Growing Hot House Orchids in Clay Pots:
Fostering Communities of Practice in a Traditional Functional Hierarchy

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Abstract

This study explores how public agencies try to foster communities of practice to enhance professional development and strengthen knowledge retention. Communities of practice are informal groups of professionals who learn and share information about key job-related processes and skills. These groups often develop organically through ties of mutual self-interest that connect individuals from several offices in one or many organizations. However, communities of practice can also emerge through cultivation by public agencies. Research on communities of practice suggests that organically developed communities (i.e. generated by participants) are more likely to be effective vehicles for knowledge transfer and retention.

Building on O'Toole and Meier's (1999) model of the impact of public management on organizational performance, we examine the effectiveness of communities of practice within a public agency. We do so by comparing and contrasting two sets of case studies of communities of practice: cases where the communities develop organically within the agency and cases where senior management sponsors the development of the community.

The performance outcome is the time and effort that managers devote to learning and retaining knowledge of key job-related processes and skills. We observe the level of manager participation in communities of practice and the degree to which participation affects these knowledge outcomes. We also assess the accuracy of knowledge by contrasting manager perceptions of best practices and agency-sanctioned standards. Manager perceptions of past performance outcomes, the stability of hierarchy within the agency, and shocks to the agency are observed in the development of each case.

We hypothesize that organically developed communities of practice emphasize time and effort investments in knowledge use while agency initiated communities of practice emphasize knowledge accuracy. Further, we hypothesize that organically developed communities buffer hierarchical instability and shocks to agency operations while agency initiated communities buttress hierarchy by mitigating shocks to the agency.

The case studies are developed from observations of the Georgia Department of Transportation (GDOT). The research employs a multiple comparative case study design to contrast communities that have developed organically with communities initiated by GDOT. We also contrast large communities (>25 managers) and small communities (<25 managers). Each case is an embedded design: within each community, we observe individual managers and contrast group of managers based on their level of participation in the community. Findings are pending as this research is currently being conducted.
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This study explores how communities of practice develop within a public agency and become a channel through which managers attempt to facilitate critical exchanges of knowledge that are then used to achieve performance outcomes. We define communities of practice as groups of professionals working on behalf of an organization who learn and share information about key job-related processes and skills (Wenger, 1998). Those public agencies that have embraced the idea of communities of practice tend to do so as part of a larger agenda of transforming traditional bureaucratic organizations into learning organizations and developing strategies for knowledge retention and management (Snyder, Wenger, and Briggs, 2004). However, one of the persistent weaknesses of communities of practice both in the research literature and as human resource practice is a limited understanding of the pathways through which communities connect to the productive enterprises of an agency. This study is a step towards addressing this problem.

Public agencies have experienced a growth in interest in supporting communities of practice (Snyder, Wenger, and Briggs, 2004). Several factors contribute to the urgency felt in human resource offices to develop effective knowledge management and learning strategies (Luen and Al-Hawamdeh, 2001; Desouza, 2009). Chief amongst these is the graying of the public sector workforce (Elliott, 1995; DeLong, 2004). To address this issue, public agencies have struggled with the development of effective strategies for transferring knowledge across generations. Supporting the development of communities of practice is seen as one way of holding onto key sources of information by embedding it into the knowledge base of groups of professionals (DeLong and Davenport, 2003).

Another challenging factor stimulating agencies to develop knowledge management and learning strategies is the dramatic increase in outsourcing of key functions of agencies to the private or non-profit sectors. When agencies operate through portfolios of contracts or through a mixed portfolio of work conducted in-house and work conducted by consultants, the skill sets of agency professionals shift to include expertise in contract management. Sometime the balance shifts precariously away from subject matter expertise to contract management expertise. Communities of practice can be used as a venue for pooling the knowledge and expertise from both the agency and the larger contractor community (Koliba, 2006).

In the public sector, there are also growing calls for the development of communities of practice that span the federalist system, linking professionals at different levels (Agranoff, 2006). These studies harken back to older narratives in the intergovernmental relations literature such as “picket fence federalism” (Nice & Fredericksen, 1995: 13-14) and ideas concerning policy networks (Heclo, 1978). An important theme to emerge out of this research is the call for strategic collaboration across the federalist layers and amongst the broader stakeholder community (Agranoff and McGuire, 2001; Vanka, Handy, and Kockelman, 2005; Fu, Mayhew, Bailey, and Shoup, 1997; Bryson, Crosby, and Stone, 2006).
While the interest in communities of practice is growing, less is known about the source and development of these associations. Studies have found that these groups often develop organically through ties of mutual self-interest that connect individuals from several offices in one or many organizations. Communities of practice can also emerge through cultivation by public agencies (Callahan, 2004). Many researchers suggest that organically developed communities (i.e., those generated by participants) buttressed with an effective virtual hub are more likely to be effective vehicles for knowledge transfer and retention. However, the quality of evidence for this finding is limited.

UNDERSTANDING COMMUNITIES OF PRACTICE

Communities of practice have been billed as a new discovery growing out of the emergence of the “Web 2.0” organization or the “learning” organization. Although the term “communities of practice” did not enter the academic literature until the 1990s, it develops themes that have been present in studies of organizational behavior and public management for decades. Perhaps the most obvious thematic connection is with the concepts of the informal organization (Barnard, 1938; Burns and Stalker, 1961). The informal or organic organization refers to the structure of associations among employees that is distinct from the formal hierarchy. Employees form these associations to advance their own mutual interests, which are distinct from and sometimes adverse to those of the organization (Burns and Stalker, 1961: 98-101).

The informal organization operates alongside formal organizational structures and processes. The formal organization provides a roadmap to professional workers of the sanctioned procedures that an organization uses in the production of outputs (Udy, 1959: 792-793). The formal structure is embodied by a hierarchy that provides a superstructure of relationships between offices and functions that are then linked through standard operating procedures (SOP). The hierarchy and the SOPs represent a form of institutional memory of hard won lessons of practices. In principle, these officially sanctioned practices are designed to allow the organization to achieve desired outputs while complying with those external demands identified by senior management as having high salience to the organization (Pfeffer and Salancik, 1974; Perrow, 1986; Weber, 1947; Mintzberg, 1979; Stinchcombe, 1965; Thompson, 1967). In most organizations, human resource officers and senior managers exert great pains to make a record of the formal organization and to disseminate this record.

Communities of practice are a more recent contribution to the narrative of the informal organization. Wenger et al. (2002) describe communities of practice as informal groups of professionals from different offices in one or many organizations who share an interest in a professional practice and exhibit a passion for improving their skills associated with that practice. A key feature of such communities is that their members consult with each other on a regular basis to learn how to improve their skills related to a professional practice. Community members may also ask each other for help in solving problems that they encounter in their work related to the focal practice.

Wenger’s description provides a useful lens for understanding how communities of practice function. Several key characteristics of communities of practice are important to this study. First, communities of practice function as networks. Membership in these networks can exhibit considerable variability with regards to the frequency of interaction or even the institutional
affiliation of the workers. Yet the communities behave as networks in that their members are self-aware that they have links with one another and in that these links are predicated upon a shared interest in the social exchange of knowledge concerning a professional practice. In the public sector, communities of practice have been found in a variety of settings from the military (Palos, 2007) to transportation agencies (Winsor et al., 2004) to the Australian civil service (Callahan, 2004). Communities of practice in each setting are loose networks of individuals trying to learn how to do something better, whether that something is a skill set associated with Air Force manpower, high performance concrete, or knowledge management in the public sector.

A second characteristic of communities of practice is that the social exchange of knowledge becomes an important component of the work lives of some participants (Wenger et al., 2002). This is generally expressed through the level of “passion” or “intensity” with which participants are committed to their communities of practice (Kwon, Pardo, and Burke, 2006; Pan and Leidner, 2003; Scarbrough and Swan, 1999). In some cases, the focus of the passion is upon building communities: professionals seek to identify other resources that can be called upon to help them in their work and also seek spaces in which they can share their knowledge and build their own reputations as resources for others to seek out. These are not mutually exclusive interests: professionals can be passionate about both gaining skills and building communities. Under these circumstances, communities of practice can become focal points through which professionals gain a significant sense of meaning and purpose in their work (Brown and Duguid, 1991; Wenger, 1998; Davenport and Hall, 2002; Gherardi and Nicolini, 2002).

A third characteristic of communities of practice is that they facilitate learning. One of the greatest interests of researchers engaged in the study of communities of practice is identifying instances of learning within these communities. This interest in learning stems from the origin of the term “communities of practice” in a study of situated learning among insurance claims processors (Lave and Wenger, 1991). In that study, Jean Lave and Etienne Wenger argued that communities of practice enabled legitimate peripheral participation. That is, newcomers to communities of practice participated on the sidelines and then moved toward the center of these groups as their base of knowledge surrounding the practices of interest increased. This conceptualization of social or situated learning draws on earlier ideas of socialization (Vygotsky, 1998), enculturation (Brown et al., 1999), and tacit knowledge (Polanyi, 1966).

A fourth characteristic noted in the literature is the organic nature of the organization of communities of practice. Participants develop communities of practice as a means of facilitating learning and problem solving. This means that the organization of the communities and the maintenance of knowledge gained through the communities are dependent upon professionals dedicating time and effort to these tasks. Even though they are not required to do so for their jobs, participants frequently dedicate time and effort to the organization and maintenance of communities of practice. In fact, the early literature on communities of practice argued that the very bottom-up, grassroots nature of communities of practice created the vitality and power necessary to foster rich learning environments. However, more recent research on communities of practice has found that many organizations not only approve of communities of practice but also devote time and resources to community operations (e.g., Gongla and Rizzuto, 2001).
An important resource in the organization of many communities of practice is the existence of an information technology backbone for facilitating knowledge exchanges and storing key information sources. For example, the Federal Highway Administration recently used Microsoft SharePoint as an anchor for multiple communities of practice (Winsor et al., 2004). The online SharePoint communities employed site administrators to remove inappropriate or irrelevant content and site facilitators with expert credentials to ensure that questions were answered quickly (Winsor et al., 2004: 93). The FHWA found that having a regulated electronic space helped facilitate communication between transportation professionals in different states and in different levels of government (Winsor et al., 2004: 94). Having a virtual space for communities of practice is a sufficiently important topic that there is a thriving sub-literature within journals related to human computer interface, knowledge management, library sciences, communications, and information studies that focus exclusively on quantitative analyses of the electronic records of communities of practice (e.g., Garcia and Donohovich, 2005; Wasko et al., 2009; Gadja and Koliba, 2007; Henri and Pudelko, 2003).

A community of practice is not entirely populated with passionate individuals eagerly communicating with each other about the latest and greatest that they have discovered in their work. Such an environment would be exhausting after a period of time. Communities of practice are also populated by less passionate people who find participation in knowledge exchange useful. This pattern of participation was found in the Federal Highway Administration study (Winsor et al., 2004). Peripheral participation is vital to the on-going health of a community because it ensures that the community has a greater reach in terms of the number and type of participants. Larger communities allow participants to solve a larger array of problems by sharing a wide variety of experiences in adapting a practice to different work contexts.

The research literatures exploring communities of practice provide important concepts that we will use in this study. Chief amongst these are strategies for identifying the existence of a community of practice. In this study, we examine networks of actors who are engaged in regular exchanges of knowledge as a necessary but not sufficient condition that a community of practice exists. We also examine whether the participants are self-aware that they are participating in a community of actors who are exchanging knowledge. In effect, we can identify boundary conditions for communities of practice.

Where we depart from the communities of practice literature is with regards to the dependent variable. Individual and community learning are the dependent variables most frequently found in studies of communities of practice, although they may not be labeled as such in research of a more interpretative tradition. This has led to laments in reviews of the literature that communities of practice need to be studied in a way that links this phenomenon to the productivity of the organization (Fox, 2000; Kimble and Hildreth, 2004; Koliba and Gadja, 2009). In this study we attempt such an exercise. To do so we borrow a model that has been used in the public management literature aimed at understanding performance.

**O’TOOLE AND MEIER’S MODEL OF PUBLIC MANAGEMENT**

Building on O’Toole and Meier’s (1999) model of the impact of public management on organizational performance, we examine the influence of communities of practice on the outputs of a public agency. We do so by examining case studies of communities of practice within a single
agency: the Georgia Department of Transportation (GDOT). The model is designed to understand the influence of managerial networking behavior on the performance of the organization (Hicklin, O'Toole and Meier, 2007). It does so by examining the frequency with which senior managers turn to external networks versus internal hierarchical controls when managing an output. This model was developed and applied in a series of surveys of Texas school district superintendents.

While this study builds upon the O'Toole and Meier model, we make several important adaptations for exploring communities of practice. First, where the O'Toole and Meier studies focused on the senior executives of school districts, we examine the use of networks by middle managers and lower ranked professionals. Second, the networks explored in this study are not simply external networks. Instead, the basic unit of analysis is the knowledge exchange network of a middle manager. Third, the outputs in this study vary from case to case. In the O'Toole and Meier studies, the output was school district performance as measured through student test scores. In this study, one of the central questions is how to determine the types of outputs that are associated with different types of communities of practice.

To set the stage for our study, we employ the most general form of the model (Hicklin, O'Toole & Meier, 2007: 255-256):

\[ O_t = \beta_1 (S+M_1) O_{t-1} + \beta_2 \left( \frac{X_t}{S} \right) (M_3/M_4) + \varepsilon_t \]

“O is some measure of outcome”
“S is a measure of stability denoting structural, procedural, and other elements that support unperturbed production”
“M denotes management, which can be divided into three parts,”
“M_1 denotes management’s contribution to organizational stability through additions to hierarchy/structure as well as regular operations”
“M_3 denotes management’s effort to exploit the environment”
“M_4 denotes management’s effort to buffer environmental shocks”
M_2 = M_3/M_4 = managerial networking
“X is a vector of environmental forces”
“\( \varepsilon \) is an error term”

Building off of this base model, we examine the outcomes for GDOT operations that result from different forms of communities of practice found within the agency. We develop case studies of these communities and explore how the managerial strategies used in each community correspond to strategies represented in M_1 and M_2 (and the associated strategies relating to M_3 and M_4).

By far the most extensively studied variable in the Meier and O'Toole model of public management is M_2, managerial networking. M_2 is defined as the ratio of M_3 over M_4 and is most frequently operationalized in the Texas schools dataset through a survey item that asks school district superintendents how often they interact with various sets of actors. The most compact operationalization asks about interactions with local business leaders, other school superintendents, state legislators, and the Texas education association. The key point for our purposes is that M_2 is operationally measured by asking respondents to indicate the frequency with which they interact with groups both inside and outside the organization. Across a wide variety of studies, M_2 has been positively linked with organizational performance, measured as the percentage of students in a school district who pass all sections of the Texas Assessment of Knowledge and Skills (TAKS). M_1, management’s contribution to organizational stability, is
operationalized through the percentage of employees in a school district classified as central administrative staff.

We extend the O’Toole and Meier model to examine the relationship between communities of practice and outcomes. One of the debates within the communities of practice literature focuses on the necessity that the associated networks be organic in nature (Koliba and Gadjia, 2009; Saint-Onge and Wallace, 2003; Swan et al., 2002). This is akin to discussions in the policy implementation literature over the types of outcomes one can expect to observe if a phenomenon is observed from a top-down (i.e., pursuing the goals of senior management or political authority) or a bottom-up perspective (i.e., from the perspective of lower level workers and affected populations).

This suggests that the outcomes pursued by managers participating in a community of practice may vary. In this study, the performance we observe is the time and effort that managers devote to learning, retaining, and applying knowledge of key job-related processes and skills to desired outcomes. Managers in an organic community of practice may pursue different outcomes from managers working in a community of practice that is formal in nature. We hypothesize that organically developed communities of practice will focus on achieving outcomes that improve the skill base of participants and adaptations of knowledge to local use by participants. In contrast, formal communities of practice initiated by senior management will emphasize knowledge accuracy and the efficient diffusion of accurate knowledge throughout the agency. Further, we hypothesize that organically developed communities buffer hierarchical instability and shocks to agency operations within the sub-units within which participants work. Formal communities of practice will attempt to buttress hierarchy by mitigating shocks to the agency as a whole.

CASE STUDY METHOD

An embedded comparative case study design is used to explore the influence of communities of practice on the outcomes of the Georgia Department of Transportation (GDOT). Each embedded case consists of an identified community of practice. We examine each case through the O’Toole and Meier model by exploring the outcomes pursued through the community of practice (O), stability and environmental factors confronting the agency (S and X), and the behavior of managers participating in the community related to supporting hierarchy (M₁), exploiting the environment (M₃) and buffering environmental shocks (M₄).

One of the first tasks of this research was to devise a means by which communities of practice could be identified. Organizations are saturated with information. Within an organization, knowledge is exchanged when information is delivered in a sufficiently coherent and timely way. However, knowledge exchanges are not sufficient to establish the existence of communities of practice; additional criteria are needed. Chief of these is that there must be a network in which the membership is self-aware and dedicated to maintaining communication aimed at improving professional skills and practices. Professionals share information frequently in episodic forms as managers pursue the knowledge that they need to complete projects. Knowledge exchanges also occur through hierarchic relationships as supervisors expand the skill sets of subordinates. However, communities of practice represent an alternative path to building professional skills and learning how to apply skills to work-related problems. In this form, managers from multiple offices and even multiple organizations recognize that they are working with similar skill sets and that
they can benefit from communication with individuals outside their immediate chains of command or project teams. Because communities of practice often exist outside formal organizational structures, they can be difficult to identify and observe.

Table 1. Candidate Communities of Practice

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Formality</th>
<th>Practice</th>
<th>Means of Exchange</th>
<th>Self-Aware</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS users’ group</td>
<td>279</td>
<td>Organic</td>
<td>Geographic information systems</td>
<td>SharePoint</td>
<td>Yes</td>
</tr>
<tr>
<td>Monthly design group workshops</td>
<td>20</td>
<td>Formal</td>
<td>Topics within design</td>
<td>Face-to-face</td>
<td>Unknown</td>
</tr>
<tr>
<td>Practical design training</td>
<td>76</td>
<td>Formal</td>
<td>Geometric design, pavement design, drainage design, capacity analysis</td>
<td>Face-to-face</td>
<td>Unknown</td>
</tr>
<tr>
<td>Construction inspectors</td>
<td>Unknown</td>
<td>Organic</td>
<td>Inspection</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maintenance engineers</td>
<td>Unknown</td>
<td>Organic</td>
<td>Maintenance engineering</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Traffic signal staff and contacts</td>
<td>5</td>
<td>Organic</td>
<td>Traffic signal engineering</td>
<td>Face-to-face, phone</td>
<td>Yes</td>
</tr>
<tr>
<td>Leadership Development in Middle Managers</td>
<td>274</td>
<td>Organic</td>
<td>Management</td>
<td>Face-to-face, phone, email</td>
<td>Unknown</td>
</tr>
<tr>
<td>Institute of Transportation Engineers (ITE)</td>
<td>33</td>
<td>Formal</td>
<td>Transportation engineering</td>
<td>Face-to-face</td>
<td>Yes</td>
</tr>
<tr>
<td>Intelligent Transportation Systems (ITS)</td>
<td>Unknown</td>
<td>Formal</td>
<td>Intelligent transportation technology (e.g., Georgia Navigator)</td>
<td>Face-to-face</td>
<td>Yes</td>
</tr>
<tr>
<td>Regional Traffic Operations Task Force (RTOTF)</td>
<td>40</td>
<td>Formal</td>
<td>Topics within traffic operations (e.g., traffic signal clearance intervals)</td>
<td>Face-to-face</td>
<td>Yes</td>
</tr>
<tr>
<td>NEPA Analysts</td>
<td>Unknown</td>
<td>Organic</td>
<td>Interpretation of the National Environmental Policy Act (NEPA)</td>
<td>Face-to-face, email</td>
<td>Yes</td>
</tr>
<tr>
<td>Cultural Resources</td>
<td>13</td>
<td>Organic</td>
<td>Identification and preservation of Georgia’s cultural resources</td>
<td>SharePoint, face-to-face, email</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Our approach was to use two panels of key informants to identify the groups within the agency that may be operating in ways consistent with a community of practice. It would do little good to approach an engineering-oriented agency like GDOT and ask for a list of communities of practice.
The term is foreign to most managers and has a soft-skill feel that often grates the organizational culture of an engineering focused agency. Consequently, we first formed an advisory board comprised of senior managers who must assure the high quality of the performance of practice in their units and in the projects that flow through their units. We also identified managers whose roles demand significant levels of coordination of work across many units within the agency. From these groups, we identified candidate communities where patterns of communication related to communities of practice occur. We then interviewed key actors within candidate communities. Across all of these actors, we conducted 15 field interviews aimed at identifying community of practice behavior and held two advisory group meetings. Based on these interviews, we identified 12 candidate communities. In this study, we report on two of these groups. Both groups demonstrate patterns of communication that are strongly consistent with a community of practice. One group is a formal community of practice and the other is an organic community of practice.

**GDOT CASE STUDY: THE CONTEXT OF S AND X**

We begin the case analysis by focusing on stability factors (S) and environmental factors (X). While output factors (O) and managerial factors (M1-M4) exhibit considerable variance at the subunit level, the stability factors and environmental factors affect the entire organization.

Hicklin, O'Toole and Meier (2007: 255) define stability factors as “structural, procedural, and other elements that support unperturbed production.” One source of stability in GDOT is the highly standardized nature of the agency’s work. The vast majority of GDOT’s work is dedicated to the design, creation, and maintenance of highway systems. While there have been advances in road construction and road design (for example, the development of smart highways and advances in construction techniques) the fundamental structure of the technology is mature and characterized by high degrees of standardization in design, construction, and maintenance work. For example, the production of a stretch of highway follows a standard form: 10 percent of the costs are dedicated to preconstruction activities and 90 percent of the costs are dedicated to construction activities. Contracts for both types of work are subject to well-specified standards and guidelines of practice allowing for the development of templates for work based upon expected ranges of performance metrics (e.g., AASHTO, 2011).

A second source of stability stems from the organizational procedures developed to implement the design, construction and maintenance of a highway system. Regulations from the Federal Highway Administration (FHWA) require state agencies to develop and publicize the procedures for all phases of the development and maintenance of a highway. For example, the Plan Development Process (PDP) governs all preconstruction activity within GDOT. The purpose of the PDP, as described in its manual, is as follows:

This document sets forth the current procedures and steps necessary for the Georgia Department of Transportation (GDOT) to administer Federal-Aid projects in accordance with the policies and objectives of Titles 23, 40, and 42 United States Code, and to administer State-Aid projects to fulfill the policies and objectives of Title 32, Official Code of Georgia Annotated. The document outlines the current process of project development from project identification through construction award or final acceptance. (GDOT, 2011a)

Preconstruction work describes all of the skill sets used in the development of a highway, including planning, environmental studies (such as archeological, ecological, and environmental impact
studies), geothermal and geophysical studies, right-of-way determinations and property acquisitions, utility reviews, road engineering design, community engagement and reviews, and project management (which varies according to whether preconstruction is performed in-house or by external consultants). The PDP is a well-structured process that has governed preconstruction activities by GDOT for over a decade.

In contrast, GDOT has experienced numerous environmental shocks that have had significant impacts upon operations. GDOT, like many public agencies, has undergone a fundamental transformation in production processes, particularly with regards to preconstruction activities. As recently as 15 years ago, GDOT conducted 90 percent of the preconstruction and engineering design work on an in-house basis; today, GDOT outsources over 60 percent of that work to external consulting engineering design firms (Ponomariov, Kingsley and Boardman, forthcoming). This outsourcing has had profound consequences for the agency as it has moved from an organization that relied on internal expertise for quality control of engineering design to an organization responsible for managing contracts for the engineering design of other organizations.

A confluence of environmental factors has increased demand for outsourcing by GDOT. Political elites in Georgia have supported the expansion of the construction of state highways and roads beyond the interstate highway system. Federal monies have also supported significant maintenance programs of highways and bridges. This has led to a sharp increase in the number of projects initiated under the State Transportation Implementation Plan. Georgia public finance rules have not permitted the addition of state personnel on the projects financed through debt instruments. At the same time, civil service rules have been relaxed through the elimination of the merit system governing state employees. This has permitted GDOT employees to retire or to join private firms and return to work for the agency as consultants.

GDOT has also come under significant political pressures as the state legislature and the governors have sought to exert greater control over decision making in the production of highways. GDOT is currently managed by the State Transportation Board, which has independent responsibility for GDOT review and approval of GDOT expenditures and operations. While board members are appointed by the legislature to represent districts within the state, and while the governor and the legislature approve the overall budget of the agency, both the executive and legislative branches of state government have attempted to place preferred candidates in the position of Commissioner of the State Transportation Board and to reduce the independence of GDOT. Further, like all state agencies, GDOT has experienced significant resource constraints with substantial reductions within the last year. Federal transportation sources provide approximately 63 percent of the funds for GDOT operations, while state motor fuel tax revenues provide approximately 36 percent of operating funds. Both sources have declined. As a result, over the last two years GDOT has reduced its workforce by 7 percent to approximately 5,000 employees (GDOT, 2011b). Most of these reductions are due to attrition from retirements and from younger employees leaving for private sector jobs. This is a remarkable milestone for the agency as employment from 2000 to 2010 held steady at approximately 5,800 employees.

All of these environmental shocks have been manifest in the high incidence of turnover amongst the senior leadership of GDOT and in an alarming number of structural reorganizations. Over the past seven years, we have found evidence of five distinct organizational structures implemented by the agency. Such reorganization is expensive: each change in the agency's organizational design incurred substantial transaction costs.
The combination of S and X factors upon GDOT has led to an interesting combination of structural instability, as the various offices and personnel are shuffled and reshuffled, coupled with procedural stability, as all of the offices and personnel are required to come together in the implementation of well-established processes and practices embodied in the PDP.

One senior manager described the current state of the agency in the following terms:

“[GDOT] is like a 100 car freight train. If it’s rolling, it takes long time to stop it, and then you stop it, it takes a long time to get it started again. We’re stopped. We’re struggling to try to get the train going again. ... In the past there were a lot more clear directions. While the train was stopping we had several folks [i.e., senior managers] wanting to drive the train, some [of these] folks didn’t know anything about road building to drive the train. So the train ain’t going nowhere [now]. ”

CASE 1 -- GEOGRAPHIC INFORMATION SYSTEMS: AN ORGANIC COMMUNITY

Building a highway requires significant levels of awareness of the geographical characteristics associated with the location of a road project. Not surprisingly, this has led many units within GDOT to develop a demand for geographic information systems (GIS). This suite of technologies facilitates the linking of global positioning systems, digital imaging systems, digital mapping technology, databases and sophisticated algorithms used in computational statistical analysis.

GDOT has approximately 450 installations of an agency approved GIS software package with approximately 200 active users of the software at any one time. There is also an individual IT officer whose job description includes supporting GIS uses and applications within GDOT. This officer provides training on GIS software, advises on adapting GIS to local problems, and communicates best practices throughout the agency. Toward these ends, this officer organized a SharePoint site to facilitate communication amongst GIS users. SharePoint is a Web platform aimed at facilitating greater interaction across groups and teams by creating a single focal point for collaborative web applications, database sharing, document management, and electronic communications. Approximately 180 GDOT employees currently have permissions to access the SharePoint site. The IT support components of the GIS application are similar to those found in software user groups.

GIS applications are distributed across the agency; however, there are clusters of intense users in the offices of transportation data, environmental services, planning, and traffic operations. There has also been strong growth in the number of applications of GIS as offices find new uses for geographic data. The IT support officer reports that this is evident in the number of solicited presentations and consultations that he given across the agency. However, this has not translated into high levels of activity associated with the SharePoint site.

THE GIS COMMUNITY AND M1

Maps and mapping technologies have long been a part of the production stream for a highway system within GDOT. Examples of applications include:

- Plans for the optimal location and production of a highway project
- Acquisition of property to establish the right-of-way for a highway project
• Studies identifying the geophysical properties of the terrain upon which a highway system may be built
• Studies of the impacts of highway systems on communities, cultural artifacts and local ecologies
• Reviews of the proposals from consultants and contractors engaged by the agency to create a highway system
• Construction documents used in the creation of a highway project
• Implementation documents for maintenance operations

Maps are thus an integral part of the standard operating procedures for the agency and a critical tool used in many practices distributed throughout the agency. GIS, however, is a relatively recent addition to the arsenal of tools used by transportation professionals.

Because the use of maps and geo-coded data is distributed across the agency, there is a natural constituency for GIS applications. Organic communities of practice are created and operated by individual community members. M1 denotes the managerial contributions to stability through contributions to hierarchy and processes that support regular operations. One might anticipate relatively little evidence of M1 managerial behavior on the part of participants in organic communities of practice.

In the case of the GIS community, evidence of M1 is found in two forms. First, GDOT has responded to the expanding usage of GIS by providing an IT officer to help facilitate the use of GIS within the agency. The role of this officer extends beyond responding to the interests of active users to promoting of the use of GIS software within the agency. Second, GDOT has endorsed a specific GIS software platform that is used across offices within the agency.

The agency has an interest in supporting best practices that are consistent with industry standards and in compliance with regulations. Because highway design and construction are mature disciplines with well-established technologies, there are relatively large numbers of professional societies and governmental agencies engaged in questions related to best practices. In order to develop a highway system, GDOT has assembled teams of employees and contractors who represent the range of skills needed in the enterprise of a highway project. Mapping is an integral part of many of the professions represented amongst GDOT personnel.

Given these environmental conditions, a state agency must make decisions concerning the balance between developing agency-specific standards for practices and drawing on the external environment to guide standards for practices. There are several points in the operations of an agency where senior management can choose to set standards. GDOT has not created a strong filter that affects the application the dissemination and adoption of GIS software. This has allowed for more organic forms of development of a community with GDOT.

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THE GIS COMMUNITY AND M2

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Studies of M2 have observed the level of interaction of school superintendents with key external actors within their environment such as key business leaders, their counterparts in other districts, state legislators, and officers in the state education bureaucracy (see Hicklin, O’Toole and Meier, 2007; Meier and O’Toole, 2008; Meier and O’Toole, 2003; O’Toole et al., 2005). In a case study environment, we can explore M2 (the ratio of M3 to M4) in greater detail. M3 observes efforts by
management to exploit the environment. M₄ is management’s effort to buffer the organization from environmental shocks. Thus if M₄ has a stronger effect than M₃, M₂ will reflect strategies to limit influences from the environment. In contrast, if M₃ is greater than M₄, M₂ will reflect managerial strategies to magnify environmental influences.

In this case, there is evidence of senior management efforts to improve access to external resources associated with GIS technology by providing resources to support the propagation of a GIS software platform and by providing IT resources to promote the use of the technology. However, from this perspective, M₁ and M₃ are indistinguishable. In essence, management is providing some structure to the ways in which GDOT managers interact with the social and technological environments related to GIS. But there is little evidence of the agency providing a stronger filter or a stronger boost to interactions with the GIS environment.

By design, the O’Toole and Meier model takes the perspective of senior management. In this study, a more interesting narrative related to management behavior emerges through the behavior of participants in the GIS community. In particular, we examine participants’ efforts to solve problems through GIS practices. In essence, we observe managerial behavior from the bottom up. To illustrate, we examine the behavior of the GIS community to address the problem of floodplain maps.

A floodplain is a lowland area next to a body of water such as a river, lake, or ocean. The designation of a floodplain is tied to the likelihood that a flood will occur during a particular time period. The Federal Emergency Management Agency’s Flood Insurance Administration is responsible for mapping known floodplains. Executive Order 11988 from 1977 directs federal agencies to avoid developing projects (including transportation projects) on a floodplain. If a floodplain map is not available, then managers must develop and/or review a flood hazard boundary map. If a project will be sited on a floodplain, then the project’s environmental documentation must include a study that is consistent with requirements in U.S. Department of Transportation Order 5650.2 “Floodplain Management and Protection” from 1979.

Several GDOT managers engaged in the PDP process are impacted by these requirements. Until recently, it was the responsibility of individual managers to ensure that the provision of information relevant to their particular offices that satisfied floodplain regulations. Over the years, as these managers left their positions through retirement, promotion, or exit, their replacements varied in their knowledge of these regulations and in their understanding which maps would satisfy GDOT needs.

In recent years, participants in the GIS community noticed that several offices needed information on floodplain maps. When projects required flood hazard boundary maps, offices searched for maps developed in earlier and similar projects. Through their interactions with the GIS IT support officer, managers began to develop lists of requirements that their individual offices have with regards to floodplains. In essence, the community has commenced a search for a comprehensive list of requirements for floodplain maps across the agency. The community is also seeking to pool existing information sources from across the agency. It is too early to tell if this type of collaboration will result in strategies of enhancing or buffering environmental influences. There are two notable aspects of the behavior of this community. First, it is aimed at providing a more coordinated and effective response to these environmental pressures. Second, it is an example of a community taking a proactive response to assembling required information rather than waiting for a hierarchical direction related to floodplains.
O is a measure of outcomes in the O'Toole and Meier model. One of the interesting aspects of the GIS community of practice is that the community includes members from all along the production process for a highway system. Since this process is essentially a sequential one, the outcomes from one office are often the inputs of another office. This means that the community does not share a common view of the outcomes of the application of GIS. One of the challenges noticed in the floodplain narrative is that individual officers may share a common problem associated with floodplains, and even a common need for floodplain maps, but the particular sets of information provided by their offices as outcomes may be different.

Developing a managerial solution to the floodplain problem is essentially one of understanding the union and the intersection of information needs from the individual offices. In this case, O is a vector of outcomes that plug into the production process at different points in time.

The GIS community of practice has been effective in identifying a common information need across several offices within the agency. However, to impact the performance of the agency, there must be improvements in the efficiency or the effectiveness of the individual offices in addressing floodplain tasks. This is not exclusive to the floodplain problem and can be generalized to apply to other GIS related tasks. As an informal network, the community has a direct impact upon the improved skills of individual participants and the quality of their work. But the coordination of floodplain information and maps can also have a direct impact upon the performance of offices linked together in a production sequences. This can be measured through improvements in the timeliness and quality of the production processes. In this case, managers have developed a single source for floodplain information that is maintained and supported by the community of practice, thereby reducing the amount of time and effort managers must devote to information retrieval.

**CASE 2 -- PRACTICAL DESIGN TRAINING: A FORMAL COMMUNITY**

One of the challenges confronting the design engineers of GDOT is assuring that all engineers are working according to the same performance standards in the design of highway systems. Some of these standards are set by GDOT. However, state transportation agencies like GDOT are also subject to standards set by the various agencies that comprise the U.S. Department of Transportation and industry groups such as American Association of State Highway and Transportation Officials (AASHTO) and the American Society of Highway Engineers (ASHE). This creates a complex web of standards aimed at guiding the development, construction, and maintenance of highway systems.

GDOT's organizational structure distributes engineering talent across the organization both geographically and functional. In geographical terms, engineers are located in the headquarters offices of Atlanta and in district offices throughout the state. In functional terms, engineers work in offices dedicated to pre-construction design, construction, and maintenance. When a change in standards occurs, it must be communicated across the geographical and functional divisions of the agency. The standards must then be incorporated into the standard operating procedures of the agency. As GDOT has outsourced design projects to consulting engineering firms, this problem has become magnified: GDOT managers must assure that consultants perform according to the appropriate standards.

GDOT engineers have developed a variety of communities aimed at communicating and adopting changes in engineering standards. Some communities emphasize affiliating with external professional associations (such as AASHTO and ASHE) for professional development training in
best practices and standards. Others have developed strategies that emphasize working groups that focus on the adaptation of standards to local problems and the promotion of best practices. This type of informal professional development has a long history within the agency.

More recently, GDOT has undergone numerous reorganizations (see S section above). In some ways, these reorganizations can create problems for standards adoption by disrupting the chain of command. However, one recent change in GDOT’s organizational structure created the Office of Design Policy and Support. This office is responsible for the dissemination of design standards amongst engineers. It is home to the Repository for Online Access to Documentation and Standards (ROADS), an online resource that maintains access to the PDP, design policy manuals, standards for plan presentation, construction standards, and standards for software.

PRACTICAL DESIGN TRAINING AND M₁

The introduction of the Office of Design Policy and Support in 2009 represented a significant effort by senior management to formalize what had heretofore been relatively informal processes governing the communication and adoption of standards. Three key domains—standards and policies, engineering software support, and surveying (i.e., location standards and technologies)—were assigned to this office. Different units within GDOT had been responsible for these domains in the past; however, they had other major functions to serve, so the topics had been neglected for some time. The new office is also responsible for reviewing the engineering literature, reducing it to a form that can be communicated, and deciding whether GDOT needs to implement it.

The Office of Design Policy and Support has opted to build upon the existing system of informal workshops built by engineers in the various design offices. It has developed a series of seminars aimed at “practical design training” in which senior engineers teach changes in standards. The seminars involve no more than six engineers at a time. The small class size is intended to give the design engineers plenty of attention to answer questions about the application of standards to the projects on which they work. Officers from the Office of Design Policy and Support also participate in the best practice workshops hosted by design engineering offices within GDOT. This provides a second avenue to introduce issues related to engineering standards. The combination of formal training seminars, informational resources regarding standards, and participation and presentation in informal best practice workshops is intended to infuse the community of design engineers with greater awareness of standards.

This approach introduces a much more formal voice into the ongoing dialog on best practices. It is intended to provide a strong reinforcement of procedures. It is also structured to ensure that design engineers and engineers working in district and construction sites are sufficiently knowledgeable about changes in standards that they can implement such changes quickly.

PRACTICAL DESIGN TRAINING AND M₂

Design engineers within GDOT have long been responsible for pursuing their own professional development. The agency has supported their continued training and development through a mix of internal workshops and training programs from external groups. However, these activities are secondary resources for learning when compared to the hierarchic structure of GDOT. One of the chief places that GDOT engineers complete on-the-job training is within their work units, learning from their superiors and from individuals and resources to which their superiors may direct them.
during the course of a project. Once a pattern of work is established within an office group, it is difficult to persuade engineers that a new approach is better. According to one respondent, this is true even when the better approach is required under the law or according to industry standards. The very number of alternative sources through which state engineers can search for guidance on standards outside GDOT actually diminishes the capacity of individual managers to make wise choices.

In this light, the community of engineers associated with practical design training serves an important function for GDOT. From the perspective of M3, the Office of Design Policy and Support serves as a megaphone augmenting the message about standards that should be adopted by GDOT engineers. From the perspective of M4, the Office of Design Policy and Support serves as a filter: it sorts the information that GDOT engineers need for different standards and then organizes this information into communications that can be digested within the agency. However, these augmentation and filtering services are insufficient to ensure adoption. It is the combination of the role of the Office of Design Policy and Support with the role of conversations about best practices amongst the design engineers that creates stronger avenues for the dissemination and adoption of standards.

To fulfill the M2 role, the practical design training community consists of three integral activities:

1. A long-standing series of informal communications concerning best practices amongst the design engineers. This discussion is conducted through regularly scheduled best practice workshops, personal mentoring amongst design engineers, and through informal communications (usually by phone) where engineers bounce ideas off their counterparts.
2. A formal office that serves strong roles for filtering or promoting information regarding standards. This office has consciously attempted to enter into and participate in the stream of informal communications amongst engineers.
3. A variety of means of storing and accessing key documents and communications electronically.

The formal nature of the practical design training community of practice gives it a much sharper focus for assessing the outcomes of work by participants. All of the participants are from the design community or are engaged in supporting design (such as the Office of Design Policy and Support) or implementing designs (such as the district engineering staff). The chief output of the design training community is the enhancement of the quality of the plans created by the design engineers. While design plans are highly complex documents, the assessment of quality is simpler than the complex vector of outputs found in the GIS community. The ultimate tests of this body of work will be found in two metrics. The first metric is the speed with which changes in standards are incorporated into plans developed by GDOT, including the designs of GDOT engineers and of consulting engineers. The second metric is the number of errors of design attributable to a failure to follow standards during the letting and construction process. Of these two, the latter is easier for GDOT to observe, as the agency currently tracks design errors during the construction process and then reviews these design errors in the quality review processes.
CONCLUSION

In this study, we have examined the efficacy of the O'Toole and Meier model of public management as a means for understanding the influence of communities of practice upon the performance outcomes of an agency. We have also compared communities of practice that are organic and formal in nature and explored hypotheses about the ways in which these different types of communities might influence performance outcomes.

We find that the O'Toole and Meier model adapts well to the study of communities of practice. The key concepts of stability, environmental influences, and managerial strategies (M1-4) together provide a framework for exploring the nature of communities of practice. There are, of course, important limitations to this study. The mechanism by which communities of practice translate influence into outcomes is still unclear and deserves greater attention. Communities of practice are informal groups and offices are the units responsible for production of outcomes. However, as we have seen in both the GIS and the practical design training cases, these communities play vital roles in shaping both the outcomes of offices and the work of individual managers.
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