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Research-in-Progress

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Abstract

In spite of the importance of knowledge reuse much is still unknown about how knowledge management artifacts influence reuse in practice. In this paper we use the concept of scaffolding to explore how knowledge repositories influence knowledgeable action. We conceptualize anchoring and adjustment as the processes involved in the use of scaffolding such as knowledge repositories. By viewing reuse in terms of these mechanisms, we can begin to consider the reuse processes individually as involving (1) choice of document for reuse and (2) adaptation of the document's suggested solution applied to a current problem. We suggest the document acts as an anchor to frame the current problem consistent with the problem solved in the document, and that the suggested solution is then adapted through the adjustment process to meet the needs of the current problem. We subsequently explore the factors that influence both anchor choice and adjustment.

Keywords: Knowledge reuse, repositories, scaffolding, anchoring, adjustment, problem solving

Introduction

Knowledge repositories are collections of documents that are useful in exploiting (Gray 2001; March 1991) a firm's codified (Nonaka 1994) knowledge resources. Understanding reuse in knowledge repositories is important because the knowledge potential of repositories is immense given the breadth and depth of knowledge contained therein (Davenport and Klahr 1998). While prior work shows that the benefits to using knowledge repositories includes both reducing costs and increasing efficiency (Davenport and Klahr 1998), less is known about how repositories influence knowledgeable action within organizations. Given that initial conversations with repository stakeholders suggest that only a small portion of the knowledge contained within repositories are reused, understanding how repositories influence knowledgeable action is of the utmost importance.

We approach understanding knowledgeable action by viewing knowledge as emerging from, embodied through, embedded in, and materially linked to practice (Orlikowski 2006, 2002). What is termed the *knowing in practice* view concerns knowledge in action, being dynamically enacted through "situated interaction with the social and physical world," whereas the *possession of knowledge* view concerns knowledge that is a static, enduring substance that can be possessed (Cook and Brown 1999 p. 383). While each view is substantially different, they are nonetheless mutually enabling, where "the interplay of knowledge and knowing can generate new knowledge and new ways of knowing," or what Cook and Brown call the *generative dance* (1999 p. 381). In terms of knowledge contained within document repositories, while this knowledge concerns *possession*, the knowledgeable action produced through its situated use concerns *practice*. It is within this space between knowledge and knowing that a greater understanding of how knowledge repositories influence organizations can emerge.

This paper examines the use of knowledge repositories in judgments under uncertainty. Specifically we look at document choice among comparable alternatives that are returned from a repository search in a problem-solving task. Drawing on work in the distributed cognition literature, we use the concept of *scaffolding* (e.g., Clark 1997) as a useful metaphor to conceptualize how knowledge repositories influence knowledgeable action in organizations. We suggest the concepts of *anchoring* and *adjustment* from the decision making literature provide the cognitive mechanisms by which scaffolding operates, such that knowledge and knowing are connected and through which knowledgeable action is enacted.

Viewing knowledgeable action as involving these two sequential mechanisms, we can derive a greater understanding of document reuse by addressing two related research questions: (1) What are the factors that influence document (anchor) choice?; and (2) What are the factors that influence the reuse (adjustment) process?

In the remainder of this paper we tackle these questions. In the next section we discuss the concept of scaffolding and how the anchoring and adjustment mechanisms provide a framework for understanding knowledgeable action. Following this, in the third section we introduce a model of anchor choice, which is a subcomponent of our theoretical model of document reuse, presented in the forth section. We close in the final section with a brief discussion of limitations and a summary of how this work contributes to the literature on knowledge reuse.

Document Repositories as Scaffolds for Knowledgeable Action

The term *scaffolding* has been suggested in the literature (Orlikowski 2006) as a useful metaphor to understand knowledgeable action by individuals. Analogous to physical scaffolds in building construction, scaffolds in the context of knowledge-work are supportive, external structures that are designed to expand the ability of individuals for action beyond what would be possible without scaffolds. The key property of scaffolds is that they provide temporary stability that aids individuals and expands their capability. We draw on the metaphor of the scaffold to conceptualize the role of organizational document repositories that are designed with the intent of enabling individuals to draw on the codified knowledge of other individuals to act more knowledgeably. Accounts of the use of document repositories in firms (Haas and Hansen 2005) reflects several properties attributed to scaffolds:

- Document repositories are *flexible* – they typically contain a wide variety of documents. The breadth of prior solutions codified in knowledge repositories can help solve a variety of localized problems.

- Document repositories are *portable* – knowledge can be used to cross boundaries and help solve problems based on experience in another field.

- Document repositories are *heterogeneous* – different kinds of knowledge contained within repositories reflect different sources and needs.

- Document repositories are *emergent* – knowledge is added over time as new problems and solutions emerge, are codified, and added to knowledge repositories. Likewise, knowledge that is no longer useful can be removed from repositories.

- Document repositories are *generative* – repositories can serve as a basis for creative action.

- Document repositories are *constitutive* – shapes repeated action and helps avoid resolving known problems.

The metaphor of the scaffold for document repositories is useful because it reflects the central motivation underlying the creation of document repositories in firms – to expand the variety of approaches to problem solving by individuals based on codified knowledge found to be useful in prior instances of similar problems.

Conceptualizing Scaffolding Use – Anchoring and Adjustment

While the metaphor of scaffolding is useful in conceiving the support provided by technology artifacts like knowledge repositories, the mechanisms involved in taking advantage of scaffolding has received little attention. In physical settings, the use of scaffolding involves a) choosing among multiple scaffolds and adopting the vantage point afforded by the most appropriate scaffold for the task at hand and b) building on the scaffold to accomplish the task at hand. As described in accounts of construction activity (Gal et al. 2008), there are often important adjustments needed to utilize scaffolding so that the task at hand can be accomplished.

We draw on anchoring and adjustment from the behavioral perspective on decision making (Tversky and Kahneman 1974) to conceptualize the processes involved in using scaffolds in contexts of knowledge-work. We suggest that the mechanisms proposed for decision making parallel the experience of individuals using scaffolds such as document repositories in contexts of knowledge-work. *Anchoring* describes the process by which *individuals take for granted as useful and are significantly influenced by the information readily available to them to solve the problem at hand* or make the decision needed. Since the information in the anchor, by itself, does not provide the solution needed, decision makers engage in adjustment, the subsequent process by which they build on the information contained in the anchor to solve the problem at hand or reach their conclusion.

Our use of anchoring and adjustment as the mechanisms involved in scaffolding use is consistent with prior work in the context of document repositories (Poston and Speier 2005). The work of Poston and Speier (2005) indicates that validity ratings and credibility indicators associated with documents serve as anchors to impact search and evaluation processes and decision performance of knowledge workers. Similarly, the detailed experimental work of Allen and Parsons (2010) highlights anchoring and adjustment as mechanisms involved in SQL query reuse. Their work reveals that individuals writing SQL queries, when provided samples of prior SQL queries, implicitly adopted the logic incorporated in the prior SQL query – an instance of *anchoring*. The query the subjects wrote to solve the problem they were assigned involved modification of the template suggested by the anchor, reflecting the process of *adjustment*.

Model of Repository Use – Anchor Choice and Adjustment

Conceptualizing knowledge repository use as involving the processes of anchoring and adjustment enables the consideration of the two important sequential processes individually. Applying the framework to the context of repository reuse, documents a problem solver chooses from are *potential* anchors. The process of document reuse involves the problem solver evaluating these documents and then choosing the one that best fits the needs of the current problem. This document is the anchor which frames the current problem consistent with the problem solved in the document. The suggested solution is then adapted through the process of *adjustment* to develop the new solution to the problem at hand.

We conceptualize repository use as a two-stage process involving:

1. Anchor Choice: The identification of the appropriate document or documents that provide the best starting point to work from, among the set suggested by a search. These documents frame the view of the problem since the decision maker adopts the logic of prior solutions incorporated in the document(s) that comprise the anchor.

2. Adjustment Process: The process of arriving at the final solution by making changes to the information or decision process suggested in the anchor.

Viewing reuse as involving the anchoring and adjustment mechanisms, we focus on the following research questions:

>   RQ1: What are the factors that influence the choice of one or more documents as the anchor?

>   RQ2: What are the factors that influence the nature of adjustment from the chosen anchor?

Anchor Choice

Our first research questions deals with factors that influence anchor choice. We suggest that this choice is influenced by two factors: anchor significance and anchor confidence. Anchor significance refers to how compelling a document's solution is, while anchor confidence refers to the extent of certainty the problem solver has that adapting the document's solution will lead to the desired outcomes. Figure 1 contains this model with its accompanying factors. Each factor, in the respective direction, makes the anchor more salient.

Figure 1. Model of Anchor Choice
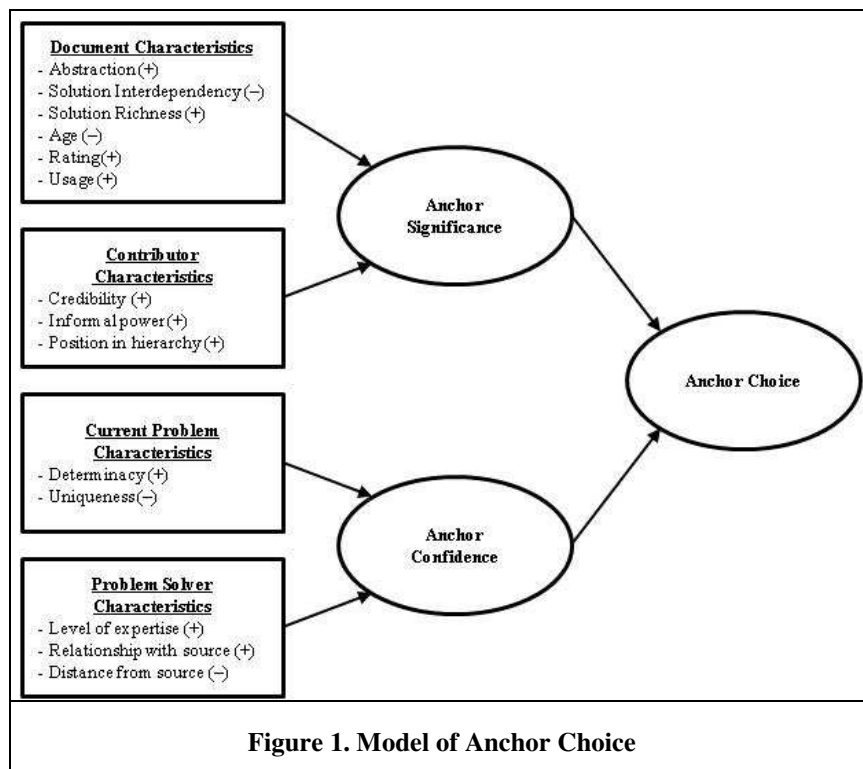
Anchor Significance

Anchor significance refers to how compelling a document's solution is, and is rooted in the possibilities for use in solving other problems inherent in a solution. It is inherently objective in nature, and flows out of the properties surrounding the prior solution and its potential use. Because a problem solver evaluates solution fit based partially on whether the current problem matches the problem the prior solution solves, anchor significance depends on the characteristics of the problem-solution situation articulated in the repository document. Further, because repository documents are often authored by repository users, accounting for the differences among the authors, particularly relating to where these differences impact document credibility, is fundamental to shaping anchor significance. As such, characteristics of both the document and the contributor are important considerations in determining anchor significance.

Document characteristics

Important characteristics of a document include the extent to which the problem-solution situation has been abstracted, the path interdependency among possible solutions, and the richness of the provided solution. Other important characteristics also include document age, rating, and usage information.

Abstraction is the extent to which cause and effect has been articulated (Boisot 1999). In a repository document, abstraction addresses the causal linkages in a prior problem-solution situation, specifying why a solution was successful in solving a given problem. We suggest that abstraction enables the problem solver to see the situation articulated in the document in a more general case, allowing for a greater comprehension of fit to the current problem situation. As such, as abstraction increases, a clearer understanding of a solution's applicability across various problem instances increases, thus increasing anchor significance.

> *Proposition 1a: The level of abstraction of a prior problem-solution situation articulated in a document will have a positive influence on anchor significance.*

Solution interdependency refers to the interdependent relationship among the respective documents' suggested solutions. Solutions that are interdependent are those that, when followed, prevent the problem solver from trying other interdependent solutions. This proves problematic when an attempted interdependent solution fails, preventing the problem solver from trying some other solutions. They are also problematic because they may change the nature of the problem, potentially adding to difficulty in solving the problem. An example of solution interdependence is the suggested solution to format an operating system hard drive when experiencing a computer problem. While this may or may not solve the problem, it prevents you from trying other interdependent solutions. As such, solution interdependency is negatively associated with anchor significance.

> *Proposition 1b: The level of a solution interdependence in a document will have a negative influence on anchor significance.*

Solution richness refers to the level of detail surrounding a document's suggested solution. A solution that is more rich enables the problem solver to better gauge whether the suggested solution steps are appropriate and feasible for the given problem situation. Because of this, a rich solution providing a broader variety of details is more compelling than a short, terse solution is, consequently increasing anchor significance.

> *Proposition 1c: The richness of a prior solution articulated in a document will have a positive influence on anchor significance.*

Document age, rating, and usage information are also important factors influencing anchor significance because they signal the respective relevance, quality, and usability, of a document for reuse. Documents that are older may be seen as containing less-relevant solutions to "out-of-touch" problems, especially given the dynamic problem solving support environment (Davenport and Klahr 1998), leading to decreased anchor significance. Likewise, documents with higher ratings may be seen as containing higher-quality solutions (e.g., Poston and Speier 2005), leading to increased significance being placed on the solution. And finally, prior document usage information contained within the document supports the view that a document is well-suited for reuse, thus enhancing how compelling, and thus significant, the anchor is.

> *Proposition 1d: The age of a document will have a negative influence on anchor significance.*

> *Proposition 1e: The rating of a document will have a position influence on anchor significance.*

> *Proposition 1f: The level of usage of a document will have a positive influence on anchor significance.*

Source characteristics

Source refers to the contributor of the prior solution. Source characteristics that influence anchor significance include *credibility*, *informal power*, and the source's *position* in the given hierarchy. Each of these signal the credence that should be given to a prior solution, thus impacting anchor significance. With a source that is more credible, has more informal power, and is in a higher position of authority, more credence will be given to a prior solution, and thus result in a more significant anchor.

> *Proposition 2a: A source's credibility will have a positive influence on anchor significance.*

Proposition 2b: A source's amount of informal power will have a positive influence on anchor significance.

Proposition 2c: A source's position in the hierarchy will have a positive influence on anchor significance.

Anchor Confidence

Anchor confidence is the extent of certainty a problem solver has regarding the ability of a document's prior solution to solve the current problem. This assurance comes from the problem solver engaging with the anchor, and is rooted in the problem solver's intuitions or feelings of fit between a prior problem-solution situation and the current problem. It is inherently subjective in nature, and as such, is influenced by the characteristics of both the current problem and the problem solver.

Current Problem characteristics

Determinacy and uniqueness are two characteristics of a problem that impact anchor confidence. *Determinacy* refers to the clarity of both a problem and what is required to solve it. It influences anchor confidence via its ability to clearly specify a problem's requirements. Since a determinate problem's specifications are well defined, the likelihood that they are more clearly understood by the problem solver increases. Like abstraction above, this clarity provides a greater comprehension of fit in the evaluation between a prior problem-solution situation and the current problem situation. Thus, as clarity increases, confidence that a prior solution is applicable to a given problem increases.

Proposition 3a: A current problem's determinacy will have a positive influence on anchor confidence.

Uniqueness refers to the rarity of the current problem, and conversely impacts anchor confidence in the reverse direction by signaling newness and unfamiliarity. A problem that is unique, by definition, is not encountered often. Because a problem is unique, uncertainty increases in a prior solution's ability to solve a given problem, thus decreasing anchor confidence.

Proposition 3b: A current problem's uniqueness will have a negative influence on anchor confidence.

Problem solver characteristics

Problem solver characteristics include the problem solver's level of expertise, relationship to the contributor of a document, and distance from this contributor. Level of expertise is an important consideration in determining anchor confidence because it influences what information may or may not be utilized in making a judgment about an anchor. This is because experts recognize important cues in their environment that novices do not. Because of this, certain important features of a document's problem-solution situation may be more salient to an expert versus a novice, thus signaling to an expert (and not the novice) that confidence can be placed in the solution.

Proposition 4a: A problem solver's level of expertise will have a positive influence anchor confidence.

Given that problem solving generally does not occur in isolation, access to others, especially the solution contributor of the prior problem's solution, is of particular importance (Boh 2008). *Relationship with the source* of a prior solution and the problem solver's *distance from this source* (e.g., divisional, discipline, etc.) are thus also influential because they affect anchor confidence via their signaling of possible continued informal support in a reuse situation. When a relationship exists, informal support is viewed as more probable, therefore increasing the problem solver's confidence in a prior solution. This is likewise the case when distance is small (i.e., the source more accessible).

Proposition 4b: A problem solver's relationship with the source will have a positive influence anchor confidence.

Proposition 4c: A problem solver's distance from the source will have a negative influence on anchor confidence.

Drivers of Anchor Choice

The level of anchor significance and the level of anchor confidence together help make the anchor more salient to the problem solver and thus influence anchor choice:

Proposition 5a: Anchor significance will have a positive influence on anchor choice.

Proposition 5b: Anchor confidence will have a positive influence on anchor choice.

Adjustment

Adjustment is an essential part of document reuse, and refers to the process by which a problem solver takes a document's suggested solution and formulates a new solution from it for a given problem. Our theoretical model of document reuse (see Figure 2) suggests adjustment is dependent on anchor choice, or how the current problem has been framed by choosing a specific document. Additionally, the model suggests that there are factors which influence the amount of adjustment performed. These factors include instability, the attentional demands on the problem solver, and the motivation of the problem solver. A discussion of these factors and their propositions follows.

Figure 2. Theoretical Model of Document Reuse
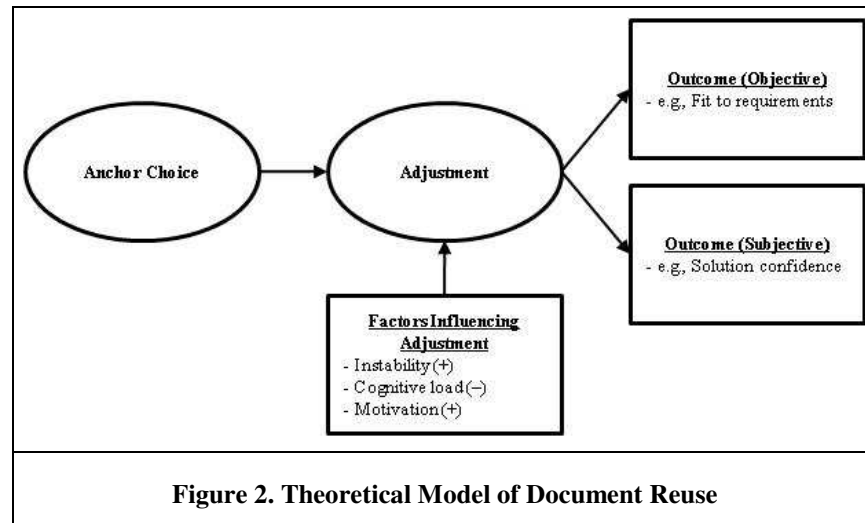
Factors Influencing Adjustment

Instability refers to the "rapid and often discontinuous changes" (Henderson and Stern 2004 p. 41) occurring in the problem solving support environment, and relates to the dynamism of support settings (Davenport and Klahr 1998). Instability makes old solutions less applicable; as instability increases, the level of adjustment needed increases. Instability induces a problem solver to be "more careful and deliberate" (Epley 2004 p. 250) in the adjustment process. Likewise, older documents chosen for reuse may require more adjustment in dynamic environments.

Proposition 6a: Instability will have a positive influence on the level of adjustment.

Since the adjustment process is attention-demanding in nature (Gilbert 2002), another factor that influences adjustment is the *cognitive load* of the problem solver. We suggest that elements that impact attentional demands indirectly influence the amount of adjustment. These elements can include, for example, the competitiveness of the reuse situation (Haas and Hansen 2005) and time pressures (Haas 2006) weighing on the problem solver. When cognitive load increases, the amount of adjustment decreases.

Proposition 6b: Cognitive load will have a negative influence on the level of adjustment.

Motivation for the problem solver to excel in the problem solving task affects the amount of adjustment via its ability to excite the problem solver to act. For example, as motivation increases, the problem solver will put in the effort to "go the extra mile" and make sure the problem is solved perfectly. This increases the amount of adjustment that occurs. Possible elements that impact motivation include problem solver accountability regarding the success of the new solution, and incentives put in place for successful document reuse.

Proposition 6c: Problem solver motivation will have a positive influence on the level of adjustment.

Outcomes of Anchoring and Adjustment Processes

We focus on two outcomes of reuse through the processes of Anchor Choice and Adjustment: objective outcomes and subjective outcomes:

> *Proposition 7a: The level of adjustment is positively related to the level of fit to requirements.*

> *Proposition 7b: The level of adjustment is positively related to the level of solution confidence.*

Discussion and Conclusions

The reuse of knowledge by individuals in a firm is recognized as being an important means to enhance both efficiency (Davenport and Klahr 1998) and the quality of problem solving (Gray 2001). However, how knowledge influences knowledgeable action, or in other words how individuals use knowledge *in practice* is less understood. In this paper we have taken a performative view of knowledge and begin to explore the relationship between document repositories and knowledgeable action. With the scaffolding metaphor as our guide, we suggest that the cognitive mechanisms of anchoring and adjustment help to better understand repository reuse.

Within this work we have still left some paths untrod. We conceptualize anchoring and adjustment as the process involved in the use of scaffolding such as knowledge repositories. In the view we adopt, we have focused on the positive and beneficial effects of such assistance. However, researchers have observed that such scaffolding can be detrimental and can constrain creativity and innovation (Swan 2006). The use of the repository, whether as a guide to build on *taken for granted* prior knowledge so that cognitive effort is focused on further innovation, or whether it is used in a black-box fashion and as a crutch so that task execution requires little cognitive effort clearly influences the nature of outcomes. A closer examination of the detrimental effects of knowledge repositories is an issue for further research. Additionally, we have not yet addressed how to empirically test the model presented. Briefly, we envision an approach that uses multiple methods and multiple sources to gather data within an organization. Methods include questionnaires and interviews, while sources include knowledge workers, documents from repositories, and system logs. For some of our variables we foresee being able to code based on a coding scheme (e.g., document abstraction, current problem determinacy, etc.), while others will require using proxies (e.g., years at organization for level of expertise, call volume and number of employees answering calls for cognitive load, etc.). While these measures are not perfect, they will allow us to test our propositions and make improvements in the model where needed.

Finally, while we believe this research moves the work on knowledge reuse forward by addressing how knowledge influences knowledgeable action, we recognize that there is still much to explore, and that this work only addresses one small part of knowledge artifacts as scaffolds to human knowledgeabilty. We do feel however, that this work is worth exploring.

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