Brown, M. J. (2007, March/April). A watershed year for green homes. *E: The Environmental Magazine,* 18, 10–11.

Bueche, D. G. (2005). Attribute perceptions of Colorado homebuilders segmented by innovativeness. (PhD, Colorado State University, 2005).

Building Technology Inc. (2005). *Overcoming barriers to innovation in the homebuilding industry*. Silver Spring, MD: US Department of Housing and Urban Development Division of Policy Development and Research & Partnership for Advancing Technology in Housing.

Cassidy, R. (2004). Progress report on sustainability. *Building Design and Construction.* Retrieved October 3, 2005, from http://www.bdcnetwork.com/contents/pdfs/bdc04White_Paper.pdf.

Census Bureau. (2005). Industry Summary: 2002 Economic Census: Construction. *United States Department of Commerce: Economics and Statistics*

Administration. Retrieved March 1, 2007, from http://www.census.gov/econ/census02/guide/INDRPT23.HTM.

Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist,* 41 (5), 521–528.

De Young, R., & Kaplan, S. (1988). On averting the tragedy of the commons. *Environmental Management,* 12 (3), 273–83.

Dooley, R., & Rivera, J. (2004, March). Green building goes mainstream. *Professional Builder,* 69, 71–72.

Evans, J. S. (2003). In two minds: Dual process accounts of reasoning. *Trends in Cognitive Science,* 7 (10), 454–59.

Gigarenzer, G. (1997). Bounded rationality: Models of fast and frugal inference. *Swiss Journal of Economics and Statistics,* 133 (2), 201–18.

Guy, S., & Shove, E. (Eds.). (2000). *A Sociology of Energy, Buildings and the Environment: Constructing Knowledge, Designing Practice*. London, UK: Routledge.

Harty, C. (2005). Innovation in construction: A sociology of technology approach. *Building Research & Information,* 33 (6), 512–22.

Hassell, S., Wong, A., Houser, A., Knopman, D., & Bernstein, M. (2003). *Building Better Homes: Government Strategies for Promoting Innovation in Housing*. Santa Monica, CA: RAND Science and Technology Policy Institute.

Holman Enterprises Ltd. (2001). *Innovation in the Housing Industry*. Institute for Research in Construction National Research Council of Canada.

Hutchings, M., & Christofferson, J. (2001). Factors leading to construction company success: Perceptions of small volume residential contractors. *Associated Schools of Construction, ASC Proceedings of the 37th Annual Conference.* Retrieved March 28, 2005, from http://www.asceditor.usm.edu/archives/2001/hutchings01.htm.

"In this special issue." (2005). In this special issue. *Building Research & Information,* 33 (6), 495–97.

"Intro to USGBC." (2004). An introduction to the U.S. Green Building Council and the LEED Green BuildingRating System®. *U.S. Green Building Council.* Retrieved February 26, 2005, from https://www.usgbc.org/Docs/Resources/usgbc_intro.ppt.

Janda, K. B. (1998). Building change: Effects of professional culture and organizational context on energy efficiency adoption in buildings. (PhD, University of California, Berkeley, 1998).

Kahneman, D. (2003). A perspective on judgment and choice—mapping bounded rationality. *American Psychologist,* 58 (9), 697–720.

Kaplan, A. W. (1999). From passive to active about solar electricity: Innovation decision process and photovoltaic interest generation. *Technovation,* 19, 467–81.

Kaplan, S. (1991). Beyond rationality: Clarity-based decision-making. In T. Gärling & G. W. Evans (Eds.), *Environment, Cognition and Action: An Integrated Approach* (pp. 171–90). New York: Oxford University Press.

Kaplan, S. (2000). New ways to promote proenvironmental behavior: Human nature and environmentally responsible behavior. *Journal of Social Issues,* 56 (3), 491–508.

Kaplan, S., & Kaplan, R. (1983). *Cognition and Environment: Functioning in an Uncertain World.* New York: Praeger. Republished by Ann Arbor: Ulrich's, 1989.

Kaplan, S., & Peterson, C. (1992). Health and environment: A psychological perspective. *Landscape and Urban Planning,* 26, 17–23.

Kearney, A. R., & Kaplan, S. (1997). Toward a methodology for the measurement of knowledge structures of ordinary people: The Conceptual Content Cognitive Map. *Environment and Behavior,* 29 (5), 579.

Kline, R. B. (2005). *Principles and Practice of Structural Equation Modeling,* 2nd ed. New York: Guilford Press.

Koebel, C. T. (1999). Sustaining sustainability: Innovation in housing and the built environment. *Journal of Urban Technology,* 6 (3), 75–94.

Koebel, C. T., & Cavell, M. (2006). *Characteristics of innovative production home builders*. Blacksburg, VA: Center for Housing Resarch.

Loftness, V. (2004). Improving Building Energy Efficiency in the U.S: Technologies and Policies for 2010 to 2050. *US Congress House Committee on Science.* Retrieved June 22, 2005, from http://www.house.gov/science/hearings/energy04/may19/loftness.pdf.

Lutzenhiser, L. (1994). Innovation and organizational networks: Barriers to energy efficiency in the US housing industry. *Energy Policy,* 22 (10), 867–76.

Lutzenhiser, L., & Janda, K. B. (1999). *Residential New Construction: Market Transformation Research Needs*. Davis, CA: California Institute for Energy Efficiency.

Manseau, A. (2005). Redefining innovation. In A. Manseau & R. Shields (Eds.), *Building Tomorrow: Innovation in Construction and Engineering* (pp. 43–55). Hants, UK: Ashgate.

Martin, C., & Bernstein, H. M. (2006). *Residential Market Research for Innovation: 2006 Technical Report*. New York: McGraw Hill Construction & Partnership for Advancing Technology in Housing.

McCombs, M., & Estrada, G. (1997). The news media and the pictures in our heads. In S. Iyengar & R. Reeves (Eds.), *Do the Media Govern? Politicians, Voters and Reporters in America* (pp. 237–47). Thousand Oaks, CA: Sage Publications.

Mead, S. P. (2001). Green building: Current status and implications for construction education. *Associated Schools of Construction, ASC Proceedings of the 37th Annual Conference.* Retrieved April 11, 2005, from http://asceditor.unl.edu/archives/2001/mead01.htm.

Municipal and Industrial Solid Waste Division. (1999). Characterization of Municipal Solid Wastes in the United States: 1998 Update. In Office of Solid Waste (Ed.) (Vol. 2005). Washington, DC.: Environmental Protection Agency.

Myers, D. G. (2002). *Intuition: Its Powers and Perils*. New Haven: Yale University Press.

Nobe, M. C., & Dunbar, B. (2004). Sustainable development trends in construction. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.ascproceedings.org/ASC%202004%20CD/2004pro/2003/MaNobe04.htm.

Peterson, C., Maier, S. F., & Seligman, M. E. P. (1993). *Learned Helplessness: A Theory for the Age of Personal Control*. New York: Oxford University Press.

Riley, D., Pexton, K., & Drilling, J. (2003). The procurement of sustainable construction services in the U.S.: The role of the contractor on green building projects. *Industry and Environment: A Quarterly Review,* 26 (2–3), 66–69. Retrieved April 11, 2005, from http://www.uneptie.org/media/review/vol26no2-3/005-098.pdf.

Rogers, E. M. (2003). *Diffusion of Innovations,* 5th ed. New York: Free Press.

Sanstad, A. H., & Koomey, J. (2007). Exploring the energy efficiency gap. *Lawrence Berkeley National Laboratory, Energy Enduse Forecasting and Market Assessment Group.* Retrieved March 1, 2007, from http://enduse.lbl.gov/Projects/EfficiencyGap.html.

Seaden, G., Guolla, M., Doutriaux, J., & Nash, J. (2003). Strategic decisions and innovation in construction firms. *Construction Management and Economics,* 21, 603–12.

Seligman, M. E. P. (1998). *Learned Optimism: How to Change Your Mind and Your Life,* 2 ed. New York: Free Press.

Shields, R. (2005). A survey of the construction innovation literature. In A. Manseau & R. Shields (Eds.), *Building Tomorrow: Innovation in Construction and Engineering* (pp. 5–22). Hants, UK: Ashgate.

Slaughter, E. S. (2000). Implementation of construction innovations. *Building Research and Information,* 28 (1), 2–17.

Sloman, S. A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment* (pp. 379–96). Cambridge, UK: Cambridge University Press.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. In S. Leinhart (Ed.), *Sociological Methodology 1982* (pp. 290–312). San Francisco: Jossey-Bass.

"Sustainable construction." (2003). Sustainable construction: Facts and figures. *Industry and Environment Review,* 26 (2–3), 5–8.

Tinker, A., & Burt, R. (2002). Characterizing green residential construction for green builder programs and construction education. *Associated Schools of Construction, ASC Proceedings of the 38th Annual Conference.* Retrieved June 2, 2005, from http://www.asceditor.usm.edu/archives/2002/Tinker02b.htm.

Tinker, A., Burt, R., Bame, S., & Speed, M. (2004). Austin Green Building Program analysis: The effects of water-related green building features on residential water consumption. *Associated Schools of Construction, ASC Proceedings of the 40th Annual Conference.* Retrieved March 28, 2005, from http://www.asceditor.usm.edu/archives/2004/Tinker04b.htm.

Todd, P., & Gigarenzer, G. (2000). Precis of simple heuristics that make us smart. *Behavioral and Brain Sciences,* 23, 727–80.

Toole, T. M. (1998). Uncertainty and home builders' adoption of technological innovations. *Journal of Construction Engineering and Management,* 124 (4), 323–32.

Turner, C. (2006). A post-occupancy look at LEED building performance. *HPAC Engineering.* Retrieved March 1, 2007, from http://www.hpac.com/GlobalSearch/Article/32116.

Vanegas, J. A., & Pearce, A. R. (2000). Drivers for change: An organizational perspective on sustainable construction. Paper presented at the Construction Congress VI, Orlando, FL.

Wejnert, B. (2002). Integrating models of diffusion of innovations: A conceptual framework. *Annual Review of Sociology,* 28, 297–326.

Wells, N. M., Lekies, K. M. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Children, Youth and Environments,* 16 (1), 25.

Wilson, A. (2006). *Your Green Home*. Gabriola, CAN: New Society Publishers.

CHAPTER 5

CONCLUSION

For most people, it may seem odd to think about homes as a tool for changing behaviors or even for changing the world. Nevertheless, the preceding chapters have argued that homes can and need to become just such a tool. In order to move toward sustainability, we as a society need to redefine what a home is. Part of that redefinition involves re-creating the job of the builder.

This dissertation has argued that creating such change is not a simple task. Green building practices are unlike other building innovations. The need for an integrated design and construction process and the diversity of possible solutions requires stakeholders to participate in new ways. While existing models of construction innovation may provide starting places for understanding the use of green building practices, this dissertation has outlined an approach to fostering green building practices that extends understanding in useful ways.

Overview of results

This dissertation has used information-processing theories and methods to understand some of the prerequisites for change, map the process of change, and define some options for supporting change within the boundaries of residential green building practices.

Informational needs as a framework

Chapter 2 applied an information-processing analysis both to the construction innovation literature and to issues of green building as an innovation. By incorporating informational needs into current theories of construction innovation, Kaplan and Kaplan's Reasonable Person Model (Kaplan & Kaplan, 2006; Kaplan, 2000; Kaplan &

Kaplan, 2003) provided a framework for analyzing residential homebuilders' understanding of green building practices. This analysis generated three recommendations for supporting builders' informational needs: attending to the structure of information, increasing opportunities for participation, and allowing time for reasonableness to develop. Utilizing the informational needs perspective generated strategies for stimulating change in the building industry that may prove more practical to implement than other approaches.

Familiarity as a tool for adoption

Chapter 3 used a specific information-processing construct, familiarity, to document builders' understanding of green building practices. This chapter provided a theoretical description of familiarity, outlined why this construct is particularly relevant in situations where people confront change, and applied the concept to two studies of builders with varying amounts of green building experience. Through Conceptual Content Cognitive Mapping (3CM) and open-ended questions, participants' familiarity in terms of their perceptions of what green building is and how it differs from conventional building was identified. These studies found systematic variations in builders' familiarity. In the 3CM study, green builders were more likely to describe green building in terms of how it is different from conventional building, whereas conventional builders were more likely to describe green building in technical or environmental terms. In the open-ended interviews, the green builders were more likely to consider their own behavior as part of what makes green building different from conventional building, whereas the conventional builders were more likely to focus on the building or project differences. The results suggest that familiarity provides a useful framework for green building communication and education programs. Further, the results led to hypotheses about how variations in familiarity might affect adoption decisions.

Measuring familiarity as a link to innovation

Based on the theoretical and empirical results arguments from Chapters 2 and 3, Chapter 4 quantitatively assessed the role of familiarity in builders' use of green practices. In particular, Chapter 4 measured whether two information-processing constructs, familiarity and attitude, mediated the effect of well-established innovation constructs (formal/informal information sources and builder/firm characteristics) on the use of green building practices. Results showed that not only do familiarity and attitude mediate these constructs but that they also play important roles of their own. Further, familiarity appears to play a more significant role as a mediator than does attitude. By combining information-processing variables with established innovation variables, this research provided preliminary evidence linking information processing to the use of more innovative green building practices.

Conceptual and methodological contributions

Critical scholarship on green building as an emerging construction practice is quite recent. For example, the first academic journal devoted to this topic, the *Journal of Green Building*, started to publish in 2006. This research thus contributes to a field in its early stages. The chapters in this dissertation not only provide descriptions of the status of green building and some of the challenges facing further growth, but they also show how green building is distinct as a construction innovation. Furthermore, the work situates green building within the broader field of construction innovation.

This dissertation advances theoretical arguments relating information processing to construction innovation. These arguments expand on the set of theoretical tools that can be used to analyze construction innovation. At the same time, this work contributes to information-processing theories through application to a new subject domain. Finally, it highlights familiarity, a particular information-processing construct, as an important means for expanding adoption of green construction practices.

The research also makes contributions to methods. The Conceptual Content Cognitive Map (3CM) method was shown in Chapter 3 to be a useful way to examine how knowledge structure might vary within a professional group that shares some background and expertise. The respondents differed in their experience with respect to green building, and 3CM was useful in identifying some themes comprising these differences.

In Chapters 3 and 4, familiarity was measured in a number of ways. The 3CM study measured familiarity in terms of knowledge structure. The open-ended interviews measured familiarity in terms of builders' perceptions of difference between conventional and green building. Both techniques assessed familiarity by looking at the topics participants discussed and then looking at the distribution of these topics across the samples. The survey measures built on previous work (A.W. Kaplan, 1999) to measure builders' familiarity in terms of confidence in their knowledge of green building. The two distinct familiarity factors these items generated were effective in explaining distinct dimensions of green building practices.

Implications and recommendations

Taken as a whole, this dissertation provides insight on the nature of change in the residential building industry as well as the importance of information-processing mechanisms, particularly familiarity, in that change. In seeking to understand the information-processing challenge faced by builders as they consider and evaluate green building practices, this research makes several contributions. As Guy and Shove have stated, "It is not simply a question of transferring technologies upon people. Instead, knowledgeable actors creatively adopt and adapt strategies and practices that suit their changing circumstances. Sometimes these favor [the environment], sometimes not" (Guy & Shove, 2000, p133). This dissertation adds to the process of understanding the creative adoption and adaptation process builders engage in as they explore green practices. Such an examination leads to recommendations for supporting the further development of green building practices.

Address the changes in builders' roles

By many accounts, green building represents a different kind of construction practice requiring new approaches to understanding and promoting its adoption. This dissertation suggests that working on green projects not only involves a change in the kinds of practices builders use but also involves changes for the builders themselves. The 3CM data identified differences among builders depending on their experience with green practices. The open-ended interviews found that builders with more green experience were more likely to address their role in the construction process. The survey results identified two types of familiarity with green building—*familiarity with techniques* and *familiarity with green systems*—that were differentially related to use of *more common green practices* and *less common green practices*. All of these findings involve changes in perception, thinking, and decision making on the part of the builder. The results suggest that builders who work on green projects have a broader perspective (the 3CM data), are more sensitive to their role (the interview data), and look at green building more systemically (the survey data). Such differences reflect not just the addition of new knowledge but a different set of priorities. While integration changes how green homes are designed and built, integration also appears to change builders themselves.

- To understand builders' existing roles, it is important to examine current training options. Very likely, the training needs to be broadened to incorporate a system-level perspective that can expand builders' capacity for green practices. If green practices and the role of the green builder are introduced at the beginning of builders' education, then the skills and perspectives identified in this dissertation will not be something builders have to adapt to but will be something they are always aware of and thus more comfortable with.
- Addressing the education of young builders does not address the knowledge base of builders already in the field. Effort also needs to be spent helping existing builders adapt to the new role that green building involves. If specific skills important to green building are lacking among conventional builders, it is important to document these skills and clearly articulate their importance. Creating opportunities for builders to learn these skills may help them to appreciate the relevance of these skills. Such efforts can better prepare builders to be effective working on green projects.
- Another aspect of changing roles is changing risks. If green building does represent a social good, and if communities want their builders to adopt green practices, laws need to be structured to facilitate, rather than inhibit, experimentation. Currently, liability laws are a great disincentive to innovation. If builders could be rewarded for being more innovative, rather than being punished, they might be more willing to try out new practices. For example, more communities are considering comprehensive $C0_2$ and energy efficiency programs. Home construction can be a part of these programs, but technologies and options for building the most energy-efficient homes

are changing rapidly. Builders are going to be key in testing out different practices to find the most effective solutions. Under current regulations, however, there is little incentive for builders to actively participate in identifying effective solutions. Providing legal support for increased experimentation may be important in encouraging builder participation in this process.

Shift the focus from innovations to adopters

Currently, the literature on construction innovation has identified many apparently important barriers to innovation, including regulations, technical diffusion, and costs. These barriers offer important insights into the conditions that are favorable to innovation. However, barriers are context specific and, as results in Chapter 4 suggest, perhaps less rigid than often considered. Knowing the barriers confronted by a particular stakeholder for a particular innovation has only so much application in a different context. The current literature suffers from what has been called a "post-hoc paradox" (Shields, 2005)—a great capacity for identifying the particular circumstances of a specific past innovation, but less capacity to develop strategies for stimulating innovation.

This dissertation applies general principles of human behavior to builders' responses to innovation. Information-processing principles are relevant, regardless of the innovation or context. Although information-processing mechanisms are not determinative of innovation adoption, addressing them can support innovative behavior. For example, if stakeholders develop strong mental models of what green building is and how it relates to conventional practices, their perception that green building is "high cost, high risk" (Dewick & Miozzo, 2004, p324) may be diminished. This dissertation shifts attention away from particular innovations and toward the capacities of the adopters. Such a shift in focus contributes to a more generalizable account of construction innovation that may provide a means for scholars and practitioners to move out of the "post-hoc paradox."

- Designing communications programs around builders' needs rather than particular innovations may prove effective. By identifying and addressing the needs of builders, such programs can identify potential adopters who are overlooked when thinking only about the innovation itself.

- The three-part framework detailed in Chapter 2 (e.g., structure of information, participatory experiences, multiple exposures) provides guidance for the development of a builder-oriented outreach program that can substantially reduce the burdens associated with learning new practices. Such a program has the potential to increase builders' engagement with green practices while not being tied to any particular innovation, allowing the program to grow and change as builders' needs change.

Familiarity—friend and foe

The shifting balance between familiarity and unfamiliarity has been a core theme of this dissertation. Chapter 4 demonstrated that builders' familiarity with different aspects of green building makes an important difference in their use of new practices. Nevertheless, questions were raised about where familiarity comes from and how best to support the development of familiarity. At the same time, as increasing familiarity with green practices may support change, familiarity with existing practices is a potential barrier to change. As seen in Chapter 3, the conventional builders were focused on products and practices, having a more building-focused perspective on what makes green building different. Such a concrete and technical orientation may make more difficult the development of the systems awareness identified in Chapter 4. Further, familiarity takes time and multiple experiences to develop. All these factors make familiarity a challenging construct to use in service of change. However, the potential for this construct suggests the benefits may be worth the effort.

- To capitalize on familiarity, green building programs can build on aspects of green building already familiar to builders while taking more time to work through the details of what is unfamiliar. Chapter 4 identified that participants are already using energy-efficient equipment and envelope systems and are familiar with green techniques, but they are less likely to be using passive solar or water conservation features and lack familiarity with green systems. This understanding of builders' familiarity is useful for shaping educational programs for different topics. With more familiar material, it is possible to let builders know that some of what they are doing is already green, which connects their existing familiarity to green building, providing a starting place for introducing more advanced material. With unfamiliar topics, care must be taken to build understanding in ways that enable builders to feel effective with the new material. Programs might focus on cultivating a foundation of knowledge before moving into specific building applications.

- Experiential activities, such as simulations, case studies, and narratives, can be well suited to developing familiarity. Although experiential activities may not seem an effective way to share technical information because they are often less content driven than a more straightforward method, they provide the opportunity to explore material that is essential to the development of familiarity. Because simulations can allow people to examine multiple outcomes rapidly, a simulation can be very effective at building mental models. Creating a database of case studies can allow builders to review multiple projects and compare salient features (e.g. cost, availability, complications). Such an opportunity makes it easier to find the information that is relevant to an individual's needs, allowing builders to explore green building at their own pace. For a number of reasons, people are skilled at processing information when it is presented in story form (Shannahan & McComas 1999, De Young & Monroe, 1996). Creating opportunities for builders to hear stories about green building from other builders can help builders to visualize the experience of doing green projects in ways that may be effective at developing their familiarity.
- Chapter 3 suggested that green building programs, through outreach and advocacy, take on a broader role in the building community. Programs could focus on coordinating the development of familiarity throughout the construction network. Such an approach recognizes the challenges and opportunities of familiarity. By taking a broader perspective on the role of familiarity in builders' behavior, new options for supporting change may emerge. Educational programs that bring stakeholders together can provide multiple and different kinds of experiences for builders to work with or hear about green practices. By working closely with diverse building industry participants (e.g., suppliers, regulators, consumers), a green

building program can help these organizations utilize familiarity rather than having to fight against it.

- Another valuable approach entails developing long-term green building programs. The information-processing approach described in this dissertation highlights the fact that change takes time. Designing long-term green building programs could support the development of familiarity by providing repeated opportunities for builders to explore what green building is. Long-term programs provide a means to maintain builders' familiarity once it develops, as builders can refresh their knowledge, try out alternative approaches, and perhaps hear more about something they did not understand the first time around. Finally, since conventional practices are well established and very familiar to builders, one-time experiences with green building are unlikely to lodge very deeply. Creating long-term green building programs helps bolster builders' familiarity with green practices in an environment that is overwhelmingly concerned with conventional practices.

Consider the whole industry

As discussed in Chapter 2, if green building remains a niche practice, the detrimental environmental effects from home construction will not be sufficiently reduced. Therefore, green builders and green building advocates should take a broader view of their role in the construction industry. To promote green building practices, it is important to promote better building practices throughout the industry. Support for innovation in the building industry practices should be a cornerstone of green building programs as much as the advancement of actual green building practices.

- One approach to achieving this goal is for green building programs and advocacy organizations to participate in the development of builder educational opportunities. Given the arguments and evidence for the role of information processing, developing a labor force that is more familiar with innovation will contribute to greater adoption of green building practices. Increasing the quality and availability of educational programs, irrespective of an emphasis on green building, is going to help prepare builders for the new roles described in Chapter 3. For example, appropriate training can lead to builders who are more comfortable with research and who have a greater capacity for managing variability. Greater availability of continuing education courses can help builders to update their skills as options change.

- Another approach, based on the Reasonable Person Model from Chapter 2, would be to increase the opportunities for builders to participate in the development of innovations. While some builders do participate in research activities, their number is likely to be small. If experimentation became a more common experience among builders, innovativeness might also become more normal. For example, working with new materials and practices can expand builders' mental models of what residential construction encompasses. Learning more about building science can lead to new competencies. Participating in the development of products that benefit the entire industry could provide builders with a strong sense of meaningful action.

Process versus outcome

How to build the most sustainable homes remains an open question. Much experimentation and testing are needed before green building becomes the norm for residential construction. At its broadest level, this dissertation is about understanding how to engage builders in the process of experimentation as much as it is about understanding the adoption of existing green practices. As mentioned in Chapter 2, learning about green building is neither straightforward nor terminal. Focusing on the outcome (i.e., adoption of green practices), rather than the process (i.e., being more comfortable with innovation), may limit change over the long term. As described in Chapter 2, model building involves exploration and understanding. If the path to becoming a green builder is only considered in terms of understanding (i.e., through mastery of particular topics), we will squander an opportunity to engage builders in exploration (i.e., through experimentation and discovery). Chapter 4 found that builders who have a system perspective on green building are more likely to be using less common green practices. Such a system perspective calls for a shift in focus away from the building and toward a broad view of the building process. Taking this broad view can lead builders to identify new relationships with other stakeholders, such as customers, subcontractors, and regulators, in ways that reflect a move from an outcome to a process orientation.

Ultimately, such a shift in orientation may be a cornerstone of what defines green building as well as its practitioners. On a number of levels, this dissertation has examined theoretical as well as empirical ways to go from an outcome to a process orientation. By recognizing builders as important actors in the development of a sustainable future, this work brings attention to their ongoing effect on this planet. By focusing on their informational needs and describing how these needs play a role in their use of green practices, this work illustrates how the process of change is relevant to the development of green building practices. As a whole, this is not about finding solutions to particular green building problems. It is about identifying ways to engage builders in the larger task of discovering how to build sustainably.

References

De Young, R. and M. Monroe. 1996. Some fundamentals of engaging stories. *Environmental Education Research,* 2, 171–87.

Dewick, P., & Miozzo, M. (2004). Networks and innovation: Sustainable technologies in Scottish social housing. *R & D Management,* 34 (3), 323–33.

Guy, S., & Shove, E. (Eds.). (2000). *A Sociology of Energy, Buildings and the Environment: Constructing Knowledge, Designing Practice*. London, UK: Routledge.

Kaplan, A. W. (1999). From passive to active about solar electricity: Innovation, decision process and photovoltaic interest generation. *Technovation,* 19, 467–81.

Kaplan, R., & Kaplan, S. (2006). *The Reasonable Person Model: A Brief Description*. Unpublished manuscript. University of Michigan, Ann Arbor.

Kaplan, S. (2000). New ways to promote proenvironmental behavior: Human nature and environmentally responsible behavior. *Journal of Social Issues*, 56 (3), 491–508.

Kaplan, S., & Kaplan, R. (2003). Health, supportive environments, and the Reasonable Person Model. *American Journal of Public Health,* 93 (9), 1484–89.

Shanahan, J., Pelstring, L. & McComas, K. S. (1999). Using narratives to think about environmental attitude and behavior: An exploratory study. *Society and Natural Resources,* 12, 405–19

Shields, R. (2005). A survey of the construction innovation literature. In A. Manseau & R. Shields (Eds.), *Building Tomorrow: Innovation in Construction and Engineering* (pp. 5–22). Hants, UK: Ashgate.

APPENDICES

Appendix A: Coding instructions for 3CM results with concepts

Description of Categories for Coding

- Items may be positively or negatively associated with a category. For example, toxicity is negative, occupant health is positive, but both are about environmental outcomes.
- Items should be placed in only one category.

- **Products and practices**
  The products, practices, etc., that make up green building or are the problem in conventional construction
  - These are the actual concrete practices and products that make up green building, the guidelines a builder might follow.
  - Ex: “no vinyl” is a technique.
- **Environmental outcomes**
  Either benefits of green building or impacts from conventional construction
  - These are the larger environmental outcomes from building practices that green building addresses.
  - Ex: “energy efficiency” is a technique, but “energy consumption” is an outcome.
- **Market incentives**
  Cost concerns, financial opportunities, market demand, uncertainties
  - Financial concerns AND financial opportunities about green building, consumer demand issues, money issues. Also items that emphasize risks or uncertainty, items that reflect builders’ worries over uncertainty or their attempts to manage it.
  - Ex: “liability issues,” “hassle can be too much for an unknown end”
  - Ex: “green consumers needed” is financial concern, but “create jobs through recycling” is an opportunity
- **The green difference**
  How green building is different than conventional building, what defines green building as compared to conventional building, reframings of builder roles or homeowner expectations
  - This is <u>not technical or product differences</u>, but how green building differs from conventional building. Expressions of how green building might change the way builders see their role. Conventional perspectives that keep builders stuck where they are. Reframed homeowner expectations are items about how a green building might change what homes mean to people or about problems with how people think of conventional homes.
  - Ex: “integrated design” is a difference between green and conventional practices.
  - Ex: “long-term mind-set” is a builder reframe, “spaces have power” is a homeowner expectation reframe.
- **Unknown or personal**
  - things that don’t fit any category or are very individual

Products and practices

earth based
no drywall
no processed finishes, plastics, or polyurethanes
no unhealthy carpets
no vinyl
not dyed
any building that uses less scarce options, more abundant
solar energy
green space
landscaping
sq ft proportional to acreage
joists made out of chips
recycled materials
recycled content
renewable
reusing energy sources
scrap lumber
We recycle lots of cardboard
Energy Star 5
low VOC paints and glues
no carpet
Ven Mar Conditioner used
energy star and green building go together
cellulose insulation
equipment to save fuel
OSB sheathing
recycling
using materials that are not taking energy to create
air infiltration
better air without recycling air as frequently
no humidifier
downsize furnace
energy framing—no cold corners
equipment to save fuel
efficiency
manufactured materials [provide] a second life
safe = nontoxics
safe = smooth clean surfaces
energy efficiency
materials efficiency—responsible resource use
site considerations
water resource conservation
passive solar design—not as important nationwide as I would give it
conserve building material resources
conserve energy resources
consideration of toxic substances during construction
don't have programs for recycling waste material
design
glazing efficiency
good construction
good framing/caulking
high-volume ceilings make no sense greenwise
insulation

Products and practices

insulation one of the most important
last a long time
mechanical system 90% efficient
not a lot of gaps
sensitive to window location
siting
solar gain
solar gain/benefits
AC 12 SEER
Durability
Energy
Geothermal
more 2x6 [framing] in the future
more geothermal in the future
[the] throwaway factor between carpet and hardwood
fireplaces are a big fuel waster
Products
woodstove efficiency
[materials that are] better stronger span greater distances
buying products that have a lifespan without throwing away [?]
energy efficient
I-joists—reproducible
natural areas in subdivisions
proper ventilation
provide people w/ nature in their own development
most cost effective = grid intertie
next rung = solar electric
bottom line usually energy efficiency and recycled [content]
preservation of green areas
reuse materials
save energy
use materials that require less energy?
water resources
EE equipment
environmentally sustainable building
lighting, appliances
primary factor energy savings
use products that save energy
windows and EE
avoid runoff
orient house to take advantage of natural features
looking at technology that lets [you] use less water
think about toilets
water system design (piping)
IAQ connected to EE
reduce infiltration
VOC
composite trim and decking
Design
durability a part of all this
life-cycle analysis at the extreme [end of GB activity]
manufactured versus conventional lumber
material composition (flyash, shingles)

Products and practices

resource efficiency
energy efficiency
energy star 86 = a green building
energy star requirements
HERS rating
care w/solvents
EE conservation
EE materials (manufactured)
environmentally cleaner
environmentally friendly
partially recyclable (possible)
proper disposal
recycling your materials (cardboard etc.)
soil erosion control
public transport integral to green building
think about how you get to jobsite
natural ventilation
overglazing—a problem in GB
think about how you cut it (site) up
think about natural elements on the property
used to be focused on everything recycled and reused
making wise use of commonly available materials
cellulose insulation
efficient windows—negotiated deals
EE envelope
EE materials
energy efficiency

Environmental outcomes

no mold
Human labor is an abundant renewable resource.
There are resources in buildings.
healthy house
material availability
material cost
transport of materials
habitat (hunting)
timber availability
forestry practices
development impacts
landfill reductions
forestry management
allergy sensitivity
air quality
energy savings
healthy home
material savings
What we're trying to do is use products that prevent use of natural resources.
air quality
comfort
quality of life inside
We use a lot of poison [in building].
conservation
conserve energy

Environmental outcomes

conserve labor
conserve water
minimizing waste
safe
healthy indoor environment
conservation of land
protection of natural features
[teardown] rather than trying to adapt a building
loss of materials in teardown
regeneration—renewable resources
ecological considerations
health considerations
inhabitant health
health considerations
live in and not get poisoned
healthy house objectives
easier on forests
We don't have unlimited resources.
Cleared lots look like rape and pillage.
did not want to build houses—carve up the land
There will be a time when there won't be more land to build on.
rather work on infrastructure than create new infrastructure
harvesting trees sustainably over steel [trees preferable]
land use = preserving and reusing what you can
water quality
mold issues
IAQ
environmental stewardship
social responsibility
building life span ~ 40 years --> impacts
environmental costs of building a home
land usage
old growth
resources not easily replaced
Everything that is manufactured has an environmental cost.
planet … species … that we are so closely intertwined with
energy costs
considering materials—are they safe?
create an environment for people inside that is healthy and safe
safe houses
GB is about developing a home that [has] less impact on the environment.
less stress on local and larger environment
safe to produce, use and be around

Market incentives

efficiencies—scale, product and resource
not cheap
Market doesn't bear the costs of extras.
comparative costs between green and nongreen
extra labor and materials
affordability
important to give people a fair price

Market incentives

profit—one of the reasons I'm doing it [building]
Being profitable allows me to support environmental and social causes.
Green is not a concern unless [it] saves money.
People would like hardwood not willing to pay [for it].
price is a big consumer [?] w/homeowner
not as far into it for economic and time reasons
economic viability
diminishing rate of return—costs versus savings with energy star
[For] green building [the customer] is going to pay a premium.
Embedded energy and [social/environmental] costs are not in the [economic] costs of materials.
economically viable
create jobs through recycling
minimize waste, maximize efficiency—allows a fair price
energy consumption post-occupancy
utilities savings
volatile/uncertain energy markets
energy costs to run a home
no financial costs upfront
Innovation may not lead to additional costs.
saved money going with Energy Star
There's lots that's not cost effective.
California corners—cost nothing
negotiate efficiencies
There are cost effective energy efficiencies that are basically free.
Builders are in it for money, you have to work with that.
[How do I realize cost savings with ES?] I beat my contractors up for [better] pricing.
green consumers needed
market demand?
number of people who buy knowing they will teardown
Homeowner makes most product selections.
Remodeling business is homeowner driven.
client choices
macro/micro economics
Hassle can be too much for an unknown end.
Salvaging can be time intensive for less result.
Cost of manufactured lumber went up [started looking at foam].
catch 22 of leading edge with green building
build consistency into an inconsistent business
certain things covered by law
have another job?
insurance
liability issues today in building
creates resistance in trades craftsmen
what's happening with energy bill in Congress
You have to be right most of the time in business.
owner/builder
start small
do things based on gut then see what [the] reception [is]

The green difference

introduced right, planned well
very hands-on/labor intensive
slowing down the process
building well
intentional
intentional about work
tradeoffs between resources, costs and environment
environmentally aware
Passive solar requires attention dedication and thoughtfulness.
built well use good products
being conscious of [the] earth and resources
conscious of your place on planet
Everything affects everything else.
You can consider natural elements without sacrificing property.
decision to think of/plan for the future
responsible way of building
taking something that has been looked at one way and rotating it to evoke a feeling
balancing time and environmental benefit
blending of approaches necessary
[green building is] very comprehensive
performance and design in a holistic fashion
holistic building design
think about what your actions impact environment
triple bottom line
integration of design
interdependencies of decisions
family and friends in building process
relationship with labor
builder—client
client—land
people—earth
relationships
relationships themselves [?]
green definition is individual
Green is up for personal interpretation.
a lot of it is subjective
all different interpretations of what is green
arguments 16 different ways over “green” standards
You can look at it a lot of different ways.
impact of other systems
go do a workshop
learn hands-on
read a lot
Nothing about green building is mysterious but it’s all unfamiliar.
education of sales force
education process for green products
educational component is the most important
clients exposure of me [to GB] has created real movement
homeowner education and operation
create a more intentional space
epiphany of interconnectedness
results of labor—a vessel for people’s lives
space resonates for a lifetime

The green difference

Spaces have power.
[green building is] what you get afterwards
customer awareness (tradeoffs)
a sense of how you can adapt your environment for comfort
For lots of people, a building is something they withstand.
Not sure that I can demonstrate the value of going as green as they can go
High-volume ceilings detract from intimate environments.
loss of personal warmth in big spaces
creating spaces that help people grow and evolve
How do we create places that feel good to be in?
special places
The whole bones and flesh carry that feeling.
what would happen if everyone used 1KW PV system?
try to convince owner to builder better but smaller
where coming from, why getting into?
a relief to create with care and love
understand what you are building and why
Building does not equal environment.
doesn't have to mean you are a tree hugger
easier as a remodeler to be green
desire to create a regional influence
making an investment into environmental movement
I am tickled my profession is allowing me to protect and preserve [the environment].
group together political and environmental beliefs
post-occupancy evaluation as feedback loop
If you pay attention to this you get attuned to the environment.
integrity
It's not just skin deep.
positive comments from public
What can I do that's easier on the planet?
New home building is product driven.
Remodeling is the original GB concept.
made a choice a long time ago [to be in remodeling because of better environmental impacts]
[get builders to] think about what they do for their own business
It's not just about supply and demand.
long-term/short-term mind-set
most builders stuck on first costs
breaking the mold of traditional building mind-set
take yourself out of the silo mind-set
think longer term
We don't stop and think about distance to site.
conventional approach = maximize pie (get as many pieces out of land)
If it's [the spec house he built] going to be a demonstration it's going to be pure
do no harm
don't build it the way you did the last one
understanding the problem
no association with clear cutting [and other "bad practices"] to market it [green products]
not hard to do
"green" term really fits
calming images
green is a nice term—forests, fields, leaves, trees

Unknown and personal

[conventional building is] What I don’t want to do
[green is] anything that isn’t horrible
I’m a huge recycler.
I’m into recycling.
Turns out environment is important to me
spent a lot of time in the woods [as a child]
I’m a homebody.
take a walk in the redwoods sail on Lake Michigan
I’m less green than I was on the west coast.
big picture/politics

Appendix B: Coding instructions for open-ended interviews with response segments

Description of Categories for Coding

- Items can be coded in more than one category, but try to focus on the dominant one or two meanings. If you cannot place an item into three or fewer categories, mark it as unknown.
- Remember to keep in mind this is about how it affects the builders' work, not other people like clients or subcontractors.
- Don't assume how it would affect the builder, look at what's being said.
  - Ex: "a lot more thinking involved in it" may require more research, but they don't say that.
  - Ex: "so you have a lot more thought and planning involved" this item may imply that it takes more time or research, but it doesn't really say that, it just says more thought (attention/awareness) and more planning (plan ahead).
- **Commitment**
  Builders need to be more committed to the process of green building, have more dedication to their values, and be more willing to stick to their principles.
  - "You are probably going to have to organize your whole job around some different principles and different priorities."
- **Research/learning**
  Builders have to do more research and learn more to do green projects.
  - "Involves more research. It involves more education."
- **Attention/awareness**
  Builders have to pay more attention throughout the building process, to bring more awareness and concern to the building process, to put more thought into green projects.
  - "There's a fundamental shift in how you approach it."
- **Variability**
  There is more variability in green products, processes, and projects. Builders need to choose among more options but there's also no one-size-fits-all with green building. Each project is different from the last.
  - "It also drives and limits material selection."
- **Communication**
  Green projects require more communication between builders and their suppliers, subcontractors, and clients. There's more communication required to do green jobs and more communication required to get and promote green projects.
  - "Explaining to the subcontractors that this is a finished surface, don't mess it up, that's a constant battle."
- **Plan ahead**
  Green projects require more advance planning, longer-term scheduling, and more foresight.
  - "going to have to source them months in advance so you can have them there"

statement	plan ahead	communication	variability	research / learning	commitment	attention / awareness
You use different products you use different practices			X			
[in commerical or large projects] You have more architectural input, more professional input. Some of those practices become an integral part of the design		X				
There's a lot of moral issue involved.						X
as long as builder understands how to assemble it they're going to be fine with it.			X	X		
We found that to use OSB correctly you have to install it differently than you would plywood….If you do all those things correctly it is actually a better material			X			
green is really a threshold issue					X	
We've probably walked away from jobs, looked at jobs and decided that they were going to be more complex. If we can't integrate green technologies easily into what we're doing than it's probably not a very good job for us.				X		
I expect it would add time to the building process	X					
Part of taking more time would involve more planning more scheduling	X					
Encouraging people to tell their friends about what they did and why, get that message out that there's a reason beyond what we're sitting in this kitchen		X				
Involves more research. It involves more education				X		
It involves more education, constantly to convince the client		X				
more showing people what you've done and explaining why, having tours, creating a forum for people to come and see what you've done		X				
More time consuming	X					
explaining to the subcontractors that this is a finished surface, don't mess it up, that's a constant battle		X				
going to have to source them months in advance so you can have them there	X					
If you are going to build entirely sustainably you are probably going to have to organize your whole job around some different principles and different priorities	X				X	
takes more planning ahead	X					
That kind of plan ahead with materials and products that are not necessarily readily available	X					
There's a fundamental shift in how you approach it.						X
There's a lot of information that is hard for most builders to grasp on to, especially since it is changing so rapidly			X	X		
There's all this information. Research – disseminate to features they can afford				X		
those kinds of things I'm having to think outside of just getting this project done on a certain time on a certain budget,						X
If you are a little more concerned about the environmental or what kind of product you are delivering then you would lean that way kind of naturally						X

statement	plan ahead	communication	variability	research / learning	commitment	attention / awareness
more concerned about your product. A little more interested in more value						X
the easiest way would be not to be concerned with green at all. Because you're not narrowing yourself down			X			
A true green builder really knows his stuff. He knows his suppliers, he knows the consequences of what his materials are, both in terms of their effect on the client and their overall effect in the general scheme of the economy and the environment			X	X		
know the alternatives to conventional building.			X	X		
not be just relying on what this manufacturer or this distributor or that salesman is saying works		X	X	X		
On the whole they really have to know more				X		
They really should be on top of their trade and really know conventional building really well				X		
You really have to make sure you do some legwork	X			X		
I have the luxury that I am up in the higher end where we have more flexibility in costs, so I would say I am probably more likely than the production builder to be able to try some new things			X			
Sometimes when we investigate them they change their mind		X		X		
they [conventional carpenters] are not accustomed to thinking of the impacts of what they are doing, and that is very hard to train		X	X			X
wanting to analyze options and try to do smart construction, not just green			X	X		
We've found it's easier to have a collaborative relationship with customers like that		X				
a green builder you have to still be open to some of those things and willing to try them. But do your research and make sure you feel real comfortable with it and that it is going to work			X	X	X	
If you try something new you wanna be very careful and very sure that that something new you are going to try is going to work,					X	
you have to be a little more flexible and a little more open at trying something new and different			X			X
a lot more thinking involved in it						X
it's just not click and go. It's more "now who do I got to call" which makes it just a little bit harder	X	X				
So you have a lot more thought and planning involved	X					X
When you get into green you got to do a lot more research				X		
you gotta call them 2 months in advance tell em what you want so they can, when it gets in you can get that stuff. For regular building I just call up and I get it tomorrow	X	X				
You have to do a little bit more research and it's a little more time consuming.				X		
You have to think a lot more about it because you want to make sure you get all the everything that meets green so you do have a lot more thought processes going involved in it.			X			X
You've got to do a little bit more networking with either your suppliers, your distributor or whatever to get the right product in for what you're doing	X	X	X			

statement	plan ahead	communication	variability	research / learning	commitment	attention / awareness
accountability is getting everyone to be accountable, even if they don't feel the same way or they aren't as emotionally attached to it as you are		X			X	
Accountability. The one thing you have to do and we learned that the hard way					X	
The folks that are out there in the field if you don't make them accountable to make sure that it gets built that way...They just go back and do the same old way		X			X	
The hardest part for us is getting them to do it. All top to bottom. This is the way we're going to do it and we are going to hold you accountable.		X				
You can't just assume that everyone feels the same way you do		X				
It takes more research, it's harder. You have to be willing to spend a little more time				X		
the ones that are interested in craftsmanship and nice materials those are the ones that will move towards green building more easily, than the guys that are just out there throwing houses together						X
There are some builders that just don't have the understanding and don't have the desire to get into some of the detail					X	
it takes a little more oversight with subcontractors and employees on construction methods		X				
Such as being way more concerned about the envelope of the house and the integrity of the envelope of the house						X
takes a lot more thought process to stay on top of it and ahead of it and keeping that in mind as you're building	X					X
To really keep that in mind throughout the project						X
it also drives and limits material selection			X			
So depending on the degree that somebody wants to adhere to green policies and practices it can affect a lot			X			
Each little step isn't really all that complicated to understand. But it's like a lot of things in life, once you put a lot of very simple things together then it's complicated				X		
that one rule doesn't do 'em any good if they don't know the other rules. There's great information out there, but people aren't educated to know that it exists		X		X		
Things are all interconnected with one another						X
things are always more complicated than they seem at first glance						X
Things are more tied together than you might think when you first look at the project			X			X
Understanding that some of these parts are really going to affect the other parts not just in schedule terms, but also in terms of indoor air quality and energy efficiency	X		X			X
Until you really realize how buildings work you don't really know that				X		
The techniques are part of it. You change in the way you approach things						X
You have to change your mindset.						X
you look at how you don't want to waste things						X

statement	plan ahead	communication	variability	research / learning	commitment	attention / awareness
You really start thinking a little bit differently about most things						X
Then it’s A a learning process and B making sure your subs know what they’re doing		X		X		
then you’ve got to make sure you understand how you put it together, your subs know how to put it together, things like that		X	X	X		
I also find a lot more personal interaction with the client		X				
it takes some dedication to something against the grain, something you have to research and find new things				X	X	
little bit more personal involvement it seems from clients		X				
So you have to have more patience and integrity around this is what you want to be doing					X	
You have to essentially train subcontractors how to deal and work around some different technology or different material.		X	X			
Being aware of the site, my clients needs and the resources that are available			X			X
More of a sense of building to the context the project is in			X			X
I would be asking qualifying questions of the client which most conventional builders wouldn’t		X	X			
Mine is are people wiling to spend a little bit more or learn a little more in order to have materials and practices that are better for the environment.		X				
You have to be oriented towards the environment to a much larger degree that the project is in.			X			
It takes more patience in my opinion. It also takes the ability to see						X
It’s just really seeing that there’s a multiplier effect there			X			X
The green builder it really necessitates that kind of vision and that kind of commitment. It can be tiring and it definitely takes a lot of patience, but it’s just crucial					X	X
You have to be able to look at it economically as well				X		
You just need to look at everything and take a step back. And be willing to put the time and energy into making it more green						X
You need to be able to look at the design and say “OK, this home is going to waste a lot of energy, inherently"				X		
First, it’s understanding that and then caring about it.						X
Greater than any technique or practice it is a general mindset						X
I don’t think it’s tied to any practice and I think it’s a sort of an open-ended evolving thing			X			
I just think it takes awareness and willingness					X	X
It requires a certain amount of stewardship and caring about what you are doing aside from making money						X
You use different products a lot of recycled materials – so what? That should not lead to a different mind-set in construction			X			X

Appendix C: Survey cover letter and questions

Residential Builders' Perspectives on Green Building

Hello and thank you for taking a look at this.

This survey is about how residential builders view "green" or environmental building practices and is part of dissertation research at the University of Michigan.

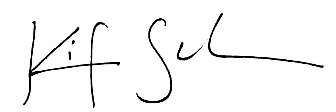
Your input is very important no matter how involved with green building you are. The quality of the results depends on getting responses from builders with a range of experience with, and attitudes about, green building.

Completing this survey takes about 15 minutes. Please know that all your answers are anonymous. Research guidelines also require that I tell you that there are no anticipated risks associated with your voluntary completion of this survey. If you have any questions about this research, please feel free to contact me.

I realize you are very busy and I can only offer you my sincerest gratitude for your time, but I hope you will take the time to help with this survey. The goal of this research is to contribute to a better understanding of the residential building industry. Your input can help create programs better suited to builders' needs in ways that I hope can facilitate your work in the long run.

Once you have completed the survey, fold it in half, seal it closed, and drop it in the mail—it's already stamped. Your help is greatly appreciated. Thank you very much and have a good day.

Sincerely,



Kif Scheuer
Doctoral Student
School of Natural Resources and Environment
University of Michigan
734-483-9043
cscheuer@umich,edu

Should you have questions regarding your rights as a participant in this research, you may contact

Kate Keever at the University's Institutional Review Board
540 East Liberty Street, Suite 202 Ann Arbor, MI 48104-2210.
(734.936.0933; irbhsbs@umich.edu).

Instructions: *Read each question in bold, note the rating scale and any specific instructions. Circle your response on the scale to the left of the items that follow each question. Please return within 2 weeks. Thank you for your participation!*

***Currently for you,* <u>how much</u> of a barrier to doing green building are the following?**

not at all a barrier		somewhat		very much a barrier	don't know	
1	2	3	4	5	□	Suppliers' knowledge of green products
1	2	3	4	5	□	Availability of products
1	2	3	4	5	□	Building codes
1	2	3	4	5	□	Construction financing
1	2	3	4	5	□	Reliability of products
1	2	3	4	5	□	Costs for green features
1	2	3	4	5	□	Realtors' understanding of green buildings
1	2	3	4	5	□	Trades / subcontractors' familiarity with green practices
1	2	3	4	5	□	Customer demand
1	2	3	4	5	□	Builders' liability insurance coverage

<u>How important</u> to you is improving the environmental performance of buildings?

not at all important		somewhat		very important	
1	2	3	4	5	Energy consumption
1	2	3	4	5	Material resource use
1	2	3	4	5	Indoor air quality
1	2	3	4	5	Plant and animal habitat impacts
1	2	3	4	5	Water resource use

<u>How often</u> are you using green practices in your construction projects?

never		sometimes		all the time	don't know	
1	2	3	4	5	□	High-efficiency energy systems (ex: high eff. HVAC, reduce air infiltration, lighting control)
1	2	3	4	5	□	Low-consumption water systems (ex: rainwater harvesting, dual-flush toilets)
1	2	3	4	5	□	Improved Indoor air quality (ex: mech. ventilation w/heat recovery, sealed combustion)
1	2	3	4	5	□	Passive solar designs (ex: window & floor plan orientation, shading, trombe walls)
1	2	3	4	5	□	Construction waste minimization (ex: chipping woodwaste onsite, recycling packaging)
1	2	3	4	5	□	High performance envelopes (ex: extra insulation, caulking, low-e windows, rainscreens)
1	2	3	4	5	□	Protection of trees and natural features on site
1	2	3	4	5	□	Materials that reduce resource use (ex: engineered, salvaged, recycled)
1	2	3	4	5	□	Low-toxicity materials (ex: formaldyhyde-free, low VOC, water-based)
1	2	3	4	5	□	Green building certification programs (ex: EnergyStar)
1	2	3	4	5	□	Advanced framing techniques
1	2	3	4	5	□	Natural or renewable materials (ex: linoleum, bamboo, sustainably harvested woods)

<u>How confident</u> are you in your current knowledge of green building techniques and issues?

not at all confident		somewhat		very confident	
1	2	3	4	5	Construction-site soil and erosion control
1	2	3	4	5	Water related environmental impacts
1	2	3	4	5	Customer demand for green features
1	2	3	4	5	Reliability of green products
1	2	3	4	5	Suppliers of green building products and equipment
1	2	3	4	5	Construction waste management
1	2	3	4	5	Water-efficient equipment (toilets, faucets, etc.)
1	2	3	4	5	Ventilation systems for improving indoor air quality
1	2	3	4	5	Health effects from mold and moisture
1	2	3	4	5	Products made from recycled materials
1	2	3	4	5	Grey water recycling
1	2	3	4	5	Non-toxic materials and finishes (paints, carpets, etc.)
1	2	3	4	5	Climate change from energy consumption
1	2	3	4	5	Advanced framing
1	2	3	4	5	Salvaging and reuse of building materials
1	2	3	4	5	Products made from natural and renewable materials
1	2	3	4	5	Costs for green building features
1	2	3	4	5	Stormwater management
1	2	3	4	5	Local codes for green practices
1	2	3	4	5	Equipment and appliance efficiency
1	2	3	4	5	Liability risks associated with green building
1	2	3	4	5	Low-impact site development
1	2	3	4	5	Passive heating and cooling
1	2	3	4	5	Building envelope performance
1	2	3	4	5	Availability of trades / subcontractors with green experience

<u>How much</u> do you rely on these information sources to learn about <u>new</u> techniques or products? ***(for either conventional or green building information)***

not at all		somewhat		very much	
1	2	3	4	5	Conventional trade associations *(Home Builder Associations, etc.)*
1	2	3	4	5	Green building organizations *(USGBC, EnergyStar, etc.)*
1	2	3	4	5	Conventional trade magazines *(JLC, Professional Builder, Fine Homebuilding, etc.)*
1	2	3	4	5	Green trade magazines *(Env. Design & Construction, Env. Bldg. News, etc.)*
1	2	3	4	5	Conventional conferences *(NAHB national conference, etc.)*
1	2	3	4	5	Green conferences *(USGBC Green Build, NAHB Green Building Conference, etc.)*
1	2	3	4	5	Conventional local seminars or workshops
1	2	3	4	5	Green local seminars or workshops
1	2	3	4	5	The internet
1	2	3	4	5	Manufacturers
1	2	3	4	5	Suppliers
1	2	3	4	5	Other builders
1	2	3	4	5	Trades people / subcontractors
1	2	3	4	5	Clients
1	2	3	4	5	Other ______________________________________

Background about you and your company

Instructions: *Write your answers in the spaces provided or check the appropriate boxes.*

Current role in your company: ______________________________

Annual gross sales (approximate)**:** ____________

Type of construction work done - percentage of practice devoted to (total equals 100%)**:**

- *Residential remodeling* ____________%
- *New single family homes - Spec.* ____________%
- *New single family homes - Custom* ____________%
- *Commercial construction* ____________%
- *Other* ____________________ ____________%

Do you develop properties as well as build? *Yes* ☐ *No* ☐

Price range of houses you work on (check your most common price range)**:**

under $250K ☐ *$250K - $800K* ☐ *over $800K* ☐

Number of years working in building trades: ____________ years

Construction background – percentage of experience from (total equals 100%):

- *On the job work (trades, labor, site supervision)* ____________ %
- *Management* ____________ %
- *Sales & marketing* ____________ %
- *Other* ____________________ ____________ %

Age: *under 25* ☐ *25-34* ☐ *35-44* ☐ *45-54* ☐ *55-65* ☐ *over 65* ☐

Sex: *Male* ☐ *Female* ☐

Education (check all that apply):

- *High school degree* ☐
- *Bachelors* ☐
- *Masters or above* ☐
- *Trade school* ☐
- *Trade-related continuing ed.* ☐

Your comments, feedback, or suggestions about this survey are welcome:

Appendix D: Builder/Firm Characteristics

Builder Characteristics	n	responses				
Owner	167	**no**	**yes**			
		28%	70%			
Majority of expeirience is on the job (trades)	171	**no**	**yes**			
		63%	37%			
Majority of experience is management	171	**no**	**yes**			
		80%	20%			
Education	167	**HSD**	**Trade schools**	**BA**	**MA or above**	
		26%	2%	47%	22%	
Age	168	**<34**	**35-44**	**45-54**	**55-65**	**>65**
		9%	27%	40%	20%	2%
number of years working in building trades	158	**<11**	**11-18**	**19-24**	**25-30**	**>30**
		20%	18%	16%	25%	13%

Firm Characteristics	n	responses				
Majority of work is remodeling	171	**no**	**yes**			
		77%	23%			
Majority of work is spec.	171	**no**	**yes**			
		84%	16%			
Majority of work is custom	171	**no**	**yes**			
		67%	33%			
Developer	167	**no**	**yes**			
		56%	42%			
Price range of houses built	168	**<$250K**	**$250K-$800K**	**>$800K**		
		17%	60%	21%		
Gross Sales	157	**<$500K**	**$500,001-1M**	**1,000,001-2M**	**2,000,001-5M**	**>5M**
		19%	21%	17%	18%	18%

Appendix E: SEM parameter estimates & Sobel test results

SEM parameter estimates

Included in the table below are unstandardized slope estimates (*B*), standard errors of the slope, the critical ratios (*B*/s.e.*B*) and the significance of the critical ratios, for both parsimonious models. The critical ratios are all significant at least at a $p<0.05$ level, most are significant at $p<0.001$ level. Items with tilde were deleted from the saturated models through model-trimming process.

			B	S.E.	C.R.	P
More common green practices						
Attitude	<---	Green info	0.43	0.09	4.91	***
Familiarity: technique	<---	Price Range	0.45	0.13	3.61	***
Familiarity:techniques	<---	Green info	0.36	0.08	4.31	***
Green Practices	<---	Familiarity:techniques	0.49	0.09	5.40	***
Green Practices	<---	Atitude	0.26	0.09	2.87	**
Attitude	<---	Price Range	~	~	~	~
Green Practices	<---	Green info	~	~	~	~
Green Practices	<---	Price Range	~	~	~	~
Less common green practices						
Atitude	<---	Gross Sales	-0.27	0.05	-5.01	***
Atitude	<---	Green info	0.36	0.08	4.46	***
Familiarity:systems	<---	Green info	0.45	0.08	5.55	***
Green Practices	<---	Familiarity: systems	0.55	0.08	7.24	***
Green Practices	<---	Atitude	0.30	0.08	3.91	***
Green Practices	<---	Green info	0.21	0.08	2.50	*
Familiarity: systems	<---	Gross Sales	~	~	~	~
Green Practices	<---	Gross Sales	~	~	~	~

** p<0.05, ** p<0.01, ***p<0.001*
~ path deleted through model trimming

Sobel test results

Calculations for this test are based on the formula z-value = $a*b\Big/\sqrt{b^2sa^2+a^2sb^2}$ where *a* and *b* are unstandardized path coefficients from the IV to the mediator and the mediator to the DV, and *sa* and *sb* are the standard errors of the path coefficients.

	More Common green practices		Less common green practices	
	Test statistic	**p**	**Test statistic**	**p**
Familiarity	3.46	0.001	4.35	0.0005
Attitude	2.47	0.05	2.88	0.005