Team Knowledge in Enterprise Architecting

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Abstract

Enterprise architecture (EA) seeks to align business process and IT, but architecting involves many stakeholders (e.g., architects, IT staff, and business staff) with very diverse and often conflicting goals, making this alignment difficult to achieve. In this study we investigate how team knowledge helps coordinate the architecting effort to achieve this alignment. We report on four case studies with various degrees of EA success. Specifically, we investigate how EA, IT and business staff coordinate their work, with special focus on implicit coordination through team knowledge.

1. Introduction

The main goal of enterprise architecture (EA) is to align and coordinate business processes with technology infrastructure, underlying data, and applications [1], in support of business strategy execution [2]. “Enterprise “architecting” (or simply “architecting”) is the actual development and management of the EA. Architecting is a complex and multi-functional activity involving participants with differing levels of dependencies, goals and motivations. Managing these dependencies is precisely what defines coordination [3, 4]. We have argued in prior research (citation omitted for blind review) that successful architecting requires tight coordination by all involved to effectively manage the dependencies among the various architecting activities.

Such coordination is facilitated by “implicit” assumptions collaborators have about what others are likely to do, termed “cognitive coordination” [5]. This cognitive coordination has a “self-fueling” effect, increasing the effectiveness of other forms of coordination combining with them to have a powerful effect on architecting effectiveness. The resulting EA in turn becomes a mechanism to facilitate coordination, further strengthening the ability to coordinate cognitively. That is, the EA itself becomes an important source of “team knowledge,” which in turn helps team members develop more common ground and a shared mental model about what EA does for the organization.

In this study we argue that team knowledge is key in achieving cognitive coordination. We use data from two prior interview cases (citation omitted for blind review) that investigated the self-fueling effect and augment our previous findings by: (1) digging deeper and more specifically into team knowledge as the main driver of cognitive coordination and the self-fueling effect; and (2) complementing our prior research with data from two additional case studies. Understanding how teams gather, hold, and use knowledge has become important as organizations increasingly depend on teams to process information [6, 7] within their enterprise architecture (EA). Thus, the goal of the present study is to better understand the role of team knowledge in helping collaborators coordinate the architecting effort effectively, and the contribution of EA to team knowledge. Our research question is, therefore: What is the role of team knowledge in enterprise architecting coordination effectiveness?

We begin by briefly discussing traditional coordination processes. We then theorize about the importance of team knowledge in the enterprise architecting process. We then describe our study methods. After this we provide a brief summary of our two prior cases, followed by a more complete discussion of our two new cases. We then provide a discussion and concluding remarks about our findings.

2. Traditional Coordination Processes

The organizational literature suggests that teams coordinate organically and mechanistically [8, 9]. “Organic coordination” refers to coordination through all forms of team communication. While team communication is important to manage day to day dependencies among members handling EA task activities, it is particularly important to foster and strengthen team knowledge. “Mechanistic coordination” refers to the use of processes, routines and plans to coordinate more routine aspects of the task.

3. Team Knowledge

Team knowledge is known by many labels and constructs defined in the cognition literature [10]. What they have in common is a basis in knowledge similarities (or overlaps) about one another and about their tasks, which help members coordinate and develop shared mental schemas [11]. Popular forms of team knowledge include: shared task knowledge – what collaborators know about each other’s tasks [11]; shared mental models -- the alignment, similarity or overlap of individual members’ knowledge connections and mental schemas [12, 13]; transactive memory – knowledge about what other members know, which helps members to locate expertise when needed [14, 15]; common ground – the mutual knowledge or knowledge members share and know they share [16, 17].

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among team members to understand and purposefully take into account how their actions will affect others in the team.

4. Study Method and Sample

We use an empirical case study method appropriate to exploratory information systems research [19-23]. We analyze 4 case studies from very different organizations with a wide range of success in EA. Because EA involves the alignment of business and IT, there are many individuals with diverse functional backgrounds who either work in EA functions or are affected by the EA. Therefore, and consistent with the key architecture roles identified in prior research [1], we interviewed 17 participants in various roles in these organizations: chief information officer (CIO); chief enterprise architect; a technical architect; an IT staff outside of EA; and a business stakeholder.

We selected the four cases because their organizations are seriously committed to their EA programs and have very competent architects, IT staff and business staff with many years of relevant experience. One organization has been widely successful in their EA program, two organizations were moderately successful with their EA efforts, whereas one of the organizations is struggling. We posit that important differences between these four organizations include their approach to architecting and how their EA activities are coordinated through team knowledge, and that these influenced the respective outcomes.

We used a semi-structured interview approach with questions to elicit information about coordination challenges, dependencies among functions and best practices. The interviews were audio recorded and transcribed verbatim, yielding approximately 12.5 hours, 224 pages and 111,300 words of interview material. The interview transcriptions were first analyzed one at a time using the Grounded Theory approach [24, 25], then analyzed by recurring themes [26], and once more by case (i.e., by organization) [23]. Grounded Theory is a widely used qualitative method in IS research [22, 27] and global collaboration [28]. Each case was analyzed to interpret similarities and differences among the two cases. Consistent with Grounded Theory, we developed an initial coding scheme through open coding of the first few interview transcriptions to uncover general recurring themes of interest, with consensus from three of the researchers involved in this study. We then refined did axial coding using NVivo© software data to find relationships among these themes. Finally, we analyzed each case individually to contrast their differences.

In the following case discussion, we provide: some background on each organization and its architecting practices; a description of key coordination processes utilized; an analysis of the role of team knowledge in the architecting process; and a summary.

5. Cases

5.1 Prior Case: Oil Extraction Company (OEC)

Background. This organization is a private oil extraction company with about 1200 employees. The EA strategy at this company is very coherent and successful and its current EA maturity level is relatively high, somewhere in level 4 of the Ross et al maturity model [2]. The business process, data, application and technology EA layers are tightly aligned and all interview participants were consistent in their high EA maturity rating of the organization. This company created a special unit called the Center for Process Excellence (CPE) to identify, define and manage all business processes and standards from the perspective of the enterprise to drive the EA. At the time of the interview there were 32 business process owners. The EA functions for the other three layers are managed by the chief enterprise architect, who reports to the CIO. The CIO and the head of the CPE collaborate very closely. The idea is for the CPE to define the most appropriate processes and for the CIO to deliver the technology to support them.

Coordination Processes. OEC members spend a substantial amount of time sharing information through one-on-one communications, helping them develop team knowledge. IT/business alignment is also achieved by proactive one-on-one discussions between EA personnel and subject matter experts, who are typically from the business side. All conflicts are quickly addressed and discussed to find the best resolution. OEC spent a few years planning their EA implementation and placed a lot of emphasis on standardization. They devoted a great deal of time finding similarities in processes to identify best practices and standardizing process components that could be replicated. They also developed metadata models and data directories to help employees get to the right data quickly and have a common frame of reference. Finally, OEC also relied on pro-active governance as a coordination mechanism. They established an architectural board responsible for reviewing IT projects and their milestones to ensure compliance with the EA and to communicate corrective actions to project teams when needed. Another aspect to governance as a coordination mechanism came from budgeting in the sense that any substantial project would only be prioritized and obtained IT resources if it was compliant with the EA.

Team Knowledge. OEC’s EA team invested in procedures to ensure that there would be collective understanding – shared mental models of the company vision and operations. Getting the EA right required a lot of changes over a long period of time and this was a very difficult thing to do. However, the top leadership
understood the value of EA and supported the EA program, not just financially but also through leadership and commitment. One important philosophy of OEC’s EA program was the strong perspective that the main customers were the business process owners. No process or system was allowed to be modified without the approval of the business process owners affected. Process owners had process analysts working with them, playing a bridging communication role between IT and business, helping to share knowledge and to establish common ground. This developed a strong shared mental model of the process.

System projects were generally led by business managers, not IT managers, thus establishing a common frame of reference. Also, the EA effort involved a substantial amount of training of all key personnel to help achieve commitment and a shared vision. Business stakeholders were also trained on EA concepts and practices to ensure everyone understood the necessary terms, definitions and principles associated with the EA, thus establishing strong common ground and commitment (i.e., a shared schema) to the EA. Discussions centered on helping employees understand that an enterprise approach was best for the company over the long run, even if it was not the most expedient approach for some groups, fostering strong shared mental models about EA.

A strong common ground was formed around data. A lot of time and effort went into creating standard data repositories with data element names that had common meaning for everyone, ensuring that the data collected met the needs of all who used it. Because everyone in the company either produces or consumes data, well defined and understood data models were instrumental in achieving common ground on EA. Over time, this increased the shared team knowledge and implicit coordination in the group. Perhaps one of the most salient aspects of OEC’s architecting was their concerted effort to develop a strong collective mind about EA. From the business perspective, everything in the EA was driven by business process needs, so no IT decisions or actions were undertaken without understanding how these supported business process needs. And from an IT perspective, business stakeholders were trained on EA practices so that their actions and decisions were optimized with respect to the EA. This kind of heedful interrelating ensured effective alignment between business and IT.

**Summary.** OEC is perhaps the most successful in their EA effort among all the companies we analyzed in this study. They obtained the buy-in from top leaders for the EA program right from the beginning, then spent substantial time planning to do it right. This shared mental model between top management and EA implementers resulted in an early commitment from the top, thus gaining acceptance among employees before EA benefits could be demonstrated. As key managers worked to develop shared mental models, common ground, and collective mind about EA, the benefits of EA (e.g., standardized data models, repeatable business processes, less redundancy, common technical language) started to materialize. The resulting EA was quite effective and became a coordination mechanism per se and a source of common ground. A second factor leading to OEC’s EA success was the conscious effort to align the technical EA layers with the EA business process layer, and not the other way around. Finally, common ground was established early about things like data definitions/models and standardized repeatable processes. Together, these efforts developed team knowledge through strong shared mental models of content and process, enabling a high level of implicit coordination. This in turn strengthened the EA, which became a further source of team knowledge.

**5.2 Prior Case: Financial Regulatory Organization (FRO)**

**Background.** This organization is an independent and private regulatory agency with over 3000 employees overseeing almost 5000 firms and institutions. Because information management is at the core of this organization’s work, data management and application development are key business activities. The organization has 6 lines of business or “towers”, plus two other groups – Product Management and the CIO’s Office. The chief architect reports to the CIO and oversees the EA, but does not have ownership over the architects or applications. He is responsible for the oversight and direction of shared services and shared frameworks, but is not involved with business process architecting. Application architects report to a manager with responsibility for all applications. There is some segmentation in the EA with “tower” architects who support applications for specific lines of business. The chief architect coordinates with the tower architects, but he does not directly supervise their work. The tower architects work with application developers to provide support for data, software and technology architecture issues. Product managers develop the requirements for these organization’s applications and help bridge business processes with EA and IT. The architecting for FRO is more focused on technical architecture aspects. FRO’s EA maturity is fairly low, around Level 2 of the Ross et al maturity model [2] and the towers operate somewhat independently in a stovepipe manner. Most architecting work is carried out at the application level.

**Coordination Processes.** There is a fair amount of coordination via one-on-one communication, but most of it is ad-hoc, as needed to manage day-to-day activities and resolve technical issues, and not much of it is aimed at developing team knowledge. A lot of this communication is between application managers and application architects, not so much with the chief...
architect or across business segments. Most communication is application specific and other communication is rare. Similarly, there are mechanistic coordination devices in place (e.g., steering committees, standards, governance procedures), but these are not strictly adhered to and are often waived when tower or application managers make a case, resulting in a complex mix of data repositories and software platforms. EA governance is primarily reactive through audits to ensure compliance. Application architecture changes are coordinated in an ad-hoc manner between developers and EA staff, rather than through formal architectural reviews. Business stakeholders participate in steering committees for projects and applications, but not in architecture steering committees.

**Team Knowledge.** There was not much evidence of team knowledge shared across groups in this organization. Most of the team knowledge observed was within groups (e.g., application developers, architects). Shared knowledge of content is limited by the segmentation of functional experts (such as the tower architects), while enduring team process knowledge is thwarted by the ad-hoc, reactive managerial practices. The application needs of the towers drive most of the development effort and many similar processes across segments are supported by different applications. EA is often perceived as a technical concern, thus the shared mental model around EA is weak. Business stakeholders also have very little shared knowledge with enterprise architects, but they do have more shared knowledge with technical project managers and technical architects, who then liaise with EA staff. Similarly, there is a weak shared mental model about standard, repeatable processes and common data among application developers and tower architects, and the focus is primarily on infrastructure.

Overall, strategic and EA knowledge are often concentrated within individuals and cliques. This inhibits the overall EA effectiveness, even when knowledge at lower organizational levels is relatively shared. For instance, the alignment between IT and business is strong at the application level, but not at the EA level. We found very little common ground among enterprise architects, application managers/developers and business stakeholders. Even common terms discussed by some during the interviews (e.g., “tower architects”) were unfamiliar to other interviewees.

**Summary.** Most coordination processes associated with architecting are nonexistent or inadequate. This organization has very talented, experienced architects and application developers who care deeply about the EA, but lack a shared mental model about it. This shared mental model exists among the EA staff, but it is not shared with the rest of the organization who view EA as a technical or compliance issue of interest to EA staff only. EA is generally perceived useful as long as it does not conflict with the needs of specific tower applications; in cases of conflicts, waivers are obtained to step out of compliance with EA standards. The lack of shared team knowledge inhibits individuals across organizational units from communicating effectively about broad strategic issues, limiting coordination as EA and team knowledge fail build upon one another to support and enhance organizational purpose.

### 5.3 New Case: Federal Government Agency (FGA)

**Background.** This organization is a small U.S. federal government oversight agency with about 3500 employees in several regional offices, most of which are based in the Washington, D.C. area. The EA function reports to the CIO who in turn reports to the chief administrative officer, one level below the agency director level. All IT functions, including IT budget management, are centralized. The CIO’s office provides all organizational IT services and support, including infrastructure, applications and EA. The organization has three sub-divisions reporting to the agency director, one that handles the main organizational mission function (and by far the largest), another that handles all the legal aspects (which are important for this agency) and the IT organization. The EA function is housed in its own division under the CIO, but separate from all other IT functions, and is responsible for overall EA, as well as business process and change management.

The current EA maturity level of this organization is relatively high, in level 3 of the Ross et al maturity model [2]. The 4 EA layers appear to well aligned and all interview participants were consistent on this view and in indicating efforts to further improve the EA maturity of the organization. The EA is organized with 4 business segments, each mapping to the main business areas of the organization. It is important to note that there was very little EA three years prior to our study and applications were generally stove piped. So there has been quite a transformation to bring the organization to its current level of EA maturity. Each EA layer has a person that oversees the changes in that layer. Also, each of the four segments has a person that oversees the changes within the segment. The chief architect helps keep changes to the layers and segments synchronized as a coherent architecture.

**Coordination Processes.** There is a substantial amount of organic coordination, mostly in meetings with cross functional participants and various IT functions, to align IT and business and also to synchronize things across business segments. Meetings tend to be frequent and long, especially at the operational levels and they trigger a lot of e-mail communication. Much of this communication is intended to help further develop team knowledge – e.g., common ground, buy-in, shared knowledge of process, etc., as a participant commented: “the easiest thing to do is to get people together to describe - here is the
process that we follow, and here is the process that we think we should follow, here is an improved process, here are the people that should do it.”

Pro-active governance plays an important role in mechanistic coordination, with regular meetings of an IT investments committee in which projects above a certain threshold (approximately $250,000 annual cost) are approved and then regularly monitored. There is also an EA oversight group that reviews for compliance between the architecture and other agency standards. Business segment managers are viewed as portfolio managers who have authority to approve what is being done within that segment. Thus, any funding needed for IT projects needs approval of the business segment managers. There is an “integrated assessment” process that IT projects have to go through to ensure compliance with the EA before approval is obtained. The EA itself and the chief architect are viewed as a bridge to connect business and IT. The chief architect fulfills the governance role of architecture assurance manager. One of the first things done by FGA was to develop a web based tool to allow analysts and business stakeholders to view components of the architecture (e.g., business processes, data models, etc.) with extensive documentation on all aspects of project implementations, which helped teams navigate through all the necessary steps.

Team Knowledge. The philosophy in the CIO office is that in order for an enterprise approach to be successful there has to be buy-in at all levels, but this needs to come with support from the top. This is difficult because the EA benefits are only visible over the long term. So the CIO focused on delivering early visible EA benefits, such as greater computer mobility and standardized data elements.

The EA evolution plan to higher maturity levels is partly owned by IT and partly owned by the business process owner. The job of the chief architect is to ensure that the segment architectures and processes are tied together into one coherent architecture; this requires tight knowledge sharing across segments. The EA caters to the core business needs, which do not change much. This requires substantial knowledge sharing between IT and business, partly because the organization has made a commitment to using commercial off-the-shelf applications without customization, which sometimes requires some business processes to be redesigned when new applications are acquired. In some cases there is a substantial amount of mapping that has to be done between the software functionality and the business functions, which requires buy-in from the business stakeholders. But the alignment between business and IT is viewed more as a governance issue than a technical issue. Initially, there was resistance to this approach, but over time the business stakeholders realized how much more effective their processes became and they quickly embraced the EA approach.

This organization places primary emphasis on the importance of collaboration between IT and business, between business segments and more importantly, to understanding the downstream and upstream effects of all actions and decisions (i.e., collective mind). To this effect, all shared artifacts (e.g., data repositories) are placed in central locations with widespread transparent access to all, and they made sure IT understood the business benefits of each implementation. In addition, the IT staff devote a lot of effort to using terminology that made sense to the business stakeholders. Despite these efforts, sometimes there are common ground problems when issues get too technical in the application or business process layers (in either the words, drawings or symbols used) for staff to understand. But the technical staff are sensitive to this issue and they make it a point to present their issues in plain terms to keep conversations clear. Comments were made that more needs to be done to develop language and diagrams that have shared meaning and to train the technical staff and architects to better understand business process issues and vice versa.

Two important aspects leading to EA success in this organization are that: (a) business owns the change management process; and (b) alignment with IT and across segments happens by developing common ground around data elements – i.e., agreeing across the organization to use the same data label for the same data element. Once this is achieved, buy in by the business stakeholders is immediate. For example, in one exercise key business process and segment owners came together and, facilitated by the EA group, reduced data elements from a few thousand to a few hundred, and this got immediate buy in for the EA approach. Moreover, skeptical members became advocates. As one participant commented: “we had an aha! moment”.

Summary. It is evident from this case that the EA itself serves as a powerful organizational coordination mechanism. FGA relies heavily on various forms of team knowledge, including: common ground about the meaning of data elements; shared schemas to help align IT with business (not the other way around); a shared mental model about what EA does for business; and a collective mind of how one’s actions affect everyone else and how the EA’s role in achieving this. As noted above, FGA has developed a number of financial and process systems which may lead to further team knowledge growth, especially as the directory structures (“know who knows what”) and transactive memory systems across teams increase the ease of implicit knowledge flow. Over time, increases in team knowledge should lead to greater implicit coordination, reducing time spent in internal transactions and
increasing the range of applications that can be understood through EA.

5.4 New Case: Asian Government Agency (AGA)

Background. This government agency in Asia is divided into two main subsidiaries – AGACorp, a subsidiary responsible for the corporate support functions, such as policy and administration, human resources and finance; and AGAOps, responsible for the operational aspects of the organization. Each of these subsidiaries has its own CIO office. In addition, a third organization, AGAIT, serves as the IT implementation arm for both subsidiaries. The respective CIO offices are responsible for the IT strategy, policies, and for interfacing with the business users in their respective organizations.

AGAIT is responsible for all technology related implementations and research projects based on the direction of AGACorp and AGAOps. AGAIT has an EA office (with about 30 people) that is responsible for the technical architecture for the whole of AGA, including the technology and applications EA layers. AGACorp is more mature and advanced in its usage of EA, compared to AGAOps. A business process architecture team with about 15 people was set up three years prior to the start of this study to manage the business process architecture and to interface with the EA office in AGAIT. This team is responsible for working with the business process owners of all the corporate support functions to map out the business processes and to define the requirements for IT projects that will then be sent to the EA office in AGAIT. AGAOps, on the other hand, has not systematically focused on EA and therefore depends on AGAIT to lead its EA efforts.

AGACorp and AGAOps are at different levels of EA maturity because of the different amount of focus and resources devoted by each subsidiary. The EA maturity level at AGACorp is relatively high, somewhere in Level 3 of the Ross et al maturity model [2]. The four EA layers appear to be well aligned. AGACorp decided three years prior to the start of this study that the CIO office should be more business driven than technology driven. The business process architecture team then started to map out the business processes in AGACorp. The team started in a more opportunistic manner – by identifying three business areas that have existing business problems, like the need to replace an existing system. The team then started to map out the business processes in the three areas to begin the build the business process map for the whole of AGACorp. Once the business processes are defined by the business process architecture team in AGACorp, they will work with the EA office in AGAIT to define the application and technical architecture that should be linked to the business process architecture.

A separate group made up of representatives from the business process architecture team and the users of the business processes are responsible for defining the information architecture that would be linked to the business process architecture. The team has completed the three projects and is already seeing the benefits of reusing some business processes and the associated applications and information structure for new projects that they are now trying to map. AGACorp thus currently has in place a systematic approach to further broaden the use of the EA and to work towards building a unified EA for the whole organization.

AGAOps, on the other hand, has a low EA maturity at the first level of EA maturity of the Ross et al model [2]. This is partly due to the fact that AGAOps has not consciously decided to focus on adopting an EA approach towards managing their business processes and IT resources. Another major reason is because AGAOps has three major lines of businesses, which operate in a stove piped manner with little standardization and coordination among them. Each line of business often views itself as having unique requirements and thus sees little need to coordinate with other lines of business. Hence, while AGAIT has mapped out some of the architectural components for the technical infrastructure and application solutions layers within each line of business segment, very little has been done to map out the EA for across the three lines of business. The remainder of this case focuses primarily on AGACorp’s coordination processes and team knowledge.

Coordination Processes. There is a substantial amount of organic coordination, both at the top management level and at the working staff level. At the top management level, an “Enterprise Business Steering Committee”, chaired by the CIO, was established for the top management to determine the business transformations required for AGACorp. This steering committee has the representation of the top management from all the key departments. The committee meets regularly to discuss the strategic directions and review the developments of key projects. At the working staff level, the business architecture team serves a key role as the liaison between the technical staff at AGAIT and the business users in AGACorp. The business architecture team is headed by a user who has significant experience documenting business processes in a multi-year SAP© project implementation. The team works closely to communicate with both the business users in AGACorp and with the technical EA team as well as the developers in AGAIT.

Recognizing that requiring business users to document the business processes represented additional work for them, AGACorp put in place a series of governance mechanisms to ensure that business users complied with this requirement. Before IT projects are
funded, they have to be reviewed to ensure that the business process architecture has been mapped out for the relevant business process, and the project is consistent with the enterprise technical architecture before the projects are approved for funding.

Another key aspect of AGACorp’s EA strategy is the use of a centralized repository, which they called “Avatar”, to store all the business process architecture artifacts developed. AGACorp’s vision is to use the repository to build up the mapping of the entire organization’s business processes, as articulated by one interviewee: “so what we do is every project, after the mapping, the business process is put into a repository, we have an enterprise wide repository and we try to link everything up. So, as you populate more and more business process, the knowledge and the usefulness gets bigger and bigger because if you start off with one, it doesn’t make any difference, you know, I only see what I already know, but once you put everything inside, then you can see the linkages, you can see the business process that cuts across different lines of business.” While the business users own the business processes and are responsible for making sure that the business architecture mappings were accurate, the business architecture team has the responsibility of managing the business processes in the central repository. This way, even if the business users and business processes owners change or leave the organization, the business processes are still retained in in the repository so that they can be reused.

Team Knowledge. Similarly to how the FGA case demonstrates the role of mechanistic coordination, this case illustrates how organic coordination can build toward team knowledge and EA. At the core, team mental models are about sharing construct meanings and how they map together. Therefore, building the shared content of team knowledge requires a mutual understanding of language and processes. For example, the key to ensuring the success of the central repository for AGACorp is the use of a common modeling language that all individuals can understand, regardless of whether the individual is in the EA team, or a business user, or an IT person. AGACorp has adopted a common modeling language that requires all IT and business users to be able to use and understand it. This modeling language provides a common framework for documenting business processes and provides a common language for discussing user requirements, fostering understanding, governing policies, and ensuring the interoperability of business processes. As noted by one interviewee: “So the model, which is that language, if we could advocate people to use that common language to describe what do you really want, so that the developer, the implementer understands, then there is no ambiguity. And also across business functions, people all understand, so the business people are able to work in terms of their way of looking at the work flow across. And technical people are able to also reach the ops and technical languages, that’s the key.”

This common modeling language not only generates common ground and facilitates communication between people with different background, but it is also extremely critical for AGACorp’s strategy of using the repository to build up the entire organization’s business process mapping. As highlighted by an interviewee: “Every project starts at a different time, I need a single language, so when you bring them to me, I can put them together. If one project uses PowerPoint©, one uses Visio©, then how would I put them together? I won’t be able to form the big picture... So if I can use the metaphor of a jigsaw puzzle, every project actually gives me a few pieces of the jigsaw puzzle, and I have to tell them what color schemes to use, what shape they are supposed to cut, so that when they give it to me, I can piece them together, and it becomes a big business map.”

A common modeling language that is invariant across time also helps the organization to utilize the repository as a knowledge management tool, to retain knowledge even after the employee has left the organization. This is because a common language ensures that the knowledge about a business process is effectively documented and can be understood by another individual even if the author has left the organization. As noted by an interviewee: “if they learn the language, they will know the process from just looking at the process model. So I don’t need to ask the guy who generated it, who may have left the organization. For example, for a recent project that we have where we are trying to reuse the business process of an earlier project, I need not get together another group of people to start doing the process mapping all over, because the process is there. I only need the ops manager to go through the process, and for him to say ‘yes this is what I want’ that is it.”

To effectively implement the use of a common modeling language, the key is to educate a broad range of users on its use. This is not easy, as it involves teaching people of different backgrounds about the use of notations more familiar to software engineers. In fact, the requirement for all projects to have the relevant business process architectures mapped requires education of even the senior managers who are reviewing the project documents. Hence, the EA team finds that much of their time is spent simply educating users about the use of the modeling language and the use of the central repository. It is also through this education process that the concepts of EA will begin to gain traction among a large group and broad base of individuals of different functions and background. While these mechanistic and organic coordination efforts may be somewhat cost- and time-intensive at this point, they have potential to engender increased
efficiency later as the team knowledge and implicit coordination increase.

**Summary.** One of the key challenges highlighted by interviewees in discussing their EA journey for AGACorp was that the value in using EA is often evident only in the long term. As noted earlier, a single project implementation of EA will often not reveal any value, as the linkages across projects and lines of business cannot be realized. A critical mass of business processes and architectures must be mapped out before the big picture can start to reveal itself. People may thus not see the value in using EA in the short term. In the case of AGACorp, the key success factor was that the leadership was committed even though they did not see the immediate benefits of using EA. As noted by an interviewee: “when you start EA, you don’t see the value. You are just investing in training, change management, telling people what is EA, and starting to build up the repository. Luckily for us, we have top management who have the vision. That’s what got us started. Then now that we have already started, as we do new projects, we can start using some of the processes. This is when people start seeing the value. So it was lucky that back when we started, we had strong leadership, if not it could not have started. If they had started by asking “what is the ROI?” there is no immediate ROI.”

6. Discussion

We have analyzed four different cases involving very different organization types with different degrees of EA success and maturity. This has enabled us to develop a more generalized perspective on the role of team knowledge on EA success. In sum, we have uncovered some best (and worst) practices associated with coordination processes, and have also found very strong support for team knowledge as the primary cognitive coordination mechanism that is central to the “self-fueling” effect. We first briefly synthesize our findings around coordination processes, then discuss the role that team knowledge plays in effective coordination of the architecting effort, and finally articulate some general aspects of team knowledge we have observed in relation to EA success.

**Coordination Processes.** Overall, we found that organic coordination (i.e., communication) is frequent and intense. However, its effectiveness depends not on the intensity of communication, but on its nature. Communication aimed at resolving issues and coordinating ad-hoc daily activities, not integrated across business units and EA layers is ineffective and often may be symptomatic of more serious problems and inefficiencies in the architecting effort. On the other hand, frequent communication aimed purposely at building team knowledge across business units and EA layers leads to successful architecting, generating a successful EA, which in turn provides the common ground for more effective communication. This provides more support for the “self-fueling” effect. In particular, early planning meetings pay off, not only in terms of getting things organized, but also to develop shared mental models about EA among those involved in architecting. Mechanistic coordination is not only very effective, but also necessary. However, when mechanistic coordination procedures are not enforced or are easily waived they become ineffective and dysfunctional. Proactive governance and steering committees with wide participation are perhaps the most effective forms of mechanistic coordination, and also help develop shared mental models about the EA, which in turns help ignite the self-fueling effects that lead to excellence in EA.

**Team Knowledge.** Our results strongly suggest that team knowledge is not only beneficial to enterprise architecting, but it is essential for successful EA implementations. This was evident in each case in our study, illustrating a strong correlation between team knowledge and EA success. The presence of team knowledge elements (e.g. shared mental models of content and process, schema, and directory structures) enhanced EA in the case studies, while poorly developed team knowledge was associated with less coordination and less effective EA. It is apparent that strong commitment and support from top management is critical to EA success, a commitment that occurs only when there is a strong shared mental model of the EA among top managers and EA implementers. We found that once some of the benefits of EA begin to materialize in tangible form (e.g., reduced duplication, replicable processes, common grounding on data elements), even the skepticals convert. However, directives from a committed top management are key up to that point. Strong mechanistic coordination may function similarly to team knowledge in limited contexts, especially when paired with organic communication, while also enhancing team knowledge development as mutual understanding increases. Resultant team knowledge and implicit coordination may provide a more efficient means to address a wider variety of EA purposes without depending on further mechanized rules and procedures.

Our findings show that strong shared mental models about business processes are critical to the alignment of the technical EA layers (i.e., data, applications and technology) with the business process layer, more than the reciprocal. EA activity tends to be dysfunctional when shared mental models are weak and focused on technical issues. At the same time, it is important to train business stakeholders on EA issues to develop shared mental model of the EA task, which leads to stronger common ground, as we discuss next. Again, a strong shared mental model about business processes and about the EA in general, leads to more
effective EA implementations, which in turn strengthen shared mental models further – a self-fueling effect.

Common ground on key technical aspects of the architecture, especially around data, key business processes and central repositories of EA documentation are essential. In just about every successful EA implementation we have studied, EA efforts are supported by trust and commitment from the top with directives to cooperate in the EA implementation, until tangible benefits begin to materialize. This typically happens when: (1) new processes need to be implemented and architects are able to reuse standardized process components to expedite the implementation; and (2) when users develop shared meaning on the data. Data has the particular property that it is the architectural element of interest to everyone, business and technical staff alike. Establishing an effective data architecture eliminates redundancies and duplications and provides a common vocabulary that business and technical staff can refer to without ambiguity.

One more important benefit of common ground comes from the EA itself. When standard modeling languages and artifacts are adopted for the EA, when business and IT staff are trained on how to use these languages and artifacts, the EA becomes a useful central repository of organizational information. This repository can be accessed by anyone who needs information about organizational processes, data, software functionalities and technology infrastructure standards, thus providing a good high level view of how the organization functions. The common ground developed through training makes this repository one of the most effective coordination mechanisms.

While having strong shared mental models and common ground are key, the strongest benefits for EA are achieved when collective mind is formed. Collective mind provides the basis for “heedful interrelating” in which every action taken by a staff is done with a deep understanding of how these actions will affect others. This is particularly important when certain application decisions may not favor the particular business unit implementing it, but the consequences of these decisions on other business units are well understood and taken into account.

**Important Team Knowledge Characteristics.** The team cognition literature has articulated a number of characteristics associated with team knowledge [29]. In this section we discuss some of these aspects of team knowledge and others we identified in this study.

- Some aspects of team knowledge are symmetrical (e.g., members need to share knowledge about data and standardized processes equally) and some shared knowledge is directional (e.g., technical staff need to know more about business process than business staff need to know about technical issues)
- Some aspects of team knowledge are shared and some are uniquely held by members. While uniquely held knowledge is important for members to do their jobs competitively, it is the shared portion of the knowledge that fosters cognitive coordination.
- Some aspects of team knowledge are fleeting (e.g., knowing if a particular application has been launched) and other aspects are long lasting (e.g., knowing how to read a data model). Our study suggests that fleeting knowledge is less important for architecting, but that long lasting knowledge is key.
- Our findings suggest that the team knowledge is an effective driver of cognitive coordination in architecting when it has the following characteristics: (1) it is highly focused on business; (2) with sufficient common ground on EA models and artifacts; (3) mostly focused on task knowledge, with some shared knowledge of the team (e.g., transactive memory) to help locate expertise and information held by others; (4) durable (rather than fleeting or perishable) and relevant to the this asynchronous, long-term task; and (5) and widely shared, not just within EA layers and business units but, more importantly, across them.

7. Limitations and Direction

Our research is not without limitations. While our case study makes important progress toward understanding the role of team knowledge in cognitive coordination in enterprise architecting, it does not comprise a thorough empirical validation. As we discuss below, gaining further support for the team knowledge construct will involve development of a measure and testing it both qualitatively and quantitatively in a variety of venues. Despite these limitations, our study illuminates the relationship of team knowledge to enterprise architecture and associated coordination outcomes. Furthermore, our research lights a path for further research toward enhanced understanding of EA and how it can improve organizational coordination.

Managers and practitioners can improve their architecting coordination and outcomes by understanding how team knowledge affects collaboration in enterprise architecting. In the four cases we studied, we drew on the testimonies of real managers and organizational leaders who have been actively involved with EA, thus illustrating best EA practices. Researchers could also examine the extent to which various forms of team knowledge exist within various EA practices. This would require development of credible and practical field measures, which could allow organizations to anticipate knowledge emergence within their teams. Such measures could help document changes in team knowledge across time through as the
EA matures. These measures could also be useful in locating team knowledge that might be relevant to the EA. For instance, organizations early in an EA cycle might find their success to depend on pockets of shared or transactional knowledge within certain teams, while more advanced EA systems share team knowledge more evenly.

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9. References


