Information Design and Uncertain Environments: Cognitive and Ecological Considerations in Technical Communication

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Abstract: While technical communication has roots in the rhetorical tradition, it also has been influenced by positivism and computationalism, which, unlike rhetoric, treat facts separately from values and isolate information from social contexts by organizing data into digital 'bits.' Technical communicators uncritical of such assumptions may unintentionally design information inappropriate for their audiences' social values or their users' situation. To illustrate, this paper analyzes a case study of technical communication graduate students who worked on an information design project that ultimately failed.

In an information design course, technical communication graduate students tried to design a short messaging service (SMS) system for clients in the Democratic Republic of the Congo. They collaborated on this project with a non-governmental organization, which asked them to devise an SMS system that could deliver pricing information to Congolese miners and farmers who own cell phones with text messaging capacities. As the students tried to design this SMS system, however, they realized that most technological aspects of the design were relatively trivial compared to its trustworthiness and context of use—e.g., they questioned where the pricing information would come from, how it could be trusted, and if it could be communicated in ways that would incentivize negotiation and cooperation among users. Concerns about trust value and usability context became greater issues than pricing information and SMS content, halting the implementation of the original SMS design.

As a case study, the SMS project demonstrates the need for cognitive and ecological considerations in technical communication. To show the importance of such considerations, this paper conducts an interdisciplinary study with a four-part inquiry: (1) a description of the case study to show what problem the information design tried to address; (2) a cognitive task analysis of the information design to reveal the technical communication grad students' assumptions during the project; (3) some theoretical reflections from cognitive science and their implications for information design; and (4) a discussion about what the students could recommend in the end, including implications about how technical communicators should think about media ecology in the context of uncertainty.

Key words: Embodied embedded cognition, Emotion, Enculturation, Socially distributed information processing, Media ecology.

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"[A] higher organism acts with reference to a spread-out environment as a single situation. … The action called 'organic' is not just that of internal structures; it is an integration of organic-environmental connections."
John Dewey (1958, 279).

"Mental facts cannot be properly studied apart from the physical environment of which they take cognizance. The great fault of the older rational psychology was to set up the soul as an absolute spiritual being with certain faculties of its own by which the several activities of remembering, imagining, reasoning, and willing, etc. were explained, almost without reference to the peculiarities of the world with which these activities deal."
William James (1984, 11).

Introduction: the difficulty of anticipating information design failure

Technical communication is the discipline of documenting scientific or technical information, making it accessible and manageable for users to process, and organizing it into technological formats, from print documents to digital databases (Defining Technical Communication, STC). Technical communicators study how people use various technologies or media to manage and communicate knowledge, which often involve practices like information design. Economically, from the perspective of producers, technical communication is a discipline that studies how professionals design information; from the perspective of consumers, technical communication studies how users process information. Technical communication is a highly interdisciplinary field, and its interdisciplinary nature shows in the different, sometimes incompatible, intellectual traditions that have constituted its history. Technical communication, for instance, has roots in the rhetorical tradition, which dates back to Greek and Roman Antiquity under the names of "rhetoric" and "eloquence" (Aristotle, 2007; Cicero, 2001). As it became a business and profession in the late 19th and early 20th centuries, technical communication was influenced by philosophies characterizing the Industrial Revolution and the Information Age, including positivism and computationalism (Miller, 1979; Longo, 2000).[1]

In technical communication theory, Classical rhetoric on one hand and positivism and computationalism on the other hand emphasize different objectives. The older tradition of rhetoric encompassed the art of persuasion in communication, which emphasized emotional values and deictic situations that reflected the civic and oratorical circumstances from which rhetoric emerged. The 19th-century philosophy of positivism claimed that literal facts acquired from sense data are the only logical representations of reality; the 20th-century theory of computationalism proposed that the mind works like a computer, in which thoughts are algorithms that represent reality. Unlike rhetoric, positivism and computationalism treat facts separately from values and isolate information from social contexts by organizing it into 'chunks'

[1] Following Aristotle, Classical rhetoric will be defined as the art of finding available means of persuasion. Positivism, more broadly known as 'analytic philosophy,' is a philosophy that reduces 'true knowledge' to literal facts acquired via the senses and understood through logical or mathematical formalisms. Computationalism, also known as 'cognitivism' in psychology, is a theory of mind that explains cognition as discrete brain states (or 'internal representations') that can be formalized as symbolic algorithms.

or ‘bits,’ accommodating the managerial agendas of industrial society and the digital demands of information technology. Since positivist and computationalist influences on technical communication assume value-independent facts and decontextualized bits of information, professionals in technical communication who are uncritical of these assumptions may design information inappropriately for their audiences’ values or their users’ situations.

To counter such assumptions, technical communication theorists have reincorporated rhetoric as well as cultural studies (Longo, 1998) and dynamic models such as activity theory (Spinuzzi, 2003), which give attention to cultural usability (Sun, 2006), or what I will call usability context. In spite of these attempts to think more contextually or ecologically, many students and professionals in technical communication continue to hold positivist or computationalist assumptions with respect to information processing itself—that is, mental processes that often rely on technology use. I will argue that subtle positivist or computationalist biases sometimes creep into information design practices because technical communication theory lacks a robust treatment of cognitive factors, including how they connect with ecological factors to create trust value together with usability context. The cognitive side of technical communication matters just as much the ecological side, and technical communicators who miss one or the other are prone to implicit positivist or computationalist biases, which can lead to information designs that fall short of users’ values and situations. In fact, this sort of design shortcoming is what a group of graduate students in technical communication struggled with while working on an information design project at the University of Minnesota.

This paper will begin by studying that particular case. In a course on information design offered during the fall and spring semesters from 2008 to 2011, technical communication professor Bernadette Longo worked with various graduate students, including me (a graduate student at the time), at the University of Minnesota on an information design project. This project involved constructing a short messaging service (SMS) system for foreign clients in the Democratic Republic of the Congo (DRC). In the interest of doing beneficial work for non-profit organizations, Longo and the graduate students collaborated with a non-governmental organization (NGO) by the name of Pact, which operated in the DRC. Pact specifically asked the designers to devise an SMS system that could deliver pricing information to Congolese miners and farmers who own and use cell phones with text messaging capacities. Presently, Congolese workers do not have access to such information, and the NGO believed that an SMS system could potentially empower many miners and farmers in the DRC by providing them with access to real-time pricing information in the form of text messages.

How exactly would pricing information empower these workers? It was meant to solve a common problem that many of these workers face as sellers: most buyers, whether domestic or foreign, typically come from better socioeconomic conditions, which presumably equip them with better intellectual resources that give them more negotiating power. Real-time pricing information could potentially tip the negotiating scale of power back to the miners and farmers.

Pact's assumption was that regularly updated pricing information in the form of text messages could give Congolese workers better opportunities to negotiate fairer prices when selling to buyers. Hence, there was a tacit social justice motive behind the SMS project (Bernadette Longo, personal communication). Nevertheless, while the technical communication grad students considered possible designs for a text messaging system that would relate basic data about farming and mining prices, they eventually realized a larger issue was at stake, which I was the first to bring up when I took the information design course during the Fall Semester of 2010: most technological and computational aspects of such designs were relatively trivial compared to their trustworthiness and context of use.

To illustrate my concern, consider the following: while the NGO partner wanted to design an SMS system that would deliver local pricing information to Congolese subscribers, the designers eventually had to question where such facts would come from and how they could be communicated in formats that would incentivize fair negotiation and cooperation among buyers and sellers. From what trustworthy source would Congolese sellers in their technologically limited situations receive relevant data via an SMS system? In short, before they even could use such information, how would they be able to trust it in the first place? Concerns about trust value and usability context, therefore, became greater issues than raw data about pricing information and technological formats, rendering the original SMS design an unsuccessful attempt to anticipate the social values and the socioeconomic situations of Congolese sellers. This shortcoming of the design ultimately halted the implementation of the SMS project.

This paper shows how, in the end, the SMS project served as a case study[2] for professionals in technical communication and demonstrated the importance of what I call cognitive and ecological considerations, namely: (1) facts are emotionally tied to values through embodied cognition; (2) facts and values are embedded in cultural contexts; and (3) facts and values are socially distributed through technologically mediated activities. These considerations undermine assumptions in positivism and computationalism but resonate with theories from cognitive science about emotion, enculturation, and socially distributed information processing. With the intent of bringing these cognitive and ecological considerations into technical communication, this paper asks three questions:

1) How exactly did the technical communication grad students try to solve the practical problems with which they were presented during the SMS design?
2) What did these problem-solving practices reveal about their theoretical assumptions, and were their assumptions valid for the information design project?
3) If their assumptions were not valid, what recommendations could they make for the SMS

[2] This case study focuses in particular on the later periods of the design project that occurred during the Fall Semester of 2010, in which I participated, and the Spring and Fall Semesters of 2011, in which I did additional research and drew the material for the following task analysis of this paper.

design in the end, and what implications may be drawn for other students and professionals who design information, especially in uncertain environments?

To address these questions, this paper conducts an interdisciplinary study that draws on research from technical communication, rhetoric, cognitive science, and media ecology.

First, this paper outlines a cognitive task analysis (CTA) of the SMS project to describe the original goals and the epistemic constraints that factored into its information design—and the design's eventual failure. This CTA follows what psychologist David Marr referred to as the three-level process for analyzing any information-processing task or technology. This three-level process is a practical method that consists of examining a "computational theory," a "representation and algorithm," and a "hardware implementation" (Marr, 1982, 22-25).[3] I also contextualize this CTA by looking at the pragmatics of SMS use, with special attention to socioeconomics. Second, this paper reviews theoretical reflections from cognitive science and their practical implications for information design. In particular, this paper looks at what philosopher Andy Clark (2008) has called "embodied embedded cognition" and its relevance for making sense of information-processing tasks. From the approach of embodied embedded cognition, I adumbrate what I call cognitive and ecological considerations for technical communication by looking at how emotion, enculturation, and socially distributed information processing affect information design. Finally, with these cognitive and ecological considerations in mind, this paper reassesses the SMS project, reframes the original goals to discuss what the technical communication grad students could recommend in the end, and indicates how technical communicators should think about media ecology, especially in uncertain environments.

Practical methods: from CTA to pragmatics of SMS

According to David Marr, any information-processing task or technology consists of at least three levels of analysis: computation, representation or algorithm, and implementation. The computational level is the most abstract and asks "what the device does and why" (Marr, 1982, 22). The "what" and the "why" of information processing can be formulated as epistemic constraints, because "the resulting operation is defined uniquely by the constraints it has to satisfy" (23). The representational or algorithmic level specifies "how" information processing takes place. That is, what representations are being used for input and output, and what algorithms are being used to transform that input and output? The implementation level asks

[3] This paper begins with Marr's computational model of information processing to analyze technologies like SMS and to show the limitations of computationalism. The intent is to contextualize information processing, which takes place through a cognitive agent coupled to an environment. As philosopher Evan Thompson says, "a natural cognitive agent . . . does not process information in a context-independent sense. Rather, it brings forth or enacts meaning in structural coupling with its environment. The meanings of an autonomous system's states are formed within (*informare*) the context of the system's dynamic and structural coupling" (Thompson, 2007, 58).

about “the type of hardware or machinery in which the algorithm is to be embodied physically” (24). In other words, how is the algorithm going to be executed through a material substrate?

Cognitive scientists Leda Cosmedes and John Tooby hold that Marr’s “three-level system applies to any device that processes information” (Gazzaniga, 1995, 1199). A technology as mundane as a cash register can be analyzed thus: on a computational level, the cash register codes the mathematics of addition; on the algorithmic/representational level, it manipulates numerical digits that represent addition; on the implementation level, it generates binary codes via digital circuitry. Since scientists have found Marr’s three-level process useful for analyzing information-processing tasks and technologies, it should be useful in technical communication. By recruiting Marr’s three-level process to analyze information-processing tasks and technologies in technical communication, this paper conducts a cognitive task analysis on the original goals and the epistemic constraints that factored into the information design project that will serve as a case study, in which technical communication grad students at the University of Minnesota tried to design an appropriate SMS system for foreign clients in the DRC. Somewhat departing from Marr, however, this paper also contextualizes that cognitive task analysis by looking at the socioeconomic pragmatics behind this three-level process.

First, consider the computational level of the information design project, which asks what problem needs to be solved and why.

The computational level

When technical communication graduate students and I began working on an information design project for a nonprofit enterprise, the project at first appeared unambiguous. It related to the operations of a nongovernmental organization (NGO) working in the Democratic Republic of the Congo (DRC), a developing African country with very limited public infrastructure or governmental services. Since the DRC has not yet developed a comprehensive public sector that empowers private businesses, many NGOs assist Congolese entrepreneurs by providing technological help, particularly in the mining and farming industries. For instance, one setback for many miners and farmers in the DRC is that they lack formal means to communicate commodity and crop prices. This setback is a burden for miners and farmers, because they may have no way to identify or set fair and competitive prices for their mineral and agricultural products, making Congolese workers and sellers highly vulnerable to price scams by unscrupulous buyers.

To help these miners and farmers improve business communication, an NGO by the name of Pact contributes technical assistance with the intent of helping workers develop sustainable information and knowledge-based networks (What We Do). With all the options of modern technology, one possibility for making communication more efficient and effective (both in the DRC and in other developing regions of the world) is Short Messaging Services (SMS). SMS is

the text-messaging component of cellular phones and other mobile media, and it has grown popular in the DRC and other countries in Africa over recent decades. Since designing a standardized SMS system for Congolese users requires expertise in information design, Pact reached out to technical communication grad students at the University of Minnesota from 2008-2012. Bernadette Longo, professor of scientific and technical communication, directed and supervised the SMS design project (Bernadette Longo, personal communication).

Understanding *what* problem needed to be solved (communicating pricing information) and through *what* kind of information technology (an SMS system), the students started to examine *why* SMS has grown in the DRC in the form of text messaging. Private technologies like cell phones are more popular in the DRC than public media such as landlines or Internet, because activities requiring public media are unfeasible due to the country's insufficient infrastructure. Nevertheless, although most Congolese people lack suitable public works like telephone landlines or Internet access, a growing number of these individuals are obtaining inexpensive cell phones, which they typically use to send and receive text messages. Text messaging continues to increase in popularity because it is an economical way to communicate over long distances. As a result, text messaging, SMS, and similar Information and Communication and Technologies (ICTs) could become promising tools for business communication and social networking among Congolese miners and farmers, as some studies suggest (Polikanov and Abramova, 2003). There is even evidence in some African countries like Ethiopia that such ICTs could facilitate socioeconomic development by creating open source software systems (Mengesha, 2010). However, there remains a significant lack of empirical data about ICT use to draw any conclusive diagnoses for African countries like the DRC (James and Versteeg, 2007).

Understanding the problem, the ICT, and the users in question, the technical communication grad students began to develop ideas about epistemic constraints they would confront in their information design. Before proceeding to ask exactly *how* the SMS system would process information, the students briefly considered material constraints. That is, they asked how the SMS system would be physically implemented. From a task analysis perspective, they dealt with the implementation level, which asks how the SMS system could be physically realized.

The implementation level

Since SMS has grown in the DRC in the form of text messaging with cellular phones, the physical implementation of the SMS system was obvious. Understanding the physical implementation of cell phones was important because it would create material constraints on representational and algorithmic formats—e.g., a limited number of digital characters that would fit on a screen. However, while many workers and businesses in the DRC own cell phones for text messaging, they normally lack an unambiguous format for communicating knowledge digitally. Professionals in North America and Europe, for instance, communicate thoughts and arrange tasks through client-server networks like IBM Notes, which uses templates with

predictable places for essential bits of information such as headings, dates, locations, attendees, supplementary notes, etc. When these workers need to communicate data, they have pre-designed formats that suit common values or purposes, promote consistency and usability, and avoid ambiguity.

Many Congolese workers do not have any internally consistent design for information—namely, a standardized linguistic and illustrative format for communicating facts in coherent and reliable ways. Congolese workers have the physical means but not the formal techniques for communicating information efficiently and effectively. The technical communication grad students, therefore, set out to design an information model for miners and farmers in the DRC. This design would formalize and facilitate SMS communication with text messaging technology. Looking at how to formalize and facilitate the SMS design, the students moved to the representational or algorithmic level of task analysis.

The representational/algorithmic level

To determine what types of formal representations to use for communicating pricing content, and to figure out what kinds of algorithms could facilitate such information, the students immediately tackled some of the most rudimentary questions about the format of the information design project. They consulted University of Minnesota engineers to work on technological mechanics in an SMS system, including character limitations. They drew upon linguistic disciplines to understand Swahili grammar and translation. They worked out a standardized syntactic format that could communicate pricing information. They even devised a business model that would allow Congolese miners and farmers to subscribe periodically to messages offered by an SMS system: with a one-time purchase to an SMS subscription, the miners and farmers could receive (thereupon free) pricing information via text messages on their cell phones (whether from a central database or directly between sellers and buyers), and they could receive these financial facts as often as needed after the one-time fee.

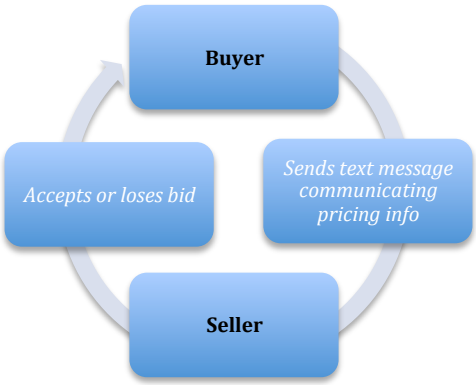
Working out pricing facts and business propositions accordingly, the students assumed that their information design would allow miners and farmers in the DRC to easily access and send data about commodities and crops. In theory, sharing this pricing information should give Congolese workers opportunities to negotiate fair and competitive sales with buyers, who, commonly coming from better-off socioeconomic ranks within the DRC or from more affluent nations, have more intellectual resources and thus an unfair advantage in making financial offers and transactions. With consistent access to pricing information, Congolese miners and farmers could know if they were getting a reasonable deal. Then they would have better chances of avoiding price scams and economic exploitation for their work, because text-messaging applications could let them check market prices regularly through a simple input-output process on their cell phones. This representational design and input-output algorithm, however, faced problems when the socioeconomics that lay behind the information design project were considered.

The socioeconomic pragmatics behind the three-level process

In the midst of working out technical and theoretical details of the SMS system, the students eventually realized a number of problematic but practical scenarios that could threaten the stability of their information design project. These scenarios revolved around a simple question: what would be the source of pricing information? The major design challenge with SMS in the context of the DRC involved the very collection and distribution of pricing information for commodities and crops. An SMS system requires a trustworthy source of pricing information before it can compute, represent, or implement this content among Congolese users.

A trustworthy source of information is important for the DRC, because the country does not have an adequate legal infrastructure to counter dishonest business activities among buyers and sellers. For example, if the source of pricing information were to come from buyers, then the prices might merely replicate one-sided offers, which would likely represent the lowest common denominator. With buyers providing pricing information, an SMS system would give them dominance over Congolese sellers in pricing bids and negotiations. Buyers could then control how much or how little they desired to pay for commodities and crops, hindering sellers and exposing Congolese miners and farmers to potential abuses and scams. The result may be the opposite of what the SMS system should do, which is empower Congolese sellers with pricing information so they have a better chance of not getting cheated (see **Figure 1**).

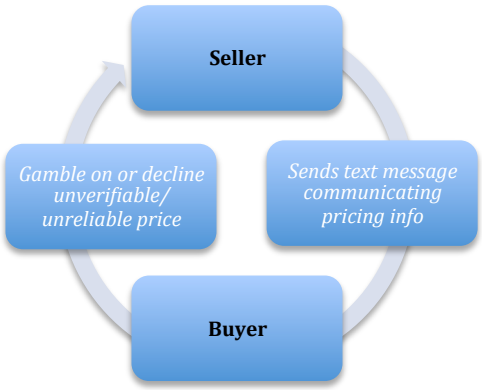
Figure 1*: One-sided offers from buyers to sellers, in which sellers can accept or lose bids but have no negotiation power in such financial transactions.*



What if the information design made sellers—Congolese miners and farmers—the source of pricing information for an SMS system instead of buyers? Many problems still could arise if financial data were collected from sellers. Since many Congolese live along the poverty line and have little or no spending money, miners and farmers understandably have no incentive for spending money to send text messages with pricing information to possible buyers, especially if there is no immediate economic benefit like a guaranteed sale. Even if sellers were to initiate

pricing information, there would be no way to verify these prices as reliable. For instance, if a few sellers in the DRC were to falsely report numbers by relating lower-than-normal prices, then they would fool competing miners and farmers to lower their prices and give deceivers an instant, artificial profit. The opposite could also occur. Sellers might report higher-than-normal prices, forcing other miners and farmers to artificially raise their overall prices and thus give cheaters an unfair competitive advantage (see **Figure 2**).

Figure 2*: Unverifiable or unreliable offers from sellers to buyers, in which sellers may gain an unfair competitive advantage by lying about pricing information.*



It is also possible that domestic or foreign buyers, who generally come from better socioeconomic conditions, could bribe sellers to falsely report their prices to the SMS system, which would force miners and farmers to clash with each other by lying about financial facts. Indeed, pecuniary cheating, financial fraud, and business bribery are highly documented in the DRC's fragile economy (IMF, 2009; Winter, 2006; Beaubien, 2006). Such abuses in the DRC's mining and farming industries may be byproducts of what economist Joseph Stiglitz calls "information asymmetry": when a buyer or seller has better or more valuable information than another seller or buyer, the former can monopolize that knowledge and exploit the latter's ignorance, sometimes for the sake of pecuniary advantage—this imbalance of socioeconomic power from information asymmetry may also lead to unforeseen and negative scenarios, such as adverse selection or market failure (Stiglitz, 2002). In broader terms, these unforeseen scenarios can create what statistician Nassim Taleb (2010) calls "Black Swan" events, or unexpected incidents that have extreme impacts on a system and its stability.

In either scenario considered, collecting and distributing accurate information through an SMS system became the major issue while designing an SMS system for clients in the DRC, because their economy is currently prone to cheating between buyers or sellers. Cheating with an SMS system could generate relentless fraudulent activity, put an SMS system into quantitative confusion, further corrupt the quality of business, generate Black Swan events, and ultimately harm rather than help Congolese miners and farmers. Therefore, an SMS system requires an information design that suits the socioeconomic realities of the DRC. This information design

should not incite incentives among buyers or sellers to cheat. Many buyers may want to underpay for cheap commodities in the DRC, so predictably they have an incentive to offer prices below any mainstream stock or commodity exchange. Sellers may falsely report information about their prices due to the poor economic and legal structures of the DRC, which at present do not necessarily encourage an honest business atmosphere. If technical communicators do not respect the socioeconomic pragmatics of technology use, then they may unintentionally design a system that creates incentives to cheat users workers instead of empowering them with information.

The technical communication grad students recognized that an SMS system for Congolese miners and farmers must design pricing information to suit the socioeconomic context of the DRC, especially if the facts are to be valuable to sellers. Information design confronts complex issues in different cultural and socioeconomic contexts, and designing an SMS system for Congolese clients is no exception. For the students, concerns about the trust value and the usability context became greater issues than raw data or facts about pricing information, because facts, figures, and information cannot stand on their own. Before facts can be communicated, before figures can be interpreted, and before information can be distributed, people have to value these facts, figures, and information in the first place; and individuals will only value such content if it suits them in their situation at hand.

In the DRC, financial facts and pricing information communicated by an SMS system must be perceived as trustworthy by Congolese miners and farmers relative to their values and context of use. Without trust, facts will carry no value for Congolese workers, and any SMS system devoid of trust may corrupt the usability of information. These aspects are what I will call the trust value and the usability context of information design. The trust value of facts and the usability context of information are indispensable for designing an SMS system. In sum, the students misapplied digital technology because they did not ask the following: what factors in information design endow facts with values to create trust, and what contexts allow information to be culturally interpreted and socially distributed so as to be used properly or as intended?

Since the students did not ask these questions before embarking on the information design, trust value and usability context were absent in the original SMS project. This situation was ironic, because Bernadette Longo has been a long-time advocate of bringing cultural studies and rhetoric into technical communication to bring attention to contextualism (Longo, 2000; 2010). In fact, in the information design course, she assigned readings that covered practical matters like rhetorical research (Spinuzzi, 1994; Sapienza, 2007; Salvo, 2001), technical themes like persona writing (Calabria, 2004), and theoretical paradigms like activity theory (Nardi, 1996). Despite these readings, her students did not ask questions about trust value and usability context until I raised them. I believe the reason for this blind spot is that technical communication theory has not entirely replaced its positivist and computationalist inheritances, especially with respect to cognitive processes that allow users to assign trust value. Although rhetoric, cultural studies, and

activity theory have given increasing attention to usability in information design, technical communication theory has had relatively little to say about trust. However, usability presupposes trust: any context of use always requires that users trust information.

In addition to cultural studies and activity theory, I suggest that technical communicators reconsider trust value and usability context in information design by drawing upon the interdisciplinary field of cognitive science, especially the 'embodied embedded' approach to cognition and communication. An embodied embedded approach highlights what I call cognitive and ecological considerations in technical communication. In particular, I consider how emotion, enculturation, and socially distributed information processing can help make sense of information design. In spite of important influences from cultural studies and activity theory, technical communicators may miss these cognitive and ecological considerations due to the biases of positivism and computationalism in their field, which pay little attention to emotional values, cultural contexts, or technologies that scaffold information.

It is true that cultural studies and activity theory have helped technical communication theory overcome these positivist and computationalist biases, but cultural studies and activity theory tend to isolate ecological considerations from cognitive ones, even though the two go together. Without both cognitive and ecological considerations, positivist and computationalist assumptions may enter and impede professionals in technical communication from properly designing information-processing systems. Since the embodied embedded approach deals with the importance of emotion, enculturation, and socially distributed information processing, this paper briefly summarizes some of that research before returning to the original information design problem. As we will see, emotional values in the context of culture matter for distributing and making sense of digital data, especially in information design.

Theoretical reflections: embodied embedded cognition and information design

The failed information design of the SMS system demonstrated a need to critique certain assumptions about cognition and communication, which the technical communication grad students may have held in their field from positivist or computationalist assumptions about information processing, despite the contrary influence of rhetoric, cultural studies, or activity theory. Indeed, it is important for professionals to note that technical communication always presupposes some theory of cognition, communication, or information processing, because for anyone to communicate technical knowledge, there has to be a cognitive agent that receives, uses, and processes that information. As previously noted, empirical theories about cognition, communication, and information processing make up a theoretical framework in cognitive science known as the "embodied embedded" approach (Clark, 2008). Technical communicators can benefit by using this approach, because what makes it different from positivism and computationalism is its robust treatment of emotion, enculturation, and socially distributed

information processing, which are factors that must be considered in information design.[4]

This paper considers these factors from the embodied embedded approach to cognition and communication, which I call cognitive and ecological considerations for technical communication. (I say these considerations are both cognitive and ecological—not cognitive on one hand or ecological on the other hand—because I wish avoid any nature-nurture or subject-object dichotomy, which cultural studies and activity theory often seem to replicate as do positivism and computationalism, albeit in opposite ways.) The first consideration is that emotion gives values to facts via embodied cognition. The second consideration is that enculturation creates an interpretive context in which facts and values are embedded. The third consideration is that information processing is socially distributed through technology and media. This paper discusses each of these considerations—emotion, enculturation, and socially distributed information processing—and their relevance to information design.

Emotion and embodied cognition: emotional values

A first consideration from the embodied embedded approach is that information processing is thoroughly emotional: it is a bodily-based activity that depends on the sensorimotor actions and the affective processes of the body. In other words, sensory and perceptual movements of the body, in conjunction with affective or emotional processes, make information processing possible. For instance, through the body's sensorimotor actions, 'higher' forms of inference that characterize human reason arise from 'lower' body-based functions, a phenomenon documented by cognitive linguist George Lakoff and philosopher Mark Johnson. According to Lakoff and Johnson (1999), 'higher,' abstract concepts only make sense, whether consciously or unconsciously, by cognitively mapping onto 'lower,' sensorimotor schemas.

To illustrate an example relevant to the case study, consider how the ability to reason about pricing information relies on metaphors that map together abstract concepts with sensorimotor schemas. On a daily basis, people around the world talk about rising or falling prices, even though prices are not physical things that literally rise or fall in space. Prices are conceptual abstractions but not arbitrary social constructions. The idea of fluctuating prices arises from a basic sensorimotor experience in visual perception: a container schema. When human beings collect more of a substance, they normally fill it up in a container, such as piling dirt into their hands or pouring water into a cup. When they have more of something, the level in their container goes up, and vice versa. People naturally project this visual experience of filling a container onto abstract domains of experience, such as economic indices, which base prices on a

[4] It should be noted that 'embodied embedded cognition' includes a variety of approaches that are not entirely commensurable—e.g., there are substantial differences between 'ecological perception,' (Gibson, 1986) 'extended cognition,' (Clark, 1997) and 'enactive cognition' (Varela et al, 1991; Noe, 2004; Thompson, 2007). For the purposes of this paper, I only concentrate on the agreements between these approaches that unite them under the framework of 'embodied embedded cognition.'

conceptual metaphor that conflates quantity with verticality: 'more (value) is up and less (value) is down.' Human reason makes extensive use of conceptual metaphors that map together concepts, which are not arbitrary abstractions but embodied concepts made possible by sensorimotor schemas.

Moreover, human cognition is embodied because the brain's abilities to reason, communicate, and make decisions are never separate from neurochemical dynamics or somatic states—i.e., emotions—which is why rational decisions, including socioeconomic decisions, cannot occur competently without emotional dispositions. Neurologists have examined how individuals under distress or emotional impairment due to brain lesions tend to make reckless decisions, and neuroscience has produced evidence that rational decisions require emotional engagement. Emotions are what give value to facts, and feeling these emotions are "an integral component of the machinery of reason," according to neuroscientist Antonio Damasio:

> emotions and feelings may not be intruders in the bastion of reason at all: they may be enmeshed in its networks. … The strategies of human reason probably did not develop . . . without the guiding force of the mechanisms of biological regulation, of which emotion and feeling are notable expressions (Damasio, 1994, xvi).

Therefore, Damasio suggests, the feelings of emotions "are a powerful influence on reason, that the brain systems required by the former are enmeshed in those needed by the latter" (245). He calls the entanglement of reason and emotion, and consequently of fact and value, the "somatic-marker hypothesis" (173).

According to Damasio's somatic-marker hypothesis, when humans perceive their environment, they create an "image" or a "map," which is a complex of neural patterns that come from "varied sensory modalities" (96). People feel these maps in their brains, thereby experiencing "images," such as "perceptual images" (directly experiences) or "recalled images" (memories) (96-97). Whenever anyone feels these images or maps, it is because they are entangled with "emotions," which Damasio, inspired by psychologist William James, defines as neurochemical, physiological states of the body proper: "I see the essence of emotion as the collection of changes in body state that are induced in myriad organs by nerve cell terminals, under the control of a dedicated brain system, which is responding to the content of thoughts relative to a particular entity or event" (139). From emotions come "feelings," which, again in neurological terms, are images perceived with emotional value: "the essence of feeling an emotion is the experience of such [neurochemical and physiological] changes in juxtaposition to the mental images that initiated the cycle" (145). In short, whenever people process information, they always feel it emotionally, which allows them to evaluate it. In sum, the "somatic-marker hypothesis" brings together the notions of images, emotions, and feelings: "Because the feeling is about the body, I gave the phenomenon the technical term somatic state ('soma' is Greek for body); and because it 'marks' an image, I called it a marker" (173). Damasio concludes,

> somatic markers are a special instance of feelings generated from secondary emotions. When a negative somatic marker is juxtaposed to a particular future outcome the combination functions as an alarm bell. When a positive somatic marker is juxtaposed instead, it becomes a beacon of incentive (174).

In this way, somatic markers give mental images positive or negative qualities so that a cognitive agent may evaluate perceptions and make rational decisions. In short, emotion permits individuals to value or evaluate facts.

For technical communicators, emotional value matters for information design, because factual content is evaluated by human attention, and attention is modulated by emotion, an observation first brought forth by economist Herbert Simon. According to Simon's theory of bounded rationality, the brain's activity of acquiring facts cannot be separated from the body's emotions that give value to facts: "facts, values, and emotions interact in our thinking about human affairs" (Simon, 1983, 8). Values, in short, give emotional quality to facts and permit focused attention on them: "focusing attention is one of the principal functions of the processes we call emotions" (21). Therefore, facts and values, as well as rationality and emotion, are entangled in information-processing tasks. Research by usability expert Donald Norman illustrates how emotion influences information design to produce "emotional design," or the fact that emotional states in information design are often more critical than technological factors:

> What role do these states have in design? First, someone who is relaxed, happy, in a pleasant mood, is more creative, more able to overlook and cope with minor problems with a device—especially if it's fun to work with. ... Second, when people are anxious, they are more focused, so where this is likely to be the case, the designer must pay special attention to ensure that all the information required to do the task is continually at hand, readily visible, with clear and unambiguous feedback about the operations that the device is performing. … Things intended to be used under stressful situations require a lot more care, with much more attention to detail (Norman, 2004, 26).

Therefore, before technical communicators design information systems that process facts, they need to know what facts are valuable to users, which requires examining the role of emotion.

Enculturation and embedded cognition: cultural contexts

A second consideration from embodied embedded cognition is that information processing is always situated or embedded in a cultural context. The sensorimotor and affective mechanisms in embodied cognition do not form an isolated system. They work in and through an environment, which includes culture. Clark observes how "we reduce the information-processing load by sensitizing the system to particular aspects of the world—aspects that have

special significance because of the environmental niche the system inhabits." Clark's technical manner of stating this is to say that the embodied system is "*niche-dependent sensing*": using biologist Jakob Von Uexkull's notion of "*Umwelt*" or 'life-world,' embodied systems cognize relative to an "*Umwelt*, defined as the set of environmental features to which a given type of animal is sensitized" (Clark, 1997, 24). For people, the *Umwelt* is a place of enculturation: human cognition and communication evaluate information relative to the cultural context in which people are embedded.

Enculturation, in the sense of cognition and communication embedded in cultural context, may appear like a truism. However, enculturation does not stop with the truism that cultural context causally supplies cognitive content. As philosopher Mark Rowlands points out, "The idea that things going on in the environment causally drive cognitive processes is an utterly mundane claim that anyone should accept" (Rowlands, 2010, 21). Enculturation also leads to the notion that "processes occurring in the environment—that is, outside the brain—can, in part, literally *constitute* cognitive processes" (22). Cognition and communication, according to this account, are processes that extend across brain, body, and cultural environment: "some mental processes . . . extend into the cognizing organism's environment in that they are *composed*, partly (and . . . *contingently*), of actions, broadly construed, performed by the organism on the world around it" (58). This 'extended' account of information processing suggests that neural, emotional, and cultural factors all constitute a cognitive system.

For technical communicators, enculturation and extended information processing highlight the need to know what facts are valuable to users relative to a cultural context. To repeat Simon's insight, rational facts cannot be separated from emotional values, because emotion enables people to focus attention on facts and give those facts social value. However, the purpose of acquiring valuable facts through emotional attention is to 'satisfice'—i.e., find good-enough solutions to—very specific situations that a cultural context presents: "your decisions are not comprehensive choices over large areas of your life, but are generally concerned with rather specific matters" (Simon, 1983, 17). Therefore, information design must consider how facts are tied to values to solve information processing tasks that extend into cultural contexts.

Socially distributed information processing and distributed cognition: ICTs scaffold information

A third cognitive and ecological consideration for technical communication comes from the fact that information processing extends across brain, body, and culture, which is equivalent to saying that cognitive processes are distributed from the brain to the environment. Distributing information processing into the environment is not superfluous but serves a parsimonious function: it helps reduce the brain's cognitive workload. As Rowlands point out,

> to the extent that you are able to avail yourself of an external information source, the complexity, and therefore difficulty of the task you have to accomplish in your head is

> correspondingly reduced. The task that you would have had to accomplish in your head it, in part, off-loaded onto the environment. Equivalently, we might say that the task is distributed onto the environment (Rowlands, 2010, 15).

Environment, in addition to brain and body, helps constitute cognitive processes because it provides "a useful *scaffolding* or *framework* within which the real cognitive processes can operate" (Rowlands, 2010, 21). This idea of scaffolding, or using environmental structures as cognitive structures, goes back to psychologist Lev Vygotsky, but more recently it has been developed by Clark, who notes, "Vygotsky stressed the way in which experience with external structures . . . might alter and inform an individual's intrinsic modes of processing and understanding" (Clark, 1997, 45). These external structures in the environment may even take the place of brain-based cognition. Consider the role of technology in scaffolding: the cognitive process of memory, for instance, can take a lot of brain effort from an organism, but the organism may relieve much of that effort by using technological props from its environment in place of memory—e.g., using notebooks or computer applications to store past or future information, instead of depending on retrospective or prospective memory alone.

As Clark observes, "The human external environment is superbly structured in virtue of our use of linguistic, logical, and geometric formalisms and the multiple external memory systems of culture and learning" (61-62). Hence, instead of relying only on individual memory to perform cognitive tasks (e.g., mathematical operations), human beings can use their culture's technological props (e.g., calculators) in place of brain-based memory, which frees the mind to perform more complex mental operations (e.g., algebra, geometry, and calculus) supported by those props, which can, in turn, lead to the creation of even more technologically advanced props (e.g., computer algorithms). As Clark summarizes, "Simple external props enable us to think better and hence to create more complex props and practices, which in turn 'turbocharge' our thoughts a little more, which leads to the development of even better props" (62). With respect to socioeconomic analyses in particular, Clark emphasizes, "scaffolding matters: the external structuring provided by institutions and organizations bears much of the explanatory burden for explaining current economic patterns" (184). For example, consider the technological props used by firms and corporations:

> firms and organizations provide an external resource in which individuals behave in ways dictated by norms, policies, and practices. Daily problem solving, in these arenas, often involves locally affective pattern-recognition strategies which are invoked as a result of some externally originating prompt (such as a green slip in the "in" tray, discharged in a present manner) and which leave their marks as further traces (slips of paper, e-mail messages, whatever) which are then available for further manipulations within the overarching machinery of the firm (185-186).

These "external structures to control, prompt, and coordinate individual actions" are what

cognitive scientists call "stigmergic algorithms," which are patterns or procedures prompted by cultural or environmental props that guide or call forth certain kinds of behavior (186). In socioeconomic contexts, humans use such stigmergic algorithms and technological props to scaffold information-processing activities such as memory. This scaffolding means that information-processing activities are distributed over brain, body, and cultural environment, in the sense that all three constitute cognitive processes. In sum, Clark says, "human reasoners are truly *distributed* cognitive engines: we call on external resources to perform specific computational tasks, much as a networked computer may call on other networked computers to perform specific jobs" (68-69). Hence, socially distributed information processing happens largely through technologies and media that scaffold knowledge.

In technical communication, technologies and media that scaffold knowledge are ICTs. Socially distributed information processing—more broadly known as distributed cognition, or the fact that some cognitive processes are distributed across multiple agents working together in a social environment (Hutchins, 1995)—therefore matters in technical communication. When technical communicators design information for ICTs, they must consider the socioeconomic pragmatics that distributes information. As this paper demonstrates for the case study in question, when trying to design an SMS system for Congolese users, the technical communication grad students realized that trust value affected how pricing data becomes socially distributed in the DRC, and this social distribution of information affected whether or not it would be processed as trustworthy in a usability context. While ICTs and pricing information may be valuable in one context (e.g., the USA) and contribute to socioeconomic stability, the same ICTs and pricing information may not be valuable in another cultural context (e.g., the DRC) and create socioeconomic instability.

Indeed, socially distributed information processing and its relevance to socioeconomics was noted by economist F. A. Hayek, who stressed two important points for the use of economic knowledge in society: the epistemological importance of tacit knowledge, or what he calls "knowledge of the particular circumstances of time and place"; and the socioeconomic importance of communicating and sharing relevant economic information from one individual to another, especially "as he needs to fit his decisions into the whole pattern of changes of the larger economic system" (Hayek, 1945). Hayek's overall moral is that no one individual, limited by his or her own tacit knowledge, can possibly know everything about an economy, but general socioeconomic knowledge may emerge from socially distributed interactions among those individuals. Price systems, for example, may partly emerge from socially distributed information processing based on the coordinated tacit knowledge of individuals interacting in a market. Representations of such price systems (e.g., numbers and graphs) are the ICTs that distribute this kind of information processing in a society.

Cognitive and ecological considerations from embodied embedded approaches to cognition and

communication have implications for technical communication. These implications led the technical communication grad students at the University of Minnesota to reassesses their SMS project and reframe their original goals. The discussion that follows examines what they could recommend when their original information design project failed. This discussion also suggests general ways in which technical communicators may think about media ecology, especially in the context of uncertainty. Before that discussion, however, this paper will briefly remark on how cognitive and ecological considerations fit into technical communication theory.

A note on embodied embedded cognition in technical communication theory

On a side note, cognitive and ecological considerations from embodied embedded cognition—emotion, enculturation, and socially distributed information processing—are much more compatible with the rhetorical tradition than with positivism or computationalism. Rhetorical theory since Classical times has produced discourses on how communication is influenced by emotional values, cultural contexts, and socially distributed information. From Aristotle[5] and several of the Sophists[6] to Cicero,[7] many major theorists in Classical rhetoric discussed the indispensability of emotion (*pathos*) in addition to reason (*logos*) for persuasive technical communication. Quintilian[8] wrote much about the cultural basis of technical knowledge and the techniques and technologies that distribute it socially into teachable forms of 'common sense.' Even in modern theories of rhetoric, Lloyd Bitzer framed communication around what he called "the rhetorical situation," or the emotional values of the audience in conjunction with cultural contexts that frame discourse and limit how it may be communicated and socially distributed (Bitzer, 1968). Since positivism and computationalism do not emphasize these qualities of cognition or communication, it is ironic that positivism and computationalism influenced technical communication to the extent they have.

Since embodied embedded cognition is more compatible with rhetoric, it gives this art of persuasion the distinction of not just "epistemic rhetoric," (Scott, 1967) but also "cognitive rhetoric" (Sperber, 1975), or "the attempt to map the space in which the imagination moves" (Turner, 1991, 247). Rhetorical practices are epistemic or knowledge creating because they are

[5] According to Aristotle, "[There is persuasion] through the hearers when they are led to feel emotion [*pathos*] by the speech…. To this . . . we said contemporary technical writers try to give their attention" (Aristotle, 2007, 39).

[6] Gorgias did not separate rational utility (e.g., educating to stop "ignorance") from emotional beauty (e.g., creating "amusement") (Dillon and Gergel, 2003, 84); Prodicus believed some emotions like "joy [*chara*]" are rational and should be distinguished from irrational passions like hedonic "pleasure [*hedone*]" (109); and Thrasymachus taught about the emotional importance of "sympathy" in addition to reason (216).

[7] Cicero observes, though his character Antonius, "people make many more judgments under the influence of hate or affection or partiality or anger or grief or joy or hope or fear or delusion or some other emotion, than on the basis of truth or an objective rule" (Cicero, 2001, 170).

[8] Quintilian comments, "common sense—where shall a young man learn it when he has separated himself from society, which is natural not to men only, but even to dumb animals?" (Quintilian, 1987, 23).

cognitive activities that connect fact with value, information with context. Since the advance of cognitive rhetoric, there have been noteworthy attempts to reconstruct rhetoric as a cognitive theory, especially in the context of pragmatics (Dascal and Gross, 1999). Among these promising convergences between cognitive science and rhetoric, cognitive scientists Deirdre Wilson and Dan Sperber have introduced "Relevance Theory," a cognitive theory of communication that studies how communicators maximize meaning (or "positive cognitive effects") via minimum mental work (or "minimal processing effort"). Through both linguistic codes ("explicatures") and cognitive inferences ("implicatures"), communicators interpret meaning by maximizing "expectations of relevance," which can result in literal statements, loose talk, or figures of speech, which were traditionally studied only in rhetoric (Sperber and Wilson, 1995; Wilson and Sperber, 2012).

Other convergences between cognitive science and technical communication theory have been put forward as well. Composition theorists Linda Flower and John Hayes (1981) have argued that technical writing practices are goal-directed cognitive processes, in which composition organizes thoughts through complex interactions between task environment, writing skill, and memory. This line of research has helped initiate numerous cognitive studies of expertise, motivation, and knowledge that shape, and are shaped by, professional and technical communication. For example, professional and technical communicators not only must possess cognitive skills that include rhetorical knowledge about genres, symbols, and media; they also must have metacognitive strategies for producing the right kind of knowledge for the right people in the right place during the right time (Schriver, 2012). Following this cognitive emphasis, we might even go so far as saying that research in technical communication is cognitive science from the standpoint of describing how tools and technologies extend cognition into the social environment (Rivers, 2011).[9] In agreement with these convergences between cognitive science and technical communication theory, I have argued that cognitive and ecological considerations can be drawn from these mutually enriching disciplines and applied to information design. In the following section, I further argue that these considerations may be combined with media ecology as a conceptual framework for technical communication.

Discussion: recommendations for media ecology in uncertain environments

When the technical communication grad students at the University of Minnesota began their information design project for the proposed SMS system, they initially missed what makes

[9] Readers familiar with Nathaniel Rivers' proposal to "position technical communication research as a necessary complement to cognitive science" will see its many affinities with my arguments—e.g., seeing how environment and technology scaffold and extend cognition (see Rivers, 2011). However, I part ways with Rivers in not limiting such research only to Clark's 'extended mind' model, which, even as a form of liberal functionalism, cannot fully do justice to the emotional nature of decision making or the dynamic interactions between mind and media that not only scaffold and extend but also, and perhaps more importantly, shape and constrain cognition (see Gallegher, 2013).

information processing possible, because they did not consider how cognitive factors work together with ecological ones. Cognitive and ecological considerations like emotion, enculturation, and socially distributed information processing shape the possibilities of information by enacting the value of trust in a context of use. Information processing always arises out of embodied embedded cognition and communication: people value facts relative to a cultural context, which distributes information through socioeconomic uses of technologies and media. Before miners can exchange financial facts through commodity transactions, before farmers can communicate information about crop prices, they must tune into socially distributed scaffolds of meaning, which involve people interacting under assumed roles such as seller and buyer, making contextual sense of information based on facts that they value as a culture. In sum, emotional values, cultural contexts, and technologies that scaffold information affect information design. If technical communicators miss these cognitive and ecological considerations, then they risk evaluating irrelevant facts, misunderstanding cultural contexts of technology use, or prescribing inappropriate models to distribute information.

Recommendations for uncertain environments

Recognizing these cognitive and ecological considerations, the technical communication grad students had to reassess their SMS project and make more modest recommendations. After working on the project, they realized how the trust value of financial facts and the usability context of information distribution mattered significantly for information design. While SMS systems are stable in some cultural environments like the USA, information design becomes problematic when situated in a risky environment such as the DRC. Since many mining and farming markets in the DRC already undergo problems like fraud and bribery on a recurrent basis (at least more so than in the USA), financial cheating is a conceivable risk for Congolese miners and farmers using an SMS system. When the conditions of socioeconomic pragmatics do not control for cheating, financial facts are prone to corruption. In more technical terms, these unexpected conditions would not allow for what financial traders call "zero-intelligence" (ZI) agents, or workers who can intuitively perform business as usual without needing to theorize or second guess, because they are socially constrained by their economic institutions to distribute information in predictable ways (Clark, 1997, 183-184).

For instance, in relatively predictable or stable environments, people who on average perform work habitually and accurately without the need to think explicitly exemplify "intuitive expertise" (Dreyfus and Dreyfus, 1998, 284). As Simon once suggested, intuitive judgments by experts may be simply understood as rapid recognition, and psychologists Daniel Kahneman and Gary Klein (2009) have recapitulated Simon's suggestion: "creative intuitions are based on finding valid patterns in memory." When experts make intuitive judgments, their expertise tends to be valid in relatively predictable or stable environments—i.e., certain rules and opportunities to learn them. Kahneman and Klein remark, "The safe way to evaluate the probable accuracy of a judgment . . . is by considering the validity of the environment in which the judgment was made

as well as the judge's history of learning the rules of that environment." Validity in an environment, of course, does not mean a complete lack of uncertainty. Kahneman and Klein note that the patterns experts internalize are sometimes statistical, and some forms of intuitive expertise may be the ability to identify favorable wagers that succeed on average.

Therefore, in environments with low validity or high degrees of uncertainty, people do not find predictable patterns or opportunities to learn them. Since the technical communication grad students at the University of Minnesota wished to avoid unpredictable situations that would corrupt pricing information, they realized that an SMS system meant to fit the DRC's socioeconomic pragmatics would require regularities in the forms of institutional rules and constraints, which would motivate and incentivize financial behavior that benefit Congolese miners and farmers. Since those regularities, rules, and constraints are not yet realities in the DRC, the students had to reassess the value of their information design project based on the socioeconomics relevant to the cultural context of their users.

When the students reframed the original problem of their information design project, they deliberated over recommendations to deal with the challenges of designing an SMS system in the DRC. One way they could reframe their goal was to design an SMS system that draws prices from a relatively impartial source, preferably a stock or commodity exchange that would correspond closely enough to the DRC's economic context (e.g., economic indices in Africa such as the Ethiopia Commodity Exchange or the Johannesburg Stock Exchange). If pricing information came from a disinterested source, then the content of the SMS system may not be as open to corruption by buyers or sellers working in the DRC. The factual information of SMS, in this scenario, might be trustworthy enough for Congolese miners and farmers, who, being less subject to business scams by buyers, could bring more confidence into ensuing business transactions. Only a series of long-term and cautious trial-and-error experiments, however, could verify this possibility as a realistic alternative.

Nevertheless, even this possibility would likely confront challenges, including cultural resistance. For instance, empirical studies on cell phone use in African show that text messaging and SMS media are typically not used for social networking purposes. In many African countries, cell phone technologies, text messaging, and SMS media are used to strengthen interpersonal relations or core networks (e.g., family and friends), not to connect with other social networks (e.g., new business associates). Studies in Kenya and Rwanda, for example, reveal that actual cell phone use does not significantly impact overall network size, because Kenyans and Rwandans typically use cell phones to contact people already in existing, core network, not to connect with new, social networks. In other words, cell phones help maintain existing social relations, but they do not expand social networks (Shrum et al., 2011; Donner, 2006). Similar studies in other developing countries like India also confirm that cell phones strengthen interpersonal relations in already existing core networks, but they do not usually support social

networking (Palackal et al., 2011). Theoretically, these studies link SMS media to regressive, social insulation or network closure, not progressive, social expansion or network growth.

In fact, Bernadette Longo and the technical communication grad students at the University of Minnesota were surprised when they learned that the idea of social networking was not a cultural concept shared by many people in the DRC (Longo, 2011). For technical communicators who practice information design, this revelation conflicts with many 'quick-fix' solutions, which assume in an almost Panglossian manner that societal problems can be solved by incorporating new media and technologies. Such solutions ignore trust value and usability context. When both trust value and usability context are considered, technical communicators may see how some technologies that play normative roles in one culture can unintentionally play destabilizing roles in a different context.[10] Therefore, before speculating over further recommendations on how to design information for new media in the DRC, it may be better to heed recommendations related to political stability, socioeconomic development, and public infrastructure. In other words, it is unrealistic to separate SMS systems and ICT uses from broader, socioeconomic topics like industrial development and modernization (Donner, 2008).

Embodied embedded cognition and media ecology

Having explored specific recommendations the technical communication grad students could make for the SMS project after the failure of their original information design, it may be appropriate to end this study with more general suggestions about how technical communicators should theorize about information design, especially in uncertain environments where media can have unpredictable effects or unintended consequences. Here, I suggest, technical communicators can begin to develop a conceptual framework by combining cognitive and ecological considerations with insights from media ecology, the study of how technologies of communication affect human perception and change environments. In particular, media theorist Marshall McLuhan's scholarship on technologies as extensions of bodily sense perceptions into cultural environments fits nicely with the embodied embedded approach to cognition and communication. As extensions of human embodiment into cultural environment, different media extend and enhance the senses in varied ways that affect perception: radio extends the ears' auditory abilities and enhances hearing and speaking; print books extend the eyes' analytical focus and enhance visual attention and fixed perspective; digital screens extend gestalt perception and enhance scanning and fluid points of view. Cell phones, in this sense, can extend auditory dialog or, through text messaging capacities, enhance visual scanning.

Media, as extensions of the body, are also extensions of the mind: they extend both bodily sense

[10] Even within the same culture, however, technologies like cell phones are "Janus faced," carrying both positive effects and negative consequences: while cell phones give users social advantages like mobility and flexibility in answering both work-related and home-related messages, they also break down the distinction between office and family and can increase time expenditure on a workplace that is not escapable (Arnold, 2003).

perception and cognition, which is what McLuhan hinted at when he said, "*the medium is the message*" (McLuhan, 2003, 25). That is, media are metaphors for cognition itself. According to McLuhan, "All media are active metaphors in their power to translate experience into new forms" (85). Media ecologist Neil Postman put this idea succinctly when he said, "the medium is the metaphor": a medium is "not merely an extension," but it is also a "transformation of . . . thinking—and, of course, of the content of . . . culture" (Postman, 2005, 13). As metaphors for cognition, media not only extend but also constrain the ways in which people perceive their environments, which, in turn, can either preserve existing ways of life or enact new forms of experience. The former will entail predictable effects, the latter unpredictable consequences.

When new media are introduced into new environments, they affect perception and interaction in those contexts and may lead to a combination of predictable effects and conditions of uncertainty. Marshall and Eric McLuhan have proposed the following "tetrad" of heuristics, or "laws of media," to analyze the potential effects of how media modify both perception and environment:

What sense, concept, or experience does the medium enhance?
What does it obsolesce or displace?
What does it retrieve that was previously obsolesced?
What does it reverse into when pushed to the extreme? (McLuhan, 1988, 98-99, 227-228)

Each of these heuristics in the tetrad is "tentative," serving merely as a point of inquiry (129). The overall purpose of these heuristics is "to draw attention to situations that are still in process, situations that are structuring new perception and shaping new environments, even while they are restructuring old ones: the structures of media dynamics and inseparable from performances" (116). That is, these heuristics apply to the dynamics between perception and environment, or cognitive and ecological considerations, to repeat my phrase. On both a theoretical level (i.e., embodied embedded cognition) and a practical level (i.e., information design), these laws of media resonate well with cognitive and ecological considerations for technical communication. Together, they may lay a conceptual framework for technical communicators who work in information design, whether for familiar situations or for uncertain environments.

Conclusion: cognitive and ecological consideration in technical communication

This paper reviewed a case study of an SMS project and argued that its shortcomings were due to a lack of both cognitive and ecological considerations by the technical communication graduate students, who eventually realized that trust value and usability context mattered just as much if not more than technological aspects of information design. Nevertheless, I anticipate a reader may say the following in response to this analysis:

OK, you've done a case study in information design and drawn cognitive and ecological considerations for technical communication. So what? There are technical communicators already incorporating rhetorical theory, cultural studies, and activity theory that recapitulate similar considerations. What does this paper say that those models don't?

It is true that technical communication theory today often incorporates rhetoric. It also is influenced by cultural studies, and it is replete with dynamic models such as activity theory, which give attention to ecological considerations that constitute usability contexts. For example, in another technical communication study of text messaging media in information design, Huatong Sun (2006) takes a "cultural usability" approach, which combines activity theory, genre theory, and (British) cultural studies to explain technology. Sun describes this approach thus:

> With a focus on the mediation *activities* and *meanings* in context, the new framework of cultural usability regards usability as a diffusing feature across the activity system, incorporates cultural factors from both the *immediate context* and *sociocultural context* into the object of inquiry and situates culture in the dynamic interactions of the *instrumental* and *social* affordances of the technological artifact.

In cultural usability, says Sun, "usability is a mediation process that consists of tool-mediated production and sign-mediated communication. It is both (a) a material interaction with the artifact and its contexts and (b) an interpretation process of this activity." Cultural usability is indeed a broad approach to understanding usability context in information design: "the process of information design is an open system with built-in instrumental affordances to invite users to localize the technological artifact and realize its social affordances according to their culture." However, this cultural usability approach says little to nothing about trust value in information design. Cognitive considerations in amalgamation with ecological ones are tacitly recognized (e.g., emotional value), but they are entirely taken for granted. Since Sun's case studies deal with intercultural communication, cognitive considerations like emotional value are important. As my case study shows, what has positive emotional valence in one culture can have neutral or even negative emotional valence in another.

In sum, technical communication theory has overcome many of its earlier positivist and computationalist biases by incorporating rhetoric, cultural studies, and activity theory, which bring some ecological considerations into information design. However, technical communication still takes cognition for granted, sometimes implicitly assuming positivist or computationalist theories that surmise 'bits' of data are transferred without any attention to emotion, enculturation, or socially distributed information processing. As Marshall and Eric McLuhan have repeatedly pointed out, "The field of 'information theory' began by using the old hardware paradigm of transportation of data from point to point" (McLuhan, 1988, 111). In particular, technical communication does not give much attention to how cognitive

considerations combine with ecological considerations to create trust value in a usability context. Moreover, it does not recognize how cognitive and ecological considerations always go hand in hand, as phenomenologists like Martin Heidegger and pragmatists like John Dewey saw when they referred to the "background," which entailed not just ecological context but also cognitive agency (Heidegger, 1962, 191; Dewey, 1934, 201).

To conclude, since technical communication is a discipline that studies how users process information, technical communicators have to adopt some kind of theory of cognition. A theory of cognition is unavoidable for professionals in this field. Indeed, technical communication has no choice but to presuppose some theory of cognition, communication, and information processing, because communicating technical knowledge always involves a cognitive agent that processes information in one way or another. Technical communicators, therefore, should engage in the best philosophical and scientific studies on mind and language if they wish to fully overcome positivist or computationalist biases in their field and use empirically responsible theories in information design. I argued that cognitive and ecological considerations from the embodied embedded approach can help technical communicators begin this enterprise. Rhetorical and cultural studies and activity theory cannot do the job without media ecology that also accounts for cognition. By combining cognitive considerations with ecological ones, which I have proposed by combining embodied embedded cognition with media ecology, technical communicators can develop a conceptual framework to tackle practical problems in information design. Rhetorical and cultural studies, including critical social perspectives, will occupy a more pragmatic place within such a framework.

Works Cited

Aristotle. (2007). *On Rhetoric*. Trans. George A. Kennedy. Oxford: Oxford University Press.

Arnold, M. (2003). On the phenomenology of technology: the "Janus-faces" of mobile phones. *Information and Organization*, 13, 231-256.

Beaubien, Jason. (2006, March 3). Mining Offers Potential, and Challenges, for Congo. NPR News. Retrieved 4-1-14, from http://www.npr.org/templates/story/story.php?storyId=5239644.

Bitzer, Lloyd. (January 1968). The Rhetorical Situation. *Philosophy and Rhetoric*, 1, 1-14.

Calabria, Tina. (2004). An introduction to personas and how to create them. Step Two Designs. Retrieved 4-1-14, from http://www.steptwo.com.au/papers/kmc_personas/index.html.

Cicero. (2001). *On the Ideal Orator*. Trans. James M. May and Jakob Wisse. New York: Oxford University Press.

Clark, Andy. (2008). Pressing the Flesh: A Tension in the study of the Embodied Embedded Mind. *Philosophy and Phenomenological Research*, 76 (1), 37-59.

Clark, Andy. (1997). *Being There: Putting Brain, Body, and World Together Again*. Cambridge: A Bradford Book, The MIT Press.

Damasio, Antonio. (1994). *Descartes Error*. New York: Penguin Books.

Defining Technical Communication. *Society for Technical Communication (STC)*. Retrieved 4-1-14, from http://www.stc.org/about-stc/the-profession-all-about-technical-communication/defining-tc.

Dewey, John. (1934). *Art as Experience*. New York: Penguin Group.

Dewey, John. (1958). Experience And Nature. New York: Dover Publications.

Dillon, John and Gergel, Tania (Trans.). (2003). *The Greek Sophists*. New York: Penguin Books.

Donner, Jonathan. (2006). The use of mobile phones by microentrepreneurs in Kigali, Rwanda: Changes to social and business networks. *Information Technologies and International Development*, 3 (2), 3-19.

Donner, Jonathan. (2008). Research Approaches to Mobile Use in the Developing World: A Review of the Literature. *The Information Society*, 24, 140-159.

Dreyfus, Hubert L. and Dreyfus, Stuart E. (1998). Frictionless Forecasting Is A Fiction. *The Necessity of Friction*. Ed. Nordal Akerman. Boulder: Westview Press.

Flower, Linda and Hayes, John. (1981). A Cognitive Process Theory of Writing. College Composition and Communication, 32 (4), 365-387.

Gazzaniga, Michael S. (Ed.). (1995). *The Cognitive Neurosciences*. Cambridge: A Bradford Book, The MIT Press.

Gallagher, Shaun. (2013). The socially extended mind. *Cognitive Systems Research*, 25/26, 4-12.

Gibson, James J. (1986). *The Ecological Approach to Visual Perception*. New York: Psychology Press, Taylor & Francis Group.

Hayek, Friedrich A. (1945). The Use of Knowledge in Society. *American Economic Review*, 35 (4), 519-530.

Heidegger, Martin. (1962). *Being And Time*. Tran. John Macquarrie and Edward Robinson. New York: Harper And Row Publishers, Inc.

International Monetary Fund. (2009, March). Democratic Republic of the Congo: Staff Report for the 2009 Article IV Consultation. Retrieved 4-1-14, from http://www.imf.org/external/pubs/ft/scr/2010/cr1088.pdf.

James, Jeffrey and Versteeg, Mila. (2007). Mobile phones in Africa: how much do we really know? Social Indicators Research, 84 (1), 117-126.

James, William. (1984) [1900]. *Psychology: Briefer Course*. Cambridge: Harvard University Press.

Kahneman, Daniel and Klein, Gary. (2009). Conditions for Intuitive Expertise: A Failure to Disagree. *American Psychologist*, 64 (6), 515-526.

Lakoff, George and Johnson, Mark. (1999). *Philosophy In The Flesh*. New York: Basic Books.

Longo, Bernadette. (1998). An approach for applying cultural study theory to technical writing research. *Technical Communication Quarterly*, 7 (1), 53-73.

Longo, Bernadette. (2000). *Spurious Coin: A History of Science, Management, and Technical Writing*. Albany: State University of New York Press.

Longo, Bernadette. (2010). "Human + Machine Culture: Where We Work." *Digital Literacy for Technical Communication: 21st Century Theory and Practice*. Ed. Rachel Spilka. New York: Routledge.

Longo, Bernadette. (2011). "Mobile Phones and Cultural Connections: Designing A Mutual World between the DR Congo and United States." *Higher Education, Emerging Technologies, and Community Partnerships: Concepts, Models, and Practices*. Ed. Melody Bowdon and Russell Carpenter. Hershey: IGI Global.

Marr, David. (1982). *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. San Francisco: W. H. Freeman and Company.

McLuhan, Marshall. (2003) [1964]. *Understanding Media: The Extensions of Man, Critical Edition*. Ed. W. Terrence Gordon. Corte Madera: Gingko Press.

McLuhan, Marshall and Eric. (1988). *Laws of Media: The New Science*. Toronto: University of Toronto Press.

Miller, Carolyn R. (1979). A Humanistic Rationale for Technical Writing. *College English,* 40, 610-617.

Nardi, Bonnie A. (1996). "Activity theory and human-computer interaction." *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Ed. Bonnie A Nardi. Cambridge: The MIT Press.

Noe, Alva. (2004). *Action In Perception*. Cambridge: The MIT Press.

Norman, Donald. (2004). *Emotional Design: Why We Love (or Hate) Everyday Things*. New York: Basic Books.

Polikanov, Dmitry and Abramova, Irina. (2003). Africa and ICT: A chance for breakthrough? Communication & Society, 6 (1), 42-56.

Palackal, Anthony, Mbatia, Paul Nyaga, Dzorgbo, Dan-Bright S., Duque, Ricardo B., Ynalvez, Marcus Antonius, and Shrum, Wesley. (2011). Are mobile phones changing social networks? A longitudinal study of core networks in Kerala. *New Media & Society*: 13(3):391-410.

Postman, Neil. (2005) [1985]. *Amusing Ourselves To Death: Public Discourse in the age of Show Business*. New York: Penguin Books.

Rivers, Nathaniel A. (2011). Future Convergences: Technical Communication Research as Cognitive Science. *Technical Communication Quarterly*, 20 (4), 412-442.

Rowlands, Mark. (2010). *The New Science of Mind: From Extended Mind to Embodied Phenomenology*. Cambridge: The MIT Press.

Salvo, Michael. (2001). Ethics of Engagement: User-Centered Design and Rhetorical Methodology. *Technical Communication Quarterly*, 10 (3), 273-290.

Sapienza, Filipp. (2007). A Rhetorical Approach to Single-Sourcing via Intertextuality. *Technical Communication Quarterly*, 16 (1), 83-101.

Scott, Robert L. (1967). On Viewing Rhetoric As Epistemic. *Central States Speech Journal,* 18, 9-17.

Schriver, Karen. (2012). What we know about expertise in professional communication. In Past, present, and future contributions of cognitive writing research to cognitive psychology (275-312). Ed. V. W. Berninger. New York: Psychology Press.

Shrum, Wesley, Mbatia, Paul Nyaga, Palackal, Anthony, Dzorgbo, Dan-Bright S., Duque, Ricardo B., and Ynalvez, Marcus Antonius. (2011). Mobile phones and core network growth in Kenya: Strengthening weak ties. *Social Science Research*, 40, 614–625.

Simon, Herbert. (1983). *Reason in Human Affairs*. Stanford: Stanford University Press.

Sperber, Dan. (2007). Rudiments of Cognitive Rhetoric. *Rhetoric Society Quarterly*, 37, 361-400.

Sperber, Dan and Wilson, Deidre. (1995). *Relevance: Communication and Cognition, 2nd ed*. Oxford: Blackwell.

Spinuzzi, C. (1994). A different kind of forum: Rethinking rhetorical strategies for electronic text media. *IEEE Transactions on Professional Communication*, 37: 213-217.

Spinuzzi, Clay. (2003). *Tracing Genres through Organizations: A Sociocultural Approach to Information Design*. Cambridge: The MIT Press.

Stiglitz, Joseph E. (2002). Information and the Change in the Paradigm in Economics,

abbreviated version of Nobel lecture. *American Economic Review*, 92 (3), 460-501.

Sun, Huatong. (2006). The Triumph of Users: Achieving Cultural Usability Goals With User Localization. *Technical Communication Quarterly*, 15 (4), 457-481.

Taleb, Nassim Nicholas. (2010). *The Black Swan: The Impact of the Highly Improbable*. New York: Random House Trade Paperbacks.

Thompson, Evan. (2007). *Mind In Life: Biology, Phenomenology, and the Sciences of Mind*. Cambridge: Harvard University Press.

Turner, Mark. (1991). *Reading Minds: The Study of English in the Age of Cognitive Science*. Princeton: Princeton University Press.

Varela, Francisco, Thompson, Evan, and Rosch, Eleanor. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: The MIT Press.

What We Do. *Pact*. Retrieved 4-1-14, from http://www.pactworld.org/cs/who_we_are/what_we_do.

Wilson, Deirdre and Sperber, Dan. (2012). *Meaning and Relevance*. Cambridge: Cambridge University Press.

Winter, Joseph. (2006, October 23). DR Congo's Justice for Sale. BBC News, Kinshasa. Retrieved 4-1-14, from http://news.bbc.co.uk/2/hi/africa/6056396.stm.