LEARNING AND DOING THROUGH SOFTWARE DOCUMENTATION

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Abstract

Documentation is a learning medium that can transform technology into useful and practical information. This study addresses the characteristics of cognitive load and constructivism that apply to software documentation. A qualitative content analysis was conducted to determine the presence of cognitive and constructivist characteristics within guides for enterprise-wide information security applications. The two research questions in the study asked what characteristics of cognitive load and constructivism would be identified, and how prevalent would these characteristics be in the examined documentation. These questions were answered using a qualitative content analysis structured around a specially developed matrix that served as the data collection and analysis instrument for the study. The characteristics were grouped into five categories: Framework of the Document, Organization of Procedural Information, Visuals, Instructional Format, and Examples that Reflect User Experiences. All characteristics were identified across the selected documents. However, no single section contained evidence of all characteristics. The data analysis of the characteristics revealed three results of particular note. First, the ratings of all characteristics in the Examples category were very low. Over half of the analyzed sections did not provide examples and more than half did not provide realistic scenarios that illustrate real world use. Second, a very critical characteristic in the Organization category, *procedural steps are clearly identified*, rated low. This was primarily due to buried procedures within paragraphs. Lastly, the use of diagrams and screen captures rated low in the Visuals category. Opportunities for helping the user understand complex content were missed throughout much of the analyzed content.

Dedication

This journey was made possible by my best friend and husband, Raymond Hogan. His unfailing support and insight have been a guiding light throughout these five years. I dedicate this dissertation to him.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

Use and Importance of Technical Communication

Written instructions govern, guide, and control user actions on a daily basis in tasks that range from operating industrial equipment, installing a wireless router, to using computer software. These instructions must be accurate and clear, as omissions or ambiguous procedures may lead to incomplete tasks or mistakes (Moore, 1996a). Incomplete tasks may result in inaccurate accounting or reporting, which could have economic consequences, and furthermore, mistakes or an accumulation of mistakes might have consequences that are more serious (Moore, 1996a). For example, comprehensive and accurate procedures are critical to the safe and effective operations in a nuclear plant. Errors encountered in following procedures can lead to permanent shutdown of a multi-million dollar investment as experienced at Three Mile Island in 1979 and can result in catastrophic events as experienced at Chernobyl in 1986 (Wieringa & Farkas, 1991).

Technical Communication in Context

Written instructions such as emergency procedures and software documentation are a genre of technical communication. This type of instruction must contain concise language, convey contextual meaning, and evoke the appropriate effect.

Language and meaning. The much-analyzed NASA *Challenger* and *Columbia* events highlight the importance of language and meaning for communication and documentation (Dombrowski, 2005). The terminology used in the internal reports within NASA have been reported as distorting the seriousness of the problems that had plagued other ships, but had not yet resulted in catastrophe. The Challenger O-ring problems were labeled as "acceptable risks" and the definitions of debris damage evolved into an "elastic waistband that . . . expanded to fit whatever explanation seemed desirable" (Dombrowski, 2007, p. 312). Language and meaning were distorted by engineers and managers, and the practice was accepted by management, as it became part of the organizational culture. These scenarios call for documentation that is accurate and definitive.

Consequences. Ambiguous or incomplete instructions can introduce risk, particularly when the user is unaware of the consequences (Moore, 1996a). For example, many home computers employ wireless routers for convenient access to the Internet by all family members. However, the privacy risks of using wireless computing may not be understood and the documentation that accompanies the hardware may not clarify the extent of the risks in such a manner that the novice computer user may understand. Home computers that use wireless connectivity may be ripe for attack if the installation has not been properly secured. These scenarios call for technical documentation that informs, and conveys the consequences in a context the user can understand.

Learning tool. Technical or software documentation is an extension and description of the software product that it accompanies (Kaner, 2003). In many cases, documentation may be taking the place of employee training, as businesses search for ways to reduce costs (Fontelera, 2009). According to Bersin & Associates 2009 Corporate Learning Factbook, spending on corporate training dropped 11 percent between 2007 and 2008 (Tremayne, 2009). According to a 2010 report, training budgets dropped 21 percent between 2008 and 2010 (O'Leonard, 2010). In response, many users turn to in-house expertise when seeking help (Redish, 2002); however, the in-house expertise may no longer be available. As a last resort, most users turn to the manual, as the software guide "remains the single most common form of support" (Barker, 2003, p. 9). Again, in these scenarios, documentation is an important support and learning tool.

Risk mitigation. Software documentation can also act as a financial risk mitigation tool, as the "cost of not providing complete and completely accurate documentation can be in the hundreds of thousands of dollars" (Cover, Cooke, & Hunt, 1995, p. 76; Spencer & Yates, 1995). In contrast, for product suppliers there is a potential liability in defective documentation, as statements that can be proved become "express warranties, guarantees that the product will work as described" (Kaner, 2004, p. 194; H. T. Smith & Shirk, 1996). If the product does not perform as described in the documentation, the "vendor has breached the contract and the customer can demand compensation" (Kaner, 2004, p. 194). Studies of the role and value of documentation have shown that high quality documentation can reduce after-sales costs, and in many cases can pay for itself (Mead, 1998). Moreover, companies may be sued for financial damages if the product documentation is determined to be imprecise or inaccurate (Caher, 1995).

Business strategy. Software documentation has evolved into a core business asset for many companies (Fulkerson, 2010). From a marketing perspective, “documentation informs prospects” (para. 8) about the product and how it is different from the competition. As a sales tool, online documentation contributes to qualified sales leads and is a revenue generator. The classic case for documentation is the reduction of customer support costs and enhanced customer satisfaction. Online and print documentation can reduce customer calls and “drastically improve your customer experience” (para. 14). While documentation serves to reduce the cost of customer support for the publisher, savings are also realized by the customer. Quality documentation contributes to efficiency of the user and can help eliminate interruptions by co-workers when seeking help (Cover et al., 1995). Fulkerson (2010) cited costs for customer support calls at $5.50 per call to as much as $50.00 per call. On the other hand, the average cost for using documentation to solve a problem is usually less than one dollar. Another business case that demonstrates the value of effective documentation is software integration. Software that provides an interface for integration with other products must be accompanied by documentation for developers, as “documentation is at the center of every relationship between a platform and a third-party developer” (para. 17). Integration, marketing, sales, and customer support are key business strategies that should be addressed by documentation.

Conclusion. Today the technical communication profession develops content with “significant consequences for the health and safety of the users” (Turner & Rainey, 2004, p. 214) of information in fields such as nuclear power, manufacturing, and health care. Accurate and descriptive information is critical to an organization, as workers rely on written procedures, reports, and software documentation to accomplish tasks in a timely and effective manner. The implications of poorly developed information can be catastrophic. Additionally, documentation is a learning medium that can transform the technology into useful and practical information. The proof of good documentation, albeit the scenario is from a movie, is evident from Kathryn Poe's (2004) editorial in *Technical Communication*.

> In *Air Force One*, the president of the United States, played by Harrison Ford, is trapped in the hold of the plane, trying to find a way to contact the folks at the White House and let them know that he is alive. Among the cargo, he finds a satellite phone still in its case. He picks it up and stares at it with great confusion; then he grabs the documentation from the case. He flips a few pages, and voila, he makes his call. The moral of the story? Good documentation saves the leader of the free world. How cool is that? (Poe, 2004, p. 11)

Statement of the Problem

Over the past two decades, researchers have raised concerns about applying theory towards developing documentation. There are numerous articles about the importance of software documentation as an instructional vehicle. However, there is a gap in the literature about how the tenets of learning theory are applied in published documentation. Writers may be aware of theory, but are principles of learning demonstrated in how the documentation is designed and information presented?

Purpose of the Study

The purpose of this study was to discover the extent to which certain characteristics of learning theory are applied toward designing and developing documentation within the targeted software industry organizations. Two primary theories were used as a basis for analysis of the sample documentation: cognitive load and constructivism. A qualitative content analysis was conducted for the presence of cognitive and constructivist characteristics within technical guides. The study involved an analysis of a selected sampling of software documentation, to examine and evaluate how tenets of learning theory are applied in the design and development of documentation. The content is generally defined as software documentation for information security applications.

Active Theories

The review of literature about technical communication reveals three primary theories that are actively researched and studied. These theories are *rhetoric*, *instrumental discourse*, and *procedural discourse*. Rhetorical theory espouses persuasion; it dates back to over two thousand years to Aristotle's definition as "an ability, in each [particular] case, to see the available means of persuasion" (Moore, 1997, p. 165). Instrumental discourse is purposeful, as "it shows a user how to perform an action" (p. 166). Procedural discourse is a blend of purposeful writing and persuasion, and is based on systems theory and rhetoric (Farkas, 1999). Of the theories that are actively researched, rhetoric is most prevalent (Schriver, 1997).

Rhetoric and instrumental discourse have been at the center of an on-going discussion amongst many academics since Patrick Moore's (1996a) article "Instrumental Discourse is as Humanistic as Rhetoric." Moore (1997) argued that the world has changed dramatically since the days of Aristotle and the art of rhetoric. In a 1994 report, graduates of technical communication programs were reported as being ill prepared for the workplace because they lacked practical expertise (Hayhoe, Stohrer, Kunz, & Southard, 1994). Additionally, others criticized that there was too much emphasis on theory and the "useless talk about rhetoric" (Carliner, 1995, p. 164). Today, there are many types of communication that are not addressed by rhetoric; these types include information that instructs the audience and controls actions (Moore, 1997). Rhetorical theory and instrumental discourse are similar in that they both address content, audience, purpose, genre, invention, and empowerment. However, the manner in which these areas are addressed by each theory is critical. "Rhetoric tends to focus on abstract ideas and beliefs" (Moore, 1996b, p. 500) while instrumental discourse focuses on standardized objects such as forms, procedures, instructions, contracts, and laws. Rhetoric emphasizes persuasion, and instrumental discourse emphasizes "knowing how to do" (p. 501), as it empowers the user by "teaching people how to execute physical tasks that create material changes in the world" (p. 501). Task orientation is an important element of instrumental discourse, and the focus of rhetoric is more abstract, that is to sell an idea (Moore, 1997).

Many technical communication authors focus on rhetorical theory, how to write persuasively, with no mention of how to write instructively from a learning viewpoint. They tend to frame technical communication as persuasive and stylish writing rather than as instructional. Yet, Moore (1997) pointed out that an important distinction between the rhetorical and instrumental approaches is purpose. Purpose drives both; the purpose of rhetoric is to persuade and the purpose of instrumental discourse is to instruct, guide, and govern.

Schriver (1997) took a different stance about rhetoric, and pointed out that rhetoric "deals with improving the quality of human communication through the ethical use of language" (p. 58). In fact, the rhetorical approach includes document design "with a rich theoretical framework for thinking about the complex relationships among the communicator, the audience, the words and pictures, and the context" (p. 58). Schriver emphasized that rhetoricians are opposed to taking advantage of an audience through verbal and visual tricks.

Expanding Role of Technical Documentation

The expanding role of technical documentation as a learning instrument suggests that a broad application or adaptation of learning theory could be beneficial. Principles of learning that might be applied to the design and development of documentation include cognitive load and constructivism. Cognitive load is concerned with long-term memory, working memory, and schema acquisition. Working memory is affected by element interactivity and instructional format, which are factors that make some material more difficult to learn. The amount of element interactivity affects cognitive load and the instructional format can serve as a help or hindrance depending on the split-attention and redundancy effects (Sweller & Chandler, 1994). Constructivism focuses on how the learner interacts with the information and how it is processed, as knowledge is constructed rather than acquired (Ormrod, 2008).

Are these principles consciously applied in the design and development of software documentation? Are these principles sanctioned by the research community as integral to the effectiveness of technical documentation? A study by J. T. Johnson (1997) concluded that writers of software documentation “generally held a moderate to high orientation toward andragogy” (p. 143). Johnson suggested that writers with a higher level of education were more likely to address user needs through task orientation, as task orientation is a key attribute of a user-centered focus. Johnson’s observations may also suggest that principles of learning could relate to instructional documentation.

Technical Communication is Evolving

Research. There is recognition within the field of technical communication that certain attributes of theory are important. Yet the mention of theory by authors is seldom explicitly discussed through the lens of the principles of learning. The rare mention of theory informs us "there is little doubt that theory—understood as critical reflection upon the various issues, conditions, and processes grounding technical communication—is valuable. Technical communication practices and curricula have always bore the marks of influential, though not always explicit, theory" (Hart-Davidson, 2001b, para 3). Grice (2001) acknowledged, "Members at all levels of STC and of the profession at large have bemoaned the lack of theoretical basis for what we do as professional technical communicators" (para. 2). However, he pointed out the works of theorists such as Karen Schriver (1997) and Janice Redish (1993) who have contributed theoretical underpinnings toward technical communication in document design and cognitive processes.

Yet, there is a theory gap in the field of technical communication (Hart-Davidson, 2001a). Hart-Davidson called for a theory in which "the ranks of working professionals *and* academics in technical communication should participate in activity that makes the core expertise of technical communication explicit" (p. 147). Hart-Davidson put forth two arguments for theory work: writing as a technology and writing as reusable. The role of technical communicators is to grow the productivity of the enterprise by developing technological expertise of their audience through identity and strategy. By translating ideas and concepts between the domain of the work and the technology, technical communicators can enable cross-functionality and efficiency (Hart-Davidson, 2001a).

Mehlenbacher (2008) addressed theory in terms of cognitive learning and information spaces in his discussion about communication design. He too admitted that much research is conducted by the instructional and communication design community; however, researchers have focused very little on their "audiences as *learners* first and foremost, who engage in complex *learning* activities whenever they interact with information" (p. 140). There has been limited "interaction between researchers studying communication design and researchers studying instructional design and learning theory" (p. 144). Research is needed to determine to what extent practitioners are actually applying the principles of cognitive load and constructivism to technical documentation.

Image. The field of technical communication is fraught with the challenges of image as a profession and its acceptance as a stand-alone discipline. For example, the Society for Technical Communication (STC) membership has been split on the issue of certification since the mid-1970s (STC Office, 2010). It is difficult to design certification for a field that lacks a coherent body of knowledge. One perception is that the voice of membership is more concerned about legal liability rather than ethical and professional responsibility (Dragga, 1996). The certification controversy has recently been resolved, as the STC announced that certification for the technical communication field will be attainable within 2011 (STC Office, 2010). Practitioners will become certified in six core competency areas of user analysis, document design, project management, authoring, delivery, and quality assurance. The recently announced certification will contribute toward building a "solid foundation for the legitimacy of technical communication" (STC Office, 2010, para. 2).

In response to the challenges in the field of technical communication, Giammona (2004) conducted a series of interviews with a group of prominent practitioners in the fall of 2003. Responses focused on key themes such as forces affecting the field and the future role of technical communication in organizations. The study revealed that technical communication is viewed largely as a service function versus a core business function. Giammona (2004) identified a lack of strategic orientation as the crux of the problem.

Technical communication as a service and support position has hampered the growth of the field in the academic and business arenas. The service model highlights the technology content perspective rather than the user aspect of documentation. In addition to the service view of the profession, there is a schism between the academic and corporate models of technical communication (Johnson-Eilola, 2004). This schism is rooted in the practitioners' view that academics' campaign for theory and research is a waste of time, and that the practitioners in the corporate world are doing the real work (Bosley, 2002). The irony is that both groups need each other to sustain and grow the field, as theory must be a part of the curriculum and must be practiced in the field (Redish, 2002).

Background of the Study

Theorists, researchers, and practitioners generally agree on the definition of learning as an "enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience" (Schunk, 2000, p. 2). Additionally, there is agreement that learning is a "long-term change in mental representations or associations as a result of experience" (Ormrod, 2008, p. 4). Both definitions focus on *change* and *experience*, as learning is a lasting change through experience (Ormrod, 2008). Learning also requires mental processing, a very important factor in the learning process (Ormrod, 2008). The change, experience, and mental processing can vary depending on the instructional objective and format.

When instruction and learning are applied in the workplace, often software and the accompanying documentation are involved. Readers of documentation "read to do" (Redish, 1989, p. 289) and "read to learn" (p. 289). The goal of *reading to do* is to "extract information for immediate action" (Redish, 1989, p. 289) and the goal of *reading to learn* is to "absorb information for future recall" (p. 289). How these goals are accomplished, depends on the approach used to design and develop the documentation. As a learning medium, technical documentation must transmit, translate, and articulate the meaning of software (Scott, Longo, & Wills, 2006). The documentation writer's responsibility is to design and develop content that promotes learning rather than simply present information. It is not enough to transmit and translate the information from the expert to the user; rather, the writer must negotiate the flow of information from the perspective of the user and draw upon the expert's knowledge (Slack, 2003).

The enigmatic process of technical writing is an art and science that requires writing talent and the capacity to translate abstract concepts and technical jargon into usable content (Slack, 2003). Technical writing involves the design and construction of documentation that "accommodates technology to the user" (Dobrin, 2004, p.107). Effective writing enables learning, as it is "a kind of semipermeable membrane that lets understanding leak through at a controlled rate" (p. 107). Designing content to support this process may be frustrating and challenging for writers because most users treat documentation as a tool, reading it only when a problem is encountered or when an explanation is needed. The reader decides what to read and how much to read and interprets the meaning based on his or her background, experience, and knowledge (Sun, 2006). Readers do not necessarily pick up a guide to read from front to back; reading is sporadic, which means that the design and packaging must meet their needs. This is the enigma of technical communication – how to convey effective information that meets the user's needs, compels the user to act upon the new information, and invites the user to return to the documentation.

Rutter (2004) declared technical writing as "one-third writing proficiency, one-third problem-solving skill, and one-third ability to work with people" (p. 21). Rutter's view is certainly valid; but perhaps the practice deserves a closer look. Effective writers bridge the gap between the expert and the end-user (non-expert); therefore, the writer must know *how* to bridge the gap, which may be very wide and murky. Practice is based on theory (Bryant, 2004). Nonetheless, are writers aware of the influence of theory? Theory provides the writer with knowledge about how to bridge the gap between the expert and the end-user (Hubbard, 2006). Furthermore, theory gives the approach its credibility, and it is theory that enables the writer to design and develop content that will serve the user (Hubbard, 2006).

Rationale

Technical communication is a multi-dimensional and multi-disciplinary field; it is comprised of visual presentation, artistic/creative expression, typography, information technology, and writing (Carliner, 2001). It is cross-disciplinary, as it overlaps and has synergy with instructional design, usability, and information design. Moreover, the technical communication genre of software documentation promotes learning, just as do these other disciplines (Coe, 1996).

There is recognition within the field of technical communication that certain elements of theory are important. Yet these mentions of theory do not explicitly discuss technical communication through the lens of learning theory. In contrast, related fields such as instructional design and information design, focus on the application of learning theory. Across these disciplines, the recurring theme is a user-centered focus in design and development (Carliner, 2001). Each discipline considers users needs from a slightly different perspective. Instructional designers must know the target audience and the specific learner characteristics. Usability experts consider the ease of use of interface designs and context. Information designers consider the overall “visual rendering” (Ding, 2000, p. 34) of the document to attract the reader, to maintain the reader's interest through context of use, and to solve a problem for the user. In the same manner, technical communicators are concerned with conveying information that helps the user accomplish a task by presenting contextually relevant information (Redish, 2002). Hart-Davidson (2001b) suggested that a focus on theory include a “user-centered design as a collection of new practices, voices, and ideas that intersect with those traditionally associated with technical communication” (p. 2). Principles of a user-centered design are evident within cognitivism and constructivism. Therefore, this study contributes new knowledge to the field of technical communication by examining the application of cognitive and constructivist principles in the design and development of software documentation.

Research Questions

This study answers the following questions in the context of cognitive load and constructivism:

1. What characteristics of cognitive load and constructivism will be identified in the analysis of the selected documents?
2. How prevalent are these characteristics in the selected documents?

Significance of the Study

The purpose and benefit of the research was to determine the principles of learning that are followed by technical communicators in the design and development of software documentation. The research shows the extent to which writers adhere to the principles of cognitive load and constructivism, in their published documentation. The outcome of the study indicates that practitioners publish documentation with a minimum to an exemplary application of learning characteristics.

The results of the study might suggest that academia consider integrating learning theory into the technical communication curriculum, or that software companies may want to reevaluate the credentials of potential new technical communicators, or may want to offer learning theory education for technical communicators. The study could also highlight the need for the technical communication profession to consider training in learning theory as a certification requirement.

Definition of Terms

Cognitive load theory addresses the balance between the learner's cognitive system and the interactions of the learner and the learning environment. The theory focuses on the cognitive load that is placed on the learner: intrinsic, extraneous, and germane. Intrinsic load addresses element interactivity. Extraneous load addresses how the information is presented. Germane load addresses the relevance of the topic to the learner (Schmidt, Loyens, Van Gog, & Paas, 2007).

Constructivism focuses on knowledge building through experiences and reflection upon those experiences (Fosnot & Perry, 2005).

Content analysis "is the process of organizing information into categories related to the central questions of the research" (Bowen, 2009, p. 32).

Documentation refers to any "textual or graphical material that instructs the user in how to use a product or service" (Mead, 1998, p. 354).

Document design is the "plan for a document and all its features (content, organization, format, style, typography, paper, binding) to make it useful and readable" (Rude, 2006, p. 454).

Ethnographic content analysis "follows a recursive and reflexive movement between concept development-sampling-data, collection-data, coding-data, and analysis-interpretation. The aim is to be systematic and analytic but not rigid" (Altheide, 1996, p. 16).

Instrumental discourse is the "governance, guidance, control, or execution of human activities" (Moore, 1996a, p. 3).

Interpretative content analysis is a form of content analysis in which "researchers draw upon their own experiences as a resource and thus are part of the research instrument" (Hijmans, 1996, p. 101). "The analysis is a concrete link between empirical material and theory rather than an illustration of already-known theoretical notions" (p. 101).

Principles of learning are the characteristics of cognitive load theory and constructivism.

Qualitative comparative analysis "focuses on making comparisons to generate explanations" (Patton, 2002, p. 492). This method "forces researchers to select cases and variables in a systematic manner" (p. 493).

Qualitative content analysis is "an approach of empirical, methodological controlled analysis of texts within their context of communication, following content analytic rules and step by step models, without rash quantification" (Schilling, 2006, p. 28).

Quantitative content analysis is a "summarizing, quantitative analysis of messages that relies on the scientific method and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented" (Neuendorf, 2002, p. 10). Additionally, quantitative content analysis seeks to "measure the frequency and extent, if not the meaning, of messages" (Altheide, 1996, p. 15).

Qualitative document analysis "relies on the researcher's interaction and involvement with documents selected for their relevance to the research topic" (Altheide, 1996, p. 24).

Rhetoric is the study of how a speaker, document, or text seeks to convey, persuade, or consolidate a particular meaning (Rapley, 2007). Rhetorical communication "aims to alter the beliefs, attitudes, values, or actions of its target audience" (Rhetorical Communication, 2009, para. 1).

Software documentation is a "form of writing for both print and online media that supports the efficient and effective use of software in its intended environment" (Barker, 2003, p. xxii).

Task orientation is an "approach to software documentation that presents information in chronological order based on the user's workplace sequences" (Barker, 2003, p. xxii).

Technical communication is a "rich field of communicating in many media . . . that includes user analysis, applying usability methods . . . and creating e-learning" ("The value," n.d., para. 1). The Society for Technical Communication proposed the following definition for technical communicators:

> Develop and design instructional and informational tools needed to assure safe, appropriate, and effective use of science and technology, intellectual property, and manufactured products and services. Combine multimedia knowledge and strong communication skills with technical expertise to educate across the entire spectrum of users' abilities, technical experience, and visual and auditory capabilities. ("What's the difference," n.d., para. 5)

Technical writing is "writing whose subject matter is technical, applied, practical, or functional" (Longo, 2000, p. ix).

Thematic analysis is a "form of pattern recognition within the data, with emerging themes becoming the categories for analysis. The process involves a careful, more focused re-reading and review of the data" (Bowen, 2009, p. 32). Codes and categories are constructed to "uncover themes pertinent to a phenomenon" (p. 32).

Usability is the "ease with which a document, such as a manual or website, can be used" (Rude, 2006, p. 461).

Assumptions

The principal assumptions of this study are:

1. The matrices include appropriate characteristics of cognitive load and constructivism that apply to software documentation. (Refer to Table 1 for an example of the matrix.)

2. Instances of the characteristics of cognitive load and constructivism are correctly identified in the documents based on the matrices. (Refer to Table 1 for an example of the matrix.)

3. The primary and secondary sources represent the state of theory application in the field of technical communication.

4. The software documentation analyzed in this study has been developed by many subject matter experts and technical writers with varied backgrounds and expertise.

5. The software documentation analyzed in this study has evolved and matured since its initial release.

6. The conclusions drawn from this study can be applied to software documentation published for enterprise systems.

Limitations

This study is limited to a review of software documentation that was designed and developed for information security applications that reside on an enterprise-wide system, for large-scale computing environments. Two of the software applications that are targeted in this study were initially developed in the 1970s and early 1980s. The other applications were developed in the 1990s. The scope of the study is limited to six documents that range in size from 200 pages to 900 pages each.

Nature of the Study

The research design for this study is a qualitative content analysis of software documentation for evidence that cognitive and constructivist characteristics have been applied in the design and development of content. Analysis indicates how learning theory has shaped the material and how well it affords learning to the reader. Therefore, the analysis is a theory directed approach, as the data are viewed through the lens of learning theory (Grbich, 2007). The design embodies the features of interpretative content analysis and qualitative comparative analysis.

Content analysis is the most suitable research design, as it is an analytic study of written documents that seeks to determine the presence of influences that have shaped the content (Labuschagne, 2003). In addition, “the goal of content analysis is to provide knowledge and understanding of the phenomenon under study” (Hsieh & Shannon, 2005, p. 1278). The investigator is central to the study, drawing on her understanding and experiences of learning theory and its application. The methodology is reflexive, oriented toward “constant discovery and constant comparison of relevant situations, settings, styles, images, meanings, and nuances” (Altheide, 1996, p. 16). In this study, the researcher seeks to determine how cognitive and constructivist principles have shaped the design and development of the selected guides. The study reflects the researcher’s interpretation of theory and its application, through interpretative analysis (Potter, 1996). The analysis is based on the evidence and the researcher’s interpretation. Objectivity is based on the researcher’s epistemological view of the world, and the extent of meaning making. In this study, the researcher applied her understanding of learning theory, her experience as a technical writer of software documentation, and her interpretation as to the existence of artifacts demonstrating the application of a specific principle of learning, and of how meaningful and effective the content is for the targeted user.

The reliability of the design focuses on identifying and documenting recurrent characteristics of learning in terms of tasks, procedures, task-oriented headings, and visuals (Labuschagne, 2003). The quality of the study is reflected in how well the research design is documented and supported through the literature. The data collection strategy focuses on software companies that publish large volumes of documentation for their respective products. The targeted companies include EKC (Eberhard Klemens Company), IBM, and Ventyx. The analysis focuses on information security software that is implemented on enterprise-wide systems. The study is limited to six guides that address a specific user group known as information security administrators. Multiple chapters were analyzed in all six guides. The number of chapters targeted for each guide range from three to five, depending on the observed scope of each chapter. Each chapter was subdivided into topics for analysis. A comparable number of topics were analyzed for each guide.

A directed approach to content analysis was utilized to validate a theoretical framework for developing software documentation (Hsieh & Shannon, 2005). Directed content analysis is guided by a more structured process as the key concepts of the selected theories will determine the coding scheme for categories. A "truth table" (Patton, 2002, p. 492) was constructed for recording the presence or absence of each characteristic selected for the analysis. The truth table was constructed as a matrix to indicate the rating for each topic that is analyzed. Data analysis of topics produced a quality rating for each characteristic of learning. Data was collected in a matrix adopted from Hargis et al. (2004), which uses a quality checklist of characteristics as guidelines (Table 1). The matrix lists categories that relate to cognitive load and constructivism, such as *organization of procedural information*. Within the category Organization of Procedural Information, a characteristic such as task-oriented headings is a key element of cognitive principles, and is important in developing user-centered instruction (Canzoneri & Van Tiem, 2005). Within this category, the characteristics were listed along with a quality rating. Some of the characteristics in the category include meaningful headings are in the context of the workplace, introductory information is provided, procedural steps are highlighted, appropriate use of bold, italics, and font size, paragraphs are structured with known material first, and information is organized into structurally similar lists and/or tables (Hargis et al., 2004). The last column of the matrix indicates the quality rating for each characteristic. The quality ratings range from -1 to 2, with -1 to indicate *not met*, 0 to indicate *not applicable*, 1 to indicate *partially met*, and 2 to indicate *largely met*. The ratings indicate if the characteristic has been applied in the documentation. *Not met* indicates no presence of the characteristic, *partially met* indicates a partial application, and *largely met* indicates the characteristic is present and complete. Ratings for each element were totaled with a summarized rating for the category. For example, the highest rating for the Organization of Procedural Information category is 20, and the lowest rating for the category is -10 (Table 1). The category ratings were compiled and reported for each analyzed unit of content. The ratings reflect an enumeration of qualities, which indicate the depth of evidence of learning theory application. The matrix for the category Organization of Procedural Information is shown in Table 1.

Table 1. Example of Matrix for Data Analysis

Organization of Procedural Information	Quality Rating			
Characteristics	-1	0	1	2
1. Headings are meaningful (context of the workplace)				
2. Headings are task-oriented				
3. Introductory paragraph before procedural steps				
4. Paragraphs structured with known material first				
5. Procedural steps are clearly identified through formatting				
6. Information organized into structurally similar lists				
7. Information organized into tables				
8. Descriptions accompany tables				
9. Appropriate use of bold, italics, font size				
10. Ample white space				
TOTAL				

Note: -1 = Not met 0 = Not applicable 1 = Partially met 2 = Largely met

Principles of interpretative research apply to the process of constantly recurring phases of reflection (Wester, Pleijter, & Renckstorf, 2004). Each analyzed topic has unique characteristics to reflect how a characteristic has been applied. The researcher followed a five-step procedure: (1) read the topic, (2) describe and summarize the topic, (3) re-read the topic and make notes, (4) analyze the topic, and (5) formulate the interpretation and record the results in the matrix. The formulated categories within the matrix follow a deductive application (Mayring, 2000).

Validity of the findings is documented in a rich, thick description of the topic ratings (Creswell, 2009). Within the description, the researcher's bias is clarified to highlight how her background, education, and experience have shaped the study. The researcher spent a prolonged amount of time analyzing the documentation to convey the appropriate level of detail in the analysis.

Organization of the Remainder of the Study

The remainder of this study is organized into the following four chapters: chapter 2 is the literature review, chapter 3 describes the methodology of the study, chapter 4 discusses and interprets the data collected, and chapter 5 discusses recommendations and conclusions drawn from the data analysis.

CHAPTER 2. LITERATURE REVIEW

Introduction

The scope of this literature review includes a brief history of technical communication, the challenges facing the field, and the cross-disciplinary nature of technical communication. The literature review explores cognitive load and constructivism, and the application of these theories in the design and development of software documentation, in support of software documentation as an instrument of learning. The literature shows that related fields such as instructional design and information design are steeped in learning theory. However, the vast majority of the literature contributors in the field of technical communication discuss theory from a different perspective. These perspectives are examined and analyzed as a potential gap in the consensus of theory that applies to the study and practice of technical communication. This chapter concludes with a review of qualitative content analysis as a tool to evaluate software documentation.

History and Challenges of Technical Communication

This section discusses the history of technical communication, the origin of its challenges, and the cross-disciplinary nature of the field.

The field of technical communication emerged in the mid-1800s as an outgrowth of the engineering profession (Kynell-Hunt, 2003; Longo, 2000). Kynell (as cited in

Hart-Davidson, 2001b) argued that “technical writing largely emerged as a result of the engineer’s increasing responsibility to communicate technological changes to a large and diverse audience—not just other engineers, but academics, lawyers, and the public” (para. 8). Consequently, technical communication inherited the same negative attitude that had been bestowed upon the engineering field, that of a vocation, a craft, versus one that stems from a formal education of enlightenment. From the early 1900s, this attitude developed into a “two cultures” (Connors, 2004, p. 6) split that was centered on the origins of engineering as a vocation, as engineers initially learned their skills on the job as apprentices, and a culture of enlightenment (Johnson-Eilola & Selber, 2004). Technical writing enjoyed a less than glorious existence, as English teachers viewed engineers as "soulless technicians, while engineers saw English teachers as dreaming aesthetes, promoting 'refinement and culture' to the exclusion of reality" (Connors, 2004, p. 6). The culture split continued throughout the decades and is best characterized as those that wish to "teach technical students to write" and those that wish to "teach them to read and appreciate great literature" (p. 15). In the early 1960s, a commentary by a co-secretary from a technical writing workshop framed the split, "My minority opinion is that there is such a thing as technical presentation and reading and writing about literature doesn't teach it" (p. 15).

The attitude of English teachers as dreaming aesthetes and engineers as soulless technicians stems from the split of rhetoric and philosophy amongst the ancient Greek teachings of Isocrates, Plato, and Aristotle (Killingsworth, 2000). Isocrates promoted rhetoric as the “art of choice in human affairs” (Whitburn, 2000, p. 227); he placed value on human problems, decision-making, and the “necessity of using judgment” (p. 227).

Whereas, Plato and Aristotle valued the "identification of truths in such areas as theology, science, and mathematics" (p. 6). Rhetoric was viewed as a "feeble companion to philosophy and at worst a form of pandering to the ignorant masses" (Killingsworth, 2000, p. xii). This split can perhaps be characterized in today's terminology as rhetoricians being blue-collar workers, the brawn, and philosophers as white-collar workers, the brains. The attitude carried over into institutions of higher learning, as they were heavily influenced by the elitism of English department literature faculty, which held themselves in high esteem, as that of philosophers (Connors, 2004). In fact, Moore (2008) noted that "The business of the American English department is not the teaching of literacy; it is the worship of literature" (p. 212), as literary studies open "Heaven's Gate" (p. 212). Rhetoric was viewed as secondary to philosophy, as rhetoric and those that taught technical writing were considered inferior and unworthy. Perhaps another perspective for understanding this split is to view it in terms of the physical and that of the mind. Language, literature, and philosophy have been "interiorized" and are accepted within the realm of human values (Knievel, 2006, p. 78). Conversely, technology lies outside this realm, and technology that calls attention to itself is resisted by humanists. This point of contention comes to fruition in the controversy between Miller (2004) and Moore (1996a).

Rise of Consumerism

With the rise of consumerism in the early 1900s, the need for technical writing and document design began to develop (Schriver, 1997). Americans were shifting their focus from being self-service providers (i.e., farming, sewing, carpentry) to consumers of goods. Making clothing, butchering meat, or chopping wood were fast disappearing as day-to-day responsibilities of the individual. Americans were becoming consumers, purchasing their daily needs from manufacturers, and with this change, advertising emerged in publications such as the *Sears Catalog* (Schriver, 1997). Advertisers were flooding the American public with information about products.

The rise of consumerism led to fraud, which was prevalent in the early 1900s, as manufacturers claimed their products could work wonders. Linking quality to the goods was dependent of the name on the package, the brand name. Thus, the birth of the Consumer's Union eventually delivered the *Consumer's Union Report*, known today as *Consumer Reports*. This demand for new products increased and along with it the need for technical writing in such forms as brochures, specifications, manuals, warranties, guarantees, and returns policies (Johnson-Eilola & Selber, 2007; Schriver, 1997).

International Plain Language Movement

Beginning in the 1960s, the cry for plain language in government and business documents was set in motion (Schriver, 1997). Citizens were tired of difficult language intertwined in government documents and forms and a grass roots movement called for improved usability in the documents encountered by average citizens. In 1978, President Carter issued an executive order to simplify documents, and a year later, the *Paperwork Reduction Act* was issued, requiring government agencies to keep forms as simple and brief as possible (Johnson-Eilola & Selber, 2007; Schriver, 1997).

Technology

Between 1900 and 1940, the massive production of machines such as automobiles, sewing machines, tractors, washing machines, refrigerators, cameras, and shortwave radios required documentation for internal and external customers. Hundreds of documents were designed during this time in response to the mass production of goods (Schriver, 1997). During the 1940s (World War II) and 1950s the defense industry needed "easy-to-understand manuals for operating its equipment" (p.44). Large corporations such as General Electric, Westinghouse, and GM developed technical writing departments. Beginning with the discovery of the transistor in 1947, electronic devices rapidly evolved in a manner that has strongly influenced the global economy and the personal lives of most world citizens (O'Hara, 2001). This discovery has also transformed nearly all aspects of technical communication. Today, the profession communicates technical information in fields such as nuclear power, mining, utilities, manufacturing, construction, and software (Turner & Rainey, 2004). The Word processing and personal computer revolution that started in the 1970s radically changed the landscape of technical communication and document design (Schriver, 1997). With the advent of the personal computer, usability of software documentation has been a central focus of marketing strategies (Johnson-Eilola & Selber, 2007).

The importance and need for technical writing became evident between the industrial and post-industrial age (Durack, 2003). In the past, technical writers were simply ones that wrote about the technology, while today "primary value is located in information itself" (p. 34). Much of the technology today is "increasingly abstract and represented in text (such as a 'package' of prepaid minutes for cellular telephone service or one-click Internet shopping)" (p. 34). Often information or documentation is the product itself, rather than as a supporting component (Mead, 1998).

Struggle for Prestige

Carolyn Miller's (2004) influential article from 1979, "A Humanistic Rationale for Technical Writing" became the "touchstone" (Rude, 2009, p. 188) for viewing the field in a new light, that of rhetoric and humanism. The article received high acclaim amongst many technical communication scholars and very few questioned its message. Of those who did question it, the message was viewed as an opportunity to re-position technical communication to appeal to faculty "prepared in literature who seek redemption for working in a practical field aligned with engineering and business" (Rude, 2009, p. 188). Moore (2008) tagged Miller's article to redefine technical communication as "literary humanism so some of its rarity and superiority can rub off on technical communication faculty and their students to give them more prestige in the positional economy" (p. 213). Moore defined the positional economy as one in which the non-English literature faculty strive for prestige and honor as that of the literature professors. Moore rejected the ongoing struggle amongst academics to redefine the field of technical communication as he stated, "Literature professors want to stay rare and superior, but some technical communication theorists want to redefine themselves in such as way as to absorb some of that rarity and superiority" (p. 214). Moore questioned the allure of English departments that are still teaching the same curriculum over those with ongoing research in technical communication that explores various theories, humanism, and rhetoric. There are more constructive approaches for furthering the field, such as creating standards for academic programs and practitioners and improving the relationship between academia and practitioners (Moore, 2008).

Moore (2008) observed, “Academic specialists in technical communication also lack value in the eyes of the workplace practitioners whom they are supposed to serve” (p. 208). He pointed out that academics live in a cultural capital that is positional, one of sought-after prestige, and practitioners live in a material capital in which many people or everyone wins. These two worlds are diametrically opposed as prestige is only awarded to the few, yet in the material world of the practitioner, it is possible for everyone to win.

Academics vs. Practitioners

Additionally, the status of the profession is clouded with a schism between academics and practitioners and the "lack of a coherent body of knowledge in both the academy and the workplace" (Johnson-Eilola & Selber, 2004, p. xxvi). While the profession suffers a culture split, it is also coping with an identity crisis that spans multiple disciplines. A study to catalog the academic programs in technical communication revealed that there is "no pattern of any kind" (p. xxvi); thus, the lack of a coherent approach within the field as a whole. Yeats and Thompson (2010) mapped the curriculum of technical and professional communication of 142 institutions and found that there is no representative technical communication program. Almost any combination of focus and degree offerings can be found. This lack of a coherent body of knowledge could explain the varied active theories and the long awaited certification.

Rude (2009) pointed out that technical communication is “commonly defined as a practice, not as an area of research” (p. 175). Her findings summarized the research questions in technical communication as being closely aligned with composition and rhetoric. Rude (2009) noted that academics and practitioners have produced a wealth of research about technical communication, but have not “articulated very well to others our contributions to the world's knowledge" (p. 207). In her analysis of the research, Rude determined that technical communication "overlaps with other communication fields" (p. 175), as it "shares and borrows methods, theories, and even content areas with design communication, speech communication, and rhetoric and composition as well as with psychology, education, and computer science" (p. 175). The common line of inquiry amongst these fields is usability, web-site design, and information management (Rude, 2009).

Cross-Disciplinary Nature of Technical Communication

The practice of technical communication has been defined by many scholars. Though each definition is slightly different, all agree that the field pulls, draws, and borrows from other disciplines. Perhaps Albers' (2003a) description of information design and its relationship to technical communication is the most succinct.

> In the final analysis, information design requires content. Although much of the information design process operates above the level of the text itself, in the final analysis, the text content must mesh with the design (Schriver, 1997). Any design lives and dies by the content it has to impart. . . .
>
> The technical communicator's skills for transforming the information from its source to the proper level for the audience underlie communicating information. This skill set will always be needed to support the work of the information designer. As part of this skill set, technical communication brings the methods of aiding information communication, such as headings, text and graphic integration, and page layout.
>
> Along with writing and editing skills, technical communication also provides the methodologies needed to define the user's needs and goals, and task and audience analysis. (Albers, 2003a, p. 6)

As a student of technical communication, Bemer (2006) described how she responds to questions from friends and associates when asked the question "What is technical communication anyway?" (p. 1). Her response evoked a list of the types of courses that encompass the curriculum such as, "technical writing, instruction manual writing, communication theory, usability testing, document design, [and] rhetorical theory" (p. 1). Hayhoe (2007) listed the varied titles held by technical communicators to include technical writer, editor, usability expert, content management specialist, user experience designer, information development manager, instructional designer, user assistance professional, and Web master.

Miller (2004) observed that technical communication programs have had trouble within the university curriculum; trying to fit in has been problematic. She suggested that the successful programs have expanded and sometimes found homes outside the English departments. She too noted that technical communication "borrows concepts, theories, and methods from other intellectual disciplines but it is rarely recognized as a contributor to them" (p. 48). The humanistic values of technical communication, as declared by Miller (2004), continue to reverberate as Rutter (2004) reminded us that the process of communication is very human, and therefore, requires a broad perspective of how to convey information with human values. This broad perspective includes awareness of interface design, information design, instructional design, and usability.

There is more to technical communication than skilled writing and subject matter expertise. The field of technical communication is changing as the focus is adjusted to include interface and interaction design, information architecture, information design, and usability (Albers, 2005). This change is particularly evident for technical writers in the software field. Traditionally the technical communication discipline required a basic knowledge of the subject matter, an ability to communicate with the subject matter experts, and the talent to translate technical jargon to meaningful and usable information for the recipient (Giammona, 2004). Today, readers need more. It is not enough to create content and transfer information; information must be communicated (Albers, 2008). Writers must view writing through a "problem-solving lens" (p. 119). To understand how people interact with information, writers must address the *problem space*, *design space*, and *user's goal space,* including the goal of learning (Albers, 2008).

Instructional Design

To understand how to address the problem spaces described by Albers (2008), consider the field of instructional design, where learner characteristics such as age, attention span, prior knowledge, language preference, and interests are important factors in the instructional design process (Seels & Glasgow, 1998). The goal of the instructional design process is to deliver effective instructional content that enables learning. The more a designer understands and considers the target audience, the more effective and efficient is the instructional content (P. L. Smith & Ragan, 1999). In addition to learner characteristics, contextual analysis provides insight into the target audience. The design must include meaningful learning experiences that provide relevant learning experiences. For example, crucial inputs to the design process of an online course include how the student will value the learning experience (Morrison, Ross, & Kemp, 2004).

Addressing the design space and user's goal space requires a user-centered design, which is the core of the usability discipline (Barnum, 2002). Usability focuses on the user in the context of interface design. Interface design must consider the user's perspective, with the objective of producing a product that helps the user accomplish specific tasks (Wania, Atwood, & McCain, 2006). Evaluation follows the design to create a usable and viable product. In a final development step, usability testing confirms that the interface is easy to use and that changes improve the product for the benefit of the user (Dumas & Redish, 1999).

Information Design

Within the Albers' (2008) design space, the context of how the information is used attracts and engages users. Spool (2005) observed, "Design happens at the intersection of the user, the interface, and their context" (para. 22). The designer must be able to organize content into a logical and usable structure that is intuitive to the user. The interface must allow the user to find the information, understand the content, and apply the information to the task. The design space must also consider the principles of information design to include the balance of visuals, the use of content, and the application of typography (Carliner, 2002). These elements play an important role in how content is designed and developed. The visual element is fundamental to information design as it can represent mental tasks (Zachry & Thralls, 2004). The content element addresses cognitive load, which involves how to manage topics by chunking content into manageable groupings with ample white space for visual balance. The typography element can set a tone or mood for the content. Often subtle, each element exudes a psychological influence over the reader. Schriver (1997) stated so eloquently that "Document design fuses art and science" (p. 11); it connects the reader by melding text, graphics, and typography into meaning that goes beyond text.

Brasseur (2005) presented a landmark example of the impact and importance of information design in Florence Nightingale's *Rose Diagrams*. Nightingale used familiar shapes of circles and wedges to illustrate statistical data. Her unique design uncovered the specifics of why the death rate was so high for soldiers during the Crimean war in the 1850s. Through her diagrams, she was able to persuade the British government to institute reforms to improve hospital sanitation conditions. Florence Nightingale's rose diagrams are a landmark example of how information design can help the user understand the meaning of statistical data through a visual diagram (Brasseur, 2005).

Principles of information design concern the balance of visuals, content, and typography. These principles play an important role in how content is developed. Effective content design is based on a semiotic theory of document design (Ding, 2000). The theory considers the overall visual representation of a page comprised of structure, placement of items, and the meaning of visual elements. Structure entails chunking text and balancing the amount of white space on the page. This structure paints an image of the page, affected by the placement of items and their relationship. How the reader interprets the message is determined by his or her own cultural experiences. The text, placement, font, graphics, and balance become an image, a "visual rendering" (p. 34) of the combined elements. This image or look and feel of the page is what can attract the reader, as the ultimate goal is to attract the reader, maintain interest, and convey information.

Information design is about solving a problem for the user. A good design is not just about the physical appearance. The designer must be able to organize content into a logical and usable structure that is receptive to the user. The interface must allow the user to find information, be able to understand the content, and be comfortable with the subject matter. This model of information design is comprised of physical, cognitive, and emotional aspects (Carliner, 2002).

Usability

Usability is about the design of the product, meaning its ease of use (Norman, 1988). One could argue that if the many manufactured devices that surround us, supposedly to enhance our lives, were designed properly, we would not need installation instructions or user guides that explain how to use these wonder machines (Norman, 1988). Usability is a critical aspect in any design, and when usability has been factored intelligently into a product, we enjoy its use. However, when usability has not been considered, we may experience high levels of stress while engaging with the device. Usability saves time, which saves money; it improves work processes, and contributes to user satisfaction. Usability planning and testing involves a set of practices that include heuristic evaluations, usability tests, and contextual inquiries.

Conclusion

Across the disciplines of instructional design, information design, and usability, the recurring theme is a user-centered focus in design and development. Each discipline considers user needs from a slightly different perspective. Instructional designers must know the target audience and the specific learner characteristics. Usability experts consider the ease of use of interface designs. Information designers consider the overall visual rendering of the document to attract the reader, to maintain the reader's interest through context of use, and to solve a problem for the user. The practice of technical communication is concerned with conveying information that helps the user accomplish a task by presenting contextually relevant information.

Albers (2008) explained that addressing the problem space, design space, and user's goal space is a study in understanding "how people interact with and interpret information" (p. 117). He labeled this as *human-information interaction (HII)*, and stressed that the technical communicator's most important objective is to maximize comprehension. Albers reinforced the premise that technical communication requires communicating content to the user. This communication must delve into human psychology and address "how a person mentally handles the information" (p. 119). HII draws from a range of fields: cognitive psychology, social psychology, information science, human factors, human-computer interaction, and technical communication. For Albers, HII revolves around providing the understanding of how the user interacts with content to accomplish a task. Albers, along with other scholars such as Redish (2002), Rude (2009), and Miller (2004), recognized the multi-disciplinary nature of technical communication and its connection to cognitive psychology, which encompasses learning theory.

Active Theories in Technical Communication

There are many theories that apply to the field of technical communication such as composition theory, visual design, literacy theory, activity theory, and linguistics. The more prevalent theories that relate to technical communication as a whole are rhetoric, instrumental discourse, and procedural discourse, with rhetoric being the most widely referenced theory in scholarly articles.

Rhetoric

Rhetoric has many definitions and explanations; however, it may be best described as a "study of human communication" (Lucaites & Condit, 1999, p. 1). The study of human communication aims to produce effective communication and to understand communication as a study of persuasion (Moore, 1997; Selzer, 2004). Today's contemporary rhetorical theory is linked to the teachings of ancient Greece and Rome, and particularly those of Isocrates, Plato, and Aristotle. Miller's (1989) analysis of rhetoric, as characterized by Aristotle, stated that rhetoric is art, termed *techne* – it "requires both particular and general knowledge, both knowing-how and knowing-that; techne is both applicable and conceptualized" (p. 21). As this definition seems to describe the practice of technical communication, Miller (1989) noted that not all scholars agree that Aristotle connected rhetoric with productive knowledge. Moore's (1997) definition of rhetoric is very frank.

> Rhetoric is not task oriented. The immediate focus of rhetoric is abstract: changing an audience's beliefs or ideas. Although the rhetorician's purpose in changing a person's beliefs may ultimately be persuading the audience to perform a task (purchasing a breakfast cereal), the immediate purpose of the rhetorical message is changing an audience's beliefs. (Moore, 1997, p. 165)

Sauer (2003) described Aristotle's rhetoric as an "inventional art" (p. 5), which is the "art of finding out the available means of persuasion" (p. 3). Aristotle's definition of rhetoric was concerned with "how individuals might employ a theoretical framework to discover arguments that might be effective in public deliberation and judgment" (p. 3). This definition of rhetoric links facts and the strategies to document those facts, such as relating to the audience attitudes and beliefs.

Rhetorical writing includes three main styles: *ethos*, *pathos*, and *logos*. Ethos is centered on the appeal of the writer, how well the writer projects character. In other words, the writer's reputation is built on how well he or she has addressed the reader's needs (Moore, 1997; Williams, 2007). The reader recognizes the value of the content and therefore, attributes ethos to the writer (Sullivan, Martin, & Anderson, 2003). Pathos is the emotional appeal of the writing, and is perhaps most applicable to advertisements (Moore, 1997; Rhetorical Communication, 2009). Logos is the appeal of the writing, which is based on logic or reason (Moore, 1997; Rhetorical Communication, 2009).

The principles of rhetoric that apply to writing include *audience*, *invention*, and *heuristics* (Schriver, 1997). *Audience* involves developing content that meets the needs of the audience, such as document design, graphics, and context. *Invention* involves style, persuasion, and understanding the audience beliefs. *Heuristics* are the strategies for developing content that addresses what is known by the reader and how to relate what is known to new concepts (Schriver, 1997).

For forty years, from the 1920s to the 1960s, the study of rhetorical theory focused on the philosophy of communication. Writing courses taught basic reading and writing skills, and introduced "rhetorical issues such as style and audience" (Knievel, 2006, p. 68; Schriver, 1997). The image of contemporary rhetoric has changed; however, the image of the past was not so glorious.

> Its significance was relegated to the margins of serious Western intellectual thought. Indeed, it was not infrequently referred to as the "Harlot of the Arts." In this context, rhetorical theorists managed to preserve some academic status for their study by conceding to a secondary or derivative role, allowing rhetoric to be cast in the role "supplement" or "handmaiden" to more authentic modes of inquiry. The primary concession here was that rhetoric existed apart from the categories of "truth" and "knowledge" whose proper intellectual domains were science and philosophy. Once one properly discovered "truth" or "knowledge," rhetoricians might help to "dress it up" so as to communicate it more effectively to a larger, more common audience; but importantly, it was believed rhetoric played *no* role in the actual process of discovering such "truth" or "knowledge." (Lucaites & Condit, 1999, p. 6)

Attitudes toward rhetoric began to change by the mid-1960s with technological changes such as television that altered the face of public discourse. Social changes such as civil rights, the antiwar movement, and the women's liberation movement questioned the classical models of rhetoric and began to shift the focus to "understanding the relationship between rhetoric and social theory" (Lucaites & Condit, 1999, p. 8). Rhetoric took on a new role of focusing on problems and social change, as it was no longer the "handmaiden" (p. 10) to philosophy.

An example of this new role is in Miller's (2004) seminal article that was published in 1979, "A Humanistic Rationale for Technical Writing." Miller solidly linked technical writing with rhetoric and humanism and posed that technical writing is too forceful, scientific, and positivistic (Knievel, 2006). She sought to bridge science and rhetoric, as a "basis for seeing technical writing as a more humanistic and less coercive endeavor" (Miller, 2004, p. 48). Miller asserted numerous groundbreaking statements about the nature of technical writing.

> Technical and scientific rhetoric becomes the skill of subduing language so that it most accurately and directly transmits reality. It aims at being an efficient way of coercing minds to submit to reality….
>
> Our thinking about technical writing seems to be heavily indebted to the positivist view of science (and of rhetoric); this view is no longer held by most philosophers of science or by most thoughtful scientists….
>
> This new epistemology makes human knowledge thoroughly relative and science fundamentally rhetorical. (Miller, 2004, p. 51)

Instrumental Discourse

In 1996, Patrick Moore (1996a) published a controversial article, "Instrumental Discourse Is as Humanistic as Rhetoric," in which he rejected claims by Miller and others, that technical communication is "coercive" (para. 1) and that "instrumental or nonrhetorical uses of language have a dubious moral value" (para.2). His position can be summarized as follows: "Overemphasizing the rhetorical, literary, and creative aspects of technical communication ignores what is socially useful and human about the instrumental aims of technical communication" (para. 5). The instrumental aims of technical communication are "governance, guidance, control, or execution of human activities" (Moore, 1997, p. 166). These aims are carried out in software documentation, reference manuals, installation instructions, laws, policies, and forms. Humanism is present within these genres of instrumental discourse.

> Such technical communication scholars, I have argued, have wandered off in the wrong direction. They have missed the humanism embedded in the standardized language and procedures of technological artifacts and language. That humanism does not focus on using artistic or rhetorical discourse to articulate the important spiritual values that bind social groups together. Instead, that humanism tries to save lives, minimize pain, minimize the socially destructive actions of dysfunctional people, provide the laws and procedures that keep social groups working more or less harmoniously together, apply material resources economically to solve problems, and improve the quality of our physical lives. (Moore, 1996a, p. 11)

Moore's position is that technical communication scholars who argue solely for rhetoric have missed the point of instrumental texts. Instrumental texts such as emergency procedures are very humanistic, as their purpose is to promote positive actions and minimize negative effects upon people, organizations, and society.

Rhetoric and Instrumental Discourse

Moore (1996a) dissected and defined rhetorical writing and instrumental discourse. Rhetorical writing focuses on audience, invention, and heuristics, with a persuasive and creative slant; instrumental discourse focuses on instruction "without the need to produce any additional 'reasons' or 'supporting arguments'" (Moore, 1996a, p. 3). Instrumental discourse serves a practical purpose as rendered in instrumental forms such as software installation instructions, emergency procedures, and instructions for filing tax returns, insurance claims, and job applications (Hagge, 1996; Moore, 2006). The how-to function of procedures is critical for documenting safety and recovery procedures in hazardous environments and numerous other procedural applications (Boelter, 2006; Sauer, 2003). These instrumental uses of communication typically do not require persuasion; therefore, a different communication approach is required. For example, it is not necessary to persuade a user to install a software product or to address an emergency in a hazardous environment; however, it is important to provide clear, concise, and usable instructions.

The definitive term for instrumental discourse is *purpose*, and for rhetoric, it is *persuasion* (Moore, 1997; Moore, 2006). Moore (1997) contrasted instrumental discourse with rhetoric using five characteristics: (1) purpose, (2) the use of reasons and appeals, (3) task orientation, (4) distance from the audience, and (5) cost. The *purpose* of instrumental discourse is to show how to do something and the purpose of rhetoric is to change a person's beliefs. Rhetoric uses *appeals* to logic, character, and emotions to present evidence, while instrumental discourse stands without the need to justify the instruction (Hagge, 1996; Moore, 1996a; Moore, 1997). To illustrate the contrast, persuasion and argument may be used to sell computer software, but there is less need to persuade the user to read and apply the installation instructions. Persuasion may be used to sell a fire extinguisher, but there is little need to persuade the user to read the instructions and apply the tool to extinguish a fire. The immediate purpose of rhetoric is persuasion, not helping a person complete a task, as persuasion is secondary in instrumental discourse. *Task orientation* is best served by instrumental discourse as it "effect[s] immediate changes in the material world" (Moore, 1997, p. 166). Task orientation is inherent to instrumental discourse as a critical element of guidance, control, and executing human activities. Accessibility, or *distance from the audience* frames the packaging and delivery of the information, such as the technology involved for Web delivery, and the process of navigating and manipulating the data. Accessibility is more complex for instrumental discourse, as the information may be stored in multiple databases and presented across multiple mediums. The final characteristic is cost. Instrumental discourse comes in many forms such as software documentation (print and online), reference and instructional materials for equipment control panels, office equipment, and computer hardware. These are typically large and expensive systems that are used in business organizations, and therefore, are critical components in daily operations. The degree of control that is achieved, between rhetoric and instrumental discourse, determines the cost to an organization. An audience can be persuaded or not about an issue, but if the manual instructs the user to "press the RETURN key" the user is expected to follow the instructions (Moore, 1997, p. 167). If instructions are not followed, catastrophic results may follow.

Hagge (1996) argued in favor of Moore's position and in particular about ethics. His support of instrumental discourse is refreshing and encouraging, as he recognized that clear, unambiguous writing, demonstrates the language of technical communication. Hagge echoed Moore's mantra that rhetoric "thrives on ambiguity," whereas instrumental discourse is diametrically opposed; it is unemotional and denotative.

Moore (1997) labeled rhetoric as abstract, which is very different from instrumental discourse, which is purposeful. Rhetoric was "never intended to address the problems that technical communicators face in the marketplace today" (Moore, 1997, p.

172). Specifically, rhetoric does not encompass managing the resources that are involved in instrumental discourse such as time, money, planning projects, developing standards, and determining the appropriate technology. Instrumental discourse has a more practical application and impact, which requires technical communicators to "think about their work in terms of its risks to lives, jobs, corporate goals, legal liability, and even personal advancement" (Moore, 1997, p. 172). In fact, technical writers must be able to "rearticulate discipline-specific knowledge to make it accessible and useful beyond the discipline" (Jeyaraj, 2004, p. 18). Standards, design, task analysis, and usability testing are just a few of the differentiating characteristics between rhetoric and instrumental discourse. These important factors contribute to the success of a documentation project, to ensure an effective end product. Effectiveness depends on understanding user traits, knowledge of subject matter, context of the subject matter from the user perspective, method of delivery, and documentation standards.

The world has changed dramatically since the days of Aristotle and the art of rhetoric (Moore, 1996b). Today, many types of communication are not addressed by rhetoric. These types include information that instructs the audience and controls actions. Rhetorical theory and instrumental discourse are similar in that they both address content, audience, purpose, genre, invention, and empowerment. However, how these areas are addressed by each theory is critical, as "Rhetoric tends to focus on abstract ideas and beliefs" while instrumental discourse focuses on standardized objects such as forms, procedures, instructions, contracts, and laws (p. 500). Rhetoric focuses on persuasion, while instrumental discourse focuses on "knowing how to do" (p. 501). Instrumental discourse empowers the user by "teaching people how to execute physical tasks that create material changes in the world" (p. 501). Moore (1997) proposed that teaching rhetorical theory is not enough to prepare students for the workplace, as rhetoric is not task-oriented, which is a concern for writers that should be developing task oriented documentation. The theory of instrumental discourse is more relevant to technical communication than rhetorical theory, as instrumental discourse focuses on content that is directed to the workplace, places emphasis on context of the material, focuses on relating how to accomplish a task, considers how to explain complex procedures, and empowers the user by teaching how to do something (Moore, 1997).

Furthermore, Moore (1996a) accused technical communication teachers of being worried about the "ethical implications of their subject" (para. 1) and as trying to "define technical communication as rhetoric so that they can make it more palatable to themselves and to other academic audiences" (para. 3). He declared that those on the creative writing bandwagon have spoiled any type of debate of nonrhetorical language, as nonrhetorical supporters are labeled as positivists or inhumane. Additionally, professional technical writers do not support the creative writing stance, as they consider it impractical. Moore complained of the heavy influence of rhetoric and composition on technical communication students, questioning the overall value once students arrive at the workplace. As a compromise, Moore proposed a definition of technical communication that includes both rhetorical and instrumental discourse and he called for awareness that "technical communication can be just as humane as rhetoric and literature" (para. 7). Moore received his requested awareness and many comments about his definition, in the form of multiple responses to his article.

The controversy of rhetoric and instrumental discourse continued amongst Moore, Miller, Kreth, Redish, R. R. Johnson, Katz, Knievel, and Hagge, with published articles over the past decade and a half. In a response by Kreth, Miller, and Redish (1996), Kreth asserted that Moore's stance on technical communication pedagogy is unwarranted, and observed, "Moore does not recognize the objectivity of instrumental discourse as a kind of ethos, a stance or persona that is projected by the writer or the writer's organization" (p. 478). Indeed, this is a very interesting point, as it contributes to the humanistic rationale of instrumental discourse, which is one of Moore's points. Of particular interest, is the response from Redish (Kreth et al., 1996), in which she concurred with Moore and extended his discussion about non-personal writing, such as software documentation.

> To technical communicators, language matters very much. Getting just the right language is critical because the point of the language is to help people use the technology successfully. It matters for all the humane reasons that Moore describes….
>
> To technical communicators, creativity is in finding the language that succeeds in its instrumental aims….To technical communicators, creativity is in finding the medium that works—again *works* in the sense of enabling people to use the technology to help themselves and others….Helping students find these creative solutions should be part of a technical communications curriculum. (Kreth et al., 1996, p. 489)

Redish (Kreth et al., 1996) also commented on the many theories that form the foundation for technical communication, such as rhetoric, cognitive psychology, organizational psychology, sociolinguistics, theories of graphics and visualization, and constructivism.

Redish (Kreth et al., 1996) concluded her response with a very pointed observation about rhetoric and instrumental discourse.

> Not all technical writing is instrumental. Sometimes technical writers produce material that is clearly rhetorical, that is meant to foster a particular point of view, with all the ethical issues that accompany such persuasive discourse. Memos within Morton Thiokol that tried to downplay problems with the O-rings are one example. Internal memos from Three Mile Island are another. Discussing these texts and analyzing the rhetorical moves in them is a legitimate study within technical communication.
>
> Studying memos and reports and how they may be used to obscure information interests many professors of rhetoric. Memos and reports are not, however, the genres of technical communication that most practitioners deal with on the job. Most technical communication practitioners today are concerned with true instrumental discourse—user's manuals for software and hardware, on-line help, policies and procedures, forms, and so on—just the types of technical communication that Moore focuses on in his article. (Kreth et al., 1996, p. 490)

Miller's (Kreth et al., 1996) response to Moore's article is one of agreement and dispute. She agreed that the study of instrumental discourse should be given more prominence within the technical communication curriculum. Miller also pointed out that in her 1979 article she was indeed promoting instrumental discourse. Perhaps it is how Miller stated her position that is difficult to grasp, as she noted, "I have been urging a rhetorical view of technical communication precisely because rhetoric is the best way I know for understanding the instrumental dimensions of discourse" (pp. 482-483). It is the "all-inclusive way" of rhetoric that Moore rejected, and may have interpreted Miller's view as the same (Moore, 1996a, para. 13).

Hagge (1996) asserted that there are two methods of "conceptualizing the relationship between words and the world" (p. 462). In his commentary on Miller's article, he clarified her position.

> For Miller and followers, only language matters. What people should consider true depends only on verbal agreements among words; truth does not depend on a correspondence between facts independently existing in the world and the words we use to refer to these facts. All we have are words. Words and their uses depend only on other words and their uses. (Hagge, 1996, p. 462)

Undoubtedly, Hagge's interpretation of Miller's message is that she paints all discourse as rhetoric. In addition, Moore (1996b) declared that Kreth and Miller are "totalizing rhetoricians," as they view all discourse as rhetoric (p. 491). Conversely, Moore's (1996b) views are that rhetoric is just one of many types of discourse.

Whitburn (2000) clarified that there are two views of rhetoric: the narrow view of Aristotle and the broader view of Isocrates. It is the view of Isocrates that encompasses all human actions and thoughts. Whitburn responded to the disparaging and distancing statements about rhetoric by Moore.

> If Moore had been aware of the full history of rhetorical theory, he would have understood that the rhetorical theories of writers such as Isocrates had sufficient scope to include all of the problems that he listed. Isocratean rhetoric could have served as a source of support for Moore's critique of the narrowness of Aristotelian rhetoric. It included not only the preparation and delivery of speeches, but also deliberation about all human endeavor, not only persuasion, but the administration or governance of tasks in any line of work. Were Moore fully aware of the teaching approaches being used in university programs across the country, he would have been surprised how many were using rhetorical theory to engage not just the technical communication problems he listed but many more as well. (Whitburn, 2000, p. 155)

Whitburn's view is that Moore based his argument on oratory rhetoric, which is designed to persuade an audience. This limited view of rhetoric placed technical communication outside the realm of rhetoric.

Persuasion can play an important role in teaching the user the necessity of procedural adherence. For example, complex software installations require well-documented procedures. The user must understand the consequences of each step. Therefore, it may be prudent to include persuasive content at critical junctures during the install process. Experienced system administrators may be inclined to skip steps that instruct the user to backup or rename files. To protect the user from errors, persuasion may be helpful in the form of large, bold fonts within a shaded box, as a way to signal the user that the information is indeed critical.

Procedural Discourse

Farkas (1999) branded his own label for technical communication within the genre of documentation as *procedural discourse*. His definition of procedural discourse is very similar to Moore's (1996a) definition of instrumental discourse, which is a blending of instrumental discourse and rhetoric.

> Procedural discourse refers to written and spoken discourse that guides people in performing a task—in other words, it is "how to" communication. (Farkas, 1999, p. 42)

The forms of procedural discourse mirror those of instrumental discourse: user guides for software, repair manuals for equipment, assembly instructions for consumer products, online help systems, and oral instructions. Yet, Farkas (1999) based his study of procedural discourse on two theoretical perspectives, that of "human problem solving in the context of systems theory" and rhetoric (p. 42). The framework for procedural discourse includes "system states and actions that changes system states" (p. 42). The system states are desired state, prerequisite state, interim states, and unwanted states. The actions are human actions, system actions, and external events (Farkas, 1999; Van der Meij & Gellevij, 2004).

As many scholars in the field of technical communication believe that technical communication is rhetorical, Farkas (1999) subscribed to procedural discourse as "always rhetorical in nature" (p. 43). The rhetorical nature is due to the need to design a procedure based on the audience in terms of actions and states, thus procedures "exist in a social context" (p. 43). The social context drives the design of the procedure, whether it is a streamlined procedure, a tutorial, or a conversation-like paragraph approach.

Similarly, Van der Meij and Gellevij (2004) proposed a theoretical framework for procedures based on the same system states and action types as noted by Farkas (1999). Their procedural model consists of four components: goals, prerequisites, actions and reactions, and unwanted states. This four-component model is grounded in systems theory and rhetoric.

Conclusion

According to Yeats and Thompson (2010), there are at least four types of theoretical influence within the curriculum of technical communication: rhetoric, instrumental discourse, liberal arts, and workplace practice. Rhetorical theory strongly influences the teaching of technical communication (Moore, 1996a). This may explain why learning theory is not promoted in the field of technical communication.

Principles of Cognitive Load and Constructivism

According to Ormrod (2008), "Theories of learning provide explanations about the underlying mechanisms involved in learning. Whereas principles tell us *what* factors are important for learning, theories tell us *why* these factors are important" (p. 5-6). Learning is steeped in theory and learning theory has a rich background, beginning with scientific inquiry and the birth of psychology that dates to the mid to late 1800s (Ormrod, 2008). The study of learning theory and psychology converged in the early 1900s with the development of behaviorism through scientific inquiry. Cognitive theory challenged and began to phase out behaviorism by the late 1960s, and constructivism was introduced into mainstream practice in the 1990s (Merriam & Cafferella, 1999).

Cognitive theories maintain that learning takes place when the student can apply newly acquired knowledge in different settings (Schunk, 2000). Both cognitive load and constructivism fall under the umbrella of cognitive theories. These theories are most appropriate for learning in complex situations such as solving mathematical problems, writing essays, and using software to solve complex problems (Schunk, 2000). This section discusses theories of learning that are most applicable to designing and developing software documentation: cognitive load and constructivism.

Cognitive Load Theory

Cognitivists are concerned with the mental processes that occur between the stimulus and response (Wortham, 2007a). Additionally, they believe that learning processes are different for humans as compared to animals (Ormrod, 2008). The learner is active in the learning process; he or she continuously builds new views and concepts of the world because humans are curious, driven by an intrinsic motivation to learn (Wortham, 2007a). Through motivation or curiosity, the learner is actively trying to make sense of the world. To illustrate, if a person were placed in a big box with a green and red disc, the mental processes might pose questions such as, why am I here, and what am I supposed to do. The mental processes work toward the context of what is happening.

Context and motivation drive learning for cognitivism (Wortham, 2007a). Cognitivists study the mental processes that people develop about their views of the world. In the learning process, the educator is a facilitator with the responsibility to create a context for learning (Wortham, 2007a). The educator must help the learner build new concepts, which requires conveying the material within a context that allows the learner to think about it in a new way (Wortham, 2007a).

Two approaches that provide a context for learning include discovery and meaningful reception learning (Schunk, 2000). Discovery learning offers a process for establishing a context in which students can encounter new concepts, as it encourages students to think about things in new ways (Schunk, 2000). Students can search, manipulate, investigate, and discover, and simultaneously, they can engage in problem solving. Discovery learning uses inductive reasoning and is most appropriate for "explaining complex forms of learning" (Schunk, 2000, p. 15), such as "mathematical word problems, drawing inferences from text, and writing essays" (p. 15). Meaningful reception learning involves a structured presentation or reading, in which the student is exposed to "ideas, concepts, and principles by relating new information to knowledge in memory" (Schunk, 2000, p. 173). This process uses deductive reasoning when general ideas are presented and followed by specific points to build upon the concept (Schunk, 2000).

The concept of cognitive load concerns the quantity of information presented and how much information the user actually reads and comprehends. The process of learning involves long-term memory, working memory, schema acquisition, instructional format, and automation (Sweller & Chandler, 1994). Working memory is limited to no more than seven items of information at a time; however, it has been suggested that the actual unit of memory is closer to three (MacGregor, 1987). The schema is the manner in which the information has been organized and presented to the learner. For example, an effective schema allows the learner to "recognize each tree that we see as a tree despite the fact that all trees differ" (Sweller & Chandler, 1994, p. 187). Automation occurs once the student learns to recognize the type of problem and realizes the schema to apply, as automatic recognition will bypass working memory, thus placing minimal demands on working memory. This integrated system reduces the burden on working memory, which allows for the transfer of learning to long-term memory.

Levels of processing. Levels of processing determine how well information is retained as either a very faint memory (surface), a memory with a moderate connection (sound), or a memory with deep meaning (semantic) (Schunk, 2000). Levels of processing are "dimensional, with physical processing being the most superficial and semantic processing being the 'deepest'" (Schunk, 2000, pp. 123-124). Information is remembered when it is "interpreted, understood, and related to previously learned information" (Ormrod, 2008, p. 187). This requires deep processing at the semantic level.

Mayer (1982) employed an "information processing framework" (p. 447) to describe how variables influence learning. In his studies, he assessed short-term memory, working memory, and long-term memory and the differences amongst learners regarding their pre-existing conceptual knowledge, how receptive the learner was to the new material, and how well the learner was able to draw upon his or her long-term memory to integrate new knowledge within working memory. The conditions for meaningful learning center on how the material is received in working memory, how much pre-existing knowledge is available in long-term memory, and how well the learner can assimilate the knowledge in long-term memory with the new information in working memory. No learning will occur if the material is not received into working memory; however, if the material is received, yet there is no pre-existing knowledge to assimilate the new material, then learning will be surface or moderate, with no deep or integrated meaning (Mayer, 1982).

Cognitive processing occurs in working memory (Ormrod, 2008). The amount of information that is received into working memory has a direct effect on the learning process, as well as the type of information (LeCompte, 1999). Too much information can overload working memory and decrease the ability to learn. Studies have shown that working memory capacity is anywhere from nine to two items (Spyridakis & Wenger, 1992), while three items may be a relatively safe number (LeCompte, 1999). The number of items may be increased by combining information, a process known as *chunking* (LeCompte, 1999). Chunking reduces the cognitive load on working memory, which can improve retention (Spyridakis & Wenger, 1992); it "helps people deal with the limitations of short-term memory" (Redish, 1997, p. 68). How the information is grouped may work well for experienced learners and perhaps not so well for novices (LeCompte, 1999).

Schema theory. Schemas are models or structures used by learners to relate the new information to their understanding of the world, in other words, how prior knowledge assists in learning new content. Schemas are methods for processing incoming stimuli. As humans develop cognitively, our schema become more refined (Wadsworth, 2004). Additionally, knowledge is stored in long-term memory based on schemata, which are categories of information and how the categories are used. For example, knowledge of mathematical calculations and how and when to apply them, are stored as schemata in long-term memory. These schemata are automated and applied when a student is faced with applying math to a problem. Schemas can also reduce the burden on working memory, thus aiding in storage and organization of information in long-term memory (Kirschner, 2002).

Schemas are memory structures that organize information into a meaningful system (Schunk, 2000). Schemas play an important role in learning because they indicate what to expect in a situation. When the student cannot apply prior knowledge with new information, then a problem occurs, as there is no schema upon which to base the new information. Schunk (2000) provided a few examples of how schemas apply in comprehending information. The first example is how a participant relayed a story about an unfamiliar culture to a second participant, and the second person relayed the story to a third, and so on. The story had been changed by each participant based on his or her own context, as unfamiliar context was eliminated. In essence, each participant "altered [the] incoming information to fit their preexisting schemata" (p. 145). Another example of a schema is a well-ordered sequence of actions or a script, such as a restaurant experience. After being seated with menus, if the wait staff does not return to take the meal order, a problem is recognized, as there is an inconsistency in the expected order of events. As noted by Kent (1987), "scripts are stereotypical sequences of actions" (p. 247) and are a form of "top-down processing" (p. 247). When readers know the script, they can process the information more efficiently and effectively (Kent, 1987).

Schemas and scripts can influence how we perceive and remember new situations (Ormrod, 2008). Schemas usually relate to objects and events and exist for concepts, ideas, and perspectives such as history, stereotypes of gender, and cultures. According to

Kent (1987), schemata "help us make inferences about concepts" (p. 245). For example, a room that has four walls, a desk, a chair, books, and a computer, may be inferred as being an office. Therefore, schemata "represent a dialectic process of knowledge formation" (p. 245). They function deductively and inductively, as a bridge that allows the learner to move from something understood to identifying with new information (Kent, 1987).

Schemas present a paradox for learners when trying to assimilate complex information (Pollock, Chandler, & Sweller, 2002). The less expertise the learner has in the domain, the more difficult it may be to adopt a schema when learning complex information.

> Very complex, high-element interactivity material cannot be understood without processing all the elements simultaneously in working memory. . . .Our cognitive architecture overcomes this problem by incorporating the elements in a schema or limited number of schemas that can be processed easily in working memory. The difficulty arises when one considers how such schemas can be constructed in the first instance, if the learner possesses no or few a priori schemas in the domain. If the material is very complex, consisting of a large number of elements that are high in element interactivity, it will not be possible to process all of the elements in working memory to be understood and for a schema to be constructed. (Pollock et al., 2002, p. 64)

To address the paradox of very complex, high element interactivity learning, Pollock et al. (2002) conducted four experiments in which material was presented to isolate the interacting elements of information. Their experiments showed that for novice learners, the "isolated-interacting elements method of instruction was superior to the interacting elements only method" (p. 83). The instructional method adopted a serial approach, by introducing elements gradually rather than simultaneously. This approach substantially reduced the working memory load, and delayed full understanding of the material; however, it was successful for certain groups of learners. Instructional designs that ignore the importance of constructing appropriate schemas for the learner will not be successful (Pollock et al., 2002).

Mental models and visuals. Appropriately designed visuals combined with words, promote the process of learning. Visuals aid in building mental models or schemas (Clark & Lyons, 2004; Mayer, 1989a). Mental models help learners to "distinguish concepts and apply relationships among concepts" (Clark & Lyons, 2004, p. 126). For example, in a manufacturing environment, counting the number of defects amongst products and counting the number of defective products are related, yet they are distinctive counts. A visual representation that accompanies the textual explanation can speed up the understanding of these two concepts. Therefore, visuals contribute toward communicating relationships and "help learners build conceptual cause-and-effect mental models" (p. 126). These types of visuals are known as *explanatory graphics* (Clark & Lyons, 2004).

Clark and Lyons (2004) identified four types of explanatory graphics as *organizational*, *relational*, *transformational*, and *interpretive*. Organizational graphics show relationships based on qualities in the form of tables, matrices, and organizational charts as a "two-dimensional layout of concepts that shows both hierarchical and coordinate relationships" (p. 131). Tables are a common form of organizing information, and are very effective for presenting massive quantities of detailed information (Horton, 1993). Relational graphics communicate quantitative relationships in the form of bar and pie charts and they are used to build cause-and-effect mental models. Transformational graphics show "movement and change in time and space" (p. 127). Examples of transformational graphics are animations and flowcharts. Interpretive graphics illustrate "theoretical or abstract relationships" (p. 127). Examples are schematic diagrams and simulations. Diagrams show organization of parts within a system and the interrelationships among components of a system (Horton, 1993). Both transformational and interpretive graphics are used to build cause-and-effect mental models (Clark & Lyons, 2004).

The key to interpretive illustrations is to "highlight the relationships between the objects being described in the text" which allows the reader to "build connections in order to draw inferences" (Clark & Lyons, 2004, p. 145). Mayer and Gallini (1990) focused on interpretive illustrations of scientific text, which they labeled as *explanative illustrations*. They identified two types of illustrations for building mental models: system topology and component behavior. A system topology shows the major parts or structure of a system and component behavior shows each major component, its state, and its relation to other components within the state change.

Lists are probably the most common visual means of presenting text in the form of bulleted and numbered lists. Lists are instrumental for presenting a group of related items in a single class, to show a series, or to show order or ranking. Effective lists begin each item with the "same type of word, such as a noun or verb" (Horton, 1993, p. 200). Lists can cue the reader and help to build mental models.

Effective visuals promote understanding when these four conditions are met: (1) explanative text provides a cause-and-effect system, (2) the learner must be able to recall conceptual information, (3) explanative illustrations must help the learner build a usable mental model of the system, and (4) the learners must be inexperienced (Mayer & Gallini, 1990).

Element interactivity and instructional format. Element interactivity and instructional format stand out as essential factors that contribute to learning new material. Element interactivity gauges the difficulty of learning and the amount of interactivity affects cognitive load (Sweller & Chandler, 1994). Instructional format can serve as a help or hindrance depending on the split-attention and redundancy effects. For example, if a topic involves many interactive elements, the presentation of the material must be carefully considered to keep cognitive load at a reasonable level. Chunking content into manageable topics is an effective approach to reducing cognitive load and avoiding adding text to diagrams may lower the mental activity (Sweller & Chandler, 1994). If the presentation is ill designed and unorganized, it can impose an extraneous cognitive load on the reader and impair learning.

Sweller and Chandler (1994) demonstrated cognitive load affects using computer applications and instructional manuals and connected the relationship of split-attention and redundancy effects. Many instructional manuals require the user to study the manual while simultaneously using the keyboard. This activity introduces the split-attention situation where the user is forced to integrate the information in the manual to the proper keyboard action. The added mental activity increases cognitive load and reduces learning. The authors suggested designing instructional manuals that do not require the student to split his or her attention by considering such approaches as imbedding the instructions with the software as online help or just-in-time assistance, or eliminate the use of the computer during the learning phase and imbed all information including diagrams in the documentation. These approaches can reduce cognitive load during the learning phase; however, these approaches are best suited for computer applications that have a high degree of intrinsic element interactivity.

Yeung (1999) studied split-attention and redundancy effects in reading comprehension and based his findings on cognitive load theory. Learning materials that may require the reader to look up the meaning of a word were used in the study. The look up activity halts the reading comprehension while the student retrieves the meaning of the word from an external glossary. On the other hand, learning materials that imbed the meaning of the word within the text reduce cognitive load, allowing the student to focus on comprehension of the passage. The action of leaving the text to retrieve the meaning of a word is an example of split-attention. Reducing or eliminating split-attention is especially effective for young readers and ESL (English as a Second Language) students.

Yeung (1999) conducted three experiments to examine the "effects of cognitive load management by inserting vocabulary definitions into reading passages" (p. 197). Experiment 1 showed that ESL 5th graders improved their comprehension when vocabulary definitions were integrated with the text. Experiment 2 showed that 8th grade ESL students improved comprehension when vocabulary definitions were integrated with the text. Experiment 3 showed that university students might benefit from having vocabulary definitions integrated with the text; however, the external list of vocabulary meanings was largely ignored by the students. For the younger groups, the integrated meaning eliminated the split-attention problem, reduced the cognitive load, and improved comprehension.

The effects of extraneous cognitive load on learning through text presentation was examined by McCrudden, Schraw, Hartley, and Kiewra (2004) to study whole text versus sentence-by-sentence text. Whole text looks at text in a linear format, as one would read a book, while sentence-by-sentence looks at text one sentence at a time with no reference to the previous sentence and no preview of the upcoming sentence (McCrudden, et al., 2004). Participant performance increased when whole text was presented because of the reduced cognitive load. The sentence-by-sentence presentation required too much load on working memory, and reduced overall comprehension as the cognitive load imposed by one variable added to the load imposed by the second variable (McCrudden, et al., 2004).

Constructivism

Constructivism is put forward by some as a "theory about knowledge and learning" (Fosnot, 2005, p. ix). Conversely, it has been labeled a "psychological and philosophical perspective" (Schunk, 2000, p. 229), a "philosophy, an epistemology, a cognitive position" (Noddings, 2007, p. 126), and a "pedagogical orientation" (p. 126). Additionally, Jonassen, Peck, and Wilson (1999), claimed that learning is "meaning making. . .at the heart of a philosophy of learning called constructivism" (p. 2).

Constructivism is "primarily an epistemological and ontological conception of what reality, knowledge, the mind, thought, and meaning are" (Jonassen, Cernusca, & Ionas, 2007, p. 46). Constructivism stems from cognitive science, with an emphasis on "how learners interpret situations and develop their cognitive structures" (Schunk, 2000, p. 23). In fact, constructivism has brought about an alternative to instructional sciences, through a new discipline, the learning sciences (Jonassen et al., 2007). Whereas the instructional sciences advocate acquisition of behaviors, the learning sciences emphasize knowledge building (Jonassen et al., 2007).

Constructivism differentiates itself from behaviorism and cognitivism through the central concept that knowledge has an "adaptive function" (Von Glasersfeld, 2005, p. 3), rather than a representative function. Knowledge is constructed through experiences and the learner's reflections of those experiences. As noted by Fosnot and Perry (2005), "cognitive development and deep understanding" (p. 10) are the focus, and learning is "complex" (p. 10) and "non-linear" (p. 10). Knowledge is a synthesis of the learner's experience and perceptions, and implies that an unbiased view of reality is not available because the individual constructs his own version, and through this construction, is transformed (Fosnot & Perry, 2005). According to Cunningham (1992), the distinction between objectivism and constructivism is *intent*. When the intent is to communicate knowledge, objectivism fits the need. When the intent is to provide students with the means to construct their own meaning of a problem, then constructivism fits the need. In both approaches, the learner processes events, however, the depth and amount of mental processing regarding the events is the differentiating factor (Duffy & Jonassen, 1992).

Constructivist techniques have been applied in the classroom to teach mathematics, language arts, to promote children's development, and to teach learners with disabilities. The approach for learning mathematics involves a process in which children explore ideas such as fractions, division, multiplication, and measurement "in relation to their own level of cognitive development" (Fosnot & Dolk, 2005, p. 187). For example, in a scenario about teaching mathematics, Schifter (2005) described how the teacher visualized her task as to "pose questions that will lead *through* – rather than around – puzzlement to the construction of important mathematical concepts" (p. 86). During the process, students actually experienced what it means to be a mathematician because they learned to "organize, and interpret their world through a mathematical lens" (Fosnot & Dolk, 2005, p. 187). Constructivism is a theory about learning and not a "description of teaching" (Fosnot & Perry, 2005, p. 187); the educator must recognize and create opportunities to foster constructivist learning, as there are no specifics for instructional techniques.

Piaget's theory of cognitive development. Piaget's theory of cognitive development is a "theory of *invention* or construction, which occurs inside the mind of the individual" (Wadsworth, 2004, p. 10). According to Piaget, children construct knowledge through their interpretation and understanding of their experiences (Ormrod, 2008). Knowledge is constructed or reconstructed when there is an imbalance between assimilation and accommodation (Wadsworth, 2004).

Piaget developed four basic cognitive concepts to understand the learning process, as *schema*, *assimilation*, *accommodation*, and *equilibration* (Wadsworth, 2004). Schemas are methods for processing incoming stimuli, as we develop cognitively our schema become more refined. Assimilation is the cognitive process of how we integrate new information. Accommodation occurs when incoming stimuli cannot be processed or assimilated with existing information. This causes a change in the schema configuration to assimilate the new information. Equilibration is a process of managing assimilation and accommodation; the balance of the two is equilibrium, and an imbalance is disequilibrium (Wadsworth, 2004). New construction occurs when the child interacts with peers or adults and encounters a challenge or criticism. The encounter may generate discomfort or disequilibrium in which the child tries to make sense and meaning of the encounter (Ormrod, 2008). The social interaction, or encounter, is a "source of necessary disequilibrium" (Wadsworth, 2004, p. 12), thus playing an important role in the process of intellectual development. The construction of knowledge is owned by the child, with the teacher in a supportive role (Wadsworth, 2004). This means that development is the driving force of intellectual development, as "new construction is always built on prior construction" (Wadsworth, 2004, p. 10).

Vygotsky's sociocultural theory. Vygotsky's sociocultural theory proposes that learning is dependent on a system that is comprised of tools such as language, cultural objects, students, a teacher or mentor, and the physical environment (Schunk, 2000). These tools are synthesized within the learning process, as the individual mediates the meaning of the parts of the system (Wortham, 2007b). Knowledge is acquired from the interaction with the system and is apparent when there has been a shift in the individual's participation in the activity (Wortham, 2007b). To illustrate, a classroom is the system and the tools are the students, the teacher, books, desks, writing instruments, conversations, discussions, presentations, debates, etc. Additional tools that are active in the system are the characteristics and dispositions of the students. These characteristics may surface during conversations and some may remain cognitive, unspoken (Ormrod, 2008). Yet, each of these characteristics, including the tools of the system, plays a role in the learning process (Wortham, 2007b). The process is collaborative for the student and teacher, but the student is the "primary figure" (Davydov & Kerr, 1995, p. 17), as "every child brings a personal contribution at the child's own level" (p. 17). The roles of the teacher and student are different, yet their roles are complementary, and "this is still real collaboration" (Davydov & Kerr, 1995, p. 17). The teacher directs and guides the activity, to encourage development and growth by applying context that is relevant to the student's social environment (Davydov & Kerr, 1995).

An important concept of Vygotsky's theory is the zone of proximal development (ZPD), which "represents the amount of learning possible by a student given proper instructional conditions" (Schunk, 2000, p. 244). The objective is to promote learning through problem-solving activities that include collaboration with other students and the teacher. Development occurs by challenging students with "concepts that lie beyond their immediate ability to accomplish, but which are within a 'zone' of possible performance that may be realized if the child works along with an adult" (Kerr, 1997, para. 4).

Application of Cognitive and Constructivist Principles in Technical Communication

Little has been written that connects the principles of learning with designing and developing software documentation. Numerous published articles promote rhetoric as the foundation of technical communication; interestingly enough, some of the principles asserted by rhetoricians are echoes of cognitive principles. Few scholars actually state that technical communication may be instructional, and fewer connect principles of learning as a foundation of the practice. Many of the scholars who recognize cognitive and constructivist principles as a foundation for technical communication are listed in Table 2. This section of the literature review discusses the application of principles of cognitive load and constructivism, to the instrumental genre of technical communication.

Table 2. Scholars Who Relate Learning Theory to Technical Communication

Author & Year	Description	Article/Book
Albers (2007)	Connected information salience, cognitive processing, and technical writing	Information Salience and Interpreting Information
Coe (1996)	Provided a theory-based human-factors methodology for designing, developing, and testing technical information	Human Factors for Technical Communicators
Karreman & Steehouder (2004)	Recognized that adding system information to procedural information in instructional texts increased cognitive load	Some Effects of System Information in Instructions for Use
Kent (1987)	Related how readers process information and how writers might organize information	Schema Theory and Technical Communication
Mayer (1999)	Connected constructivist learning to designing text-based instruction	Designing Instruction for Constructivist Learning
Mayer & Gallini (1990)	Proved that effective illustrations in scientific text improve performance on recall of conceptual information and creative problem solving	When is an Illustration Worth Ten Thousand Words?
Mehlenbacher (2008)	Stressed interaction between communication design and learning theory	Communication Design and Theories of Learning
Mirel (1998a)	Connected technical communication and constructivism	Applied Constructivism for User Documentation: Alternatives to Conventional Task-Orientation
Moore (1996a)	Defined technical communication as instrumental and rhetorical	Instrumental Discourse is as Humanistic as Rhetoric
Redish (1997)	Applied cognitive psychology and constructivism to technical communication	Understanding People: The Relevance of Cognitive Psychology to Technical Communication
Van der Meij (2000)	Pointed to cognitive load theory as the underlying principle of the proper use of screen images embedded in text	The Role and Design of Screen Images in Software Documentation
Walters & Beck (1992)	Connected cognitive factors to the design of software documentation	A Discourse Analysis of Software Documentation: Implications for the Professions

Cognitive Load

This section addresses technical communication studies that are based on theories of cognitive load. The studies include schema theory, illustrations in text, implicatures and pragmatics, document design, and minimalism.

Schema theory. Redish (1997) prescribed consistency as a key element for developing appropriate schemas. Writers must be consistent with terminology and phraseology throughout the document. Another important element is parallel sentence structure for paragraphs, headings, and lists. Lists should always be structurally similar, as this approach helps readers in developing schemas. Terminology, phraseology, and headings must also be consistent throughout the guide. Lastly, page layout must be usable and consistent.

Kent (1987) identified three of the most important writing guidelines for technical writers and connected them to schema theory: (1) move from information readers know to information they do not know, (2) move from the most general information to the most particular information, and (3) employ formats and organization strategies that the reader recognizes. Readers can process new information more effectively when they have a schema that is recognizable. Top-down processing helps the reader move from general information to more specific information, as the reader can visualize their "journey through the text" (p. 250). The writer should start with general concepts and gradually add the specific details (Coe, 1996). This approach builds complexity layer by layer and helps to control the pace of the schema creation. Another effective strategy is to use universal metaphors that are common in daily life.

Redish (1993) connected schema theory to how readers interpret what they read, as she observed, "Meaning does not reside in the text of a document; it exists only in the minds of communicators who produce documents and readers who use documents" (p. 22). Redish related schemas to technical documents through the following principles: (1) provide an explicit schema, (2) follow a framework that reinforces the schema, (3) maintain coherence and consistency, and (4) provide multiple pathways through a document.

Headings and titles. An explicit schema may incorporate headings and titles that cue the reader about the framework of the document, and those headings are displayed in the table of contents. Useful titles and illustrations go a long way to making "explicit connections to readers' prior knowledge and expectations" (Redish, 1993, p. 28). A good practice is to use headings that indicate meaningful user tasks such as *Writing a Letter*, *Monitoring Nodes*, *Starting and Stopping a Service*, and *Configuring for Automatic Startup*. These headings also prescribe a specific action through the gerund form, which "convey a sense of process" (Farkas, 1999, p. 46) and give the user a sense of decision versus other forms such as a noun, root, or infinitive (Farkas, 1999; Walters & Beck, 1992).

Context. The key element that can engage the user early in the process is context; the user must be able to relate to the instructional content. Context is a moving target; writers must recognize when they have fallen into the trap of organizing information based on the software menu structure rather than focusing on user tasks (Redish, 1998). Barker (2003) labeled such an approach the *default manual*, a manual that defines the user as "a person who operates a computer" (p. 11). The default approach limits and isolates the user from his or her activities in the workplace. The use of real-world examples with an action-oriented approach can help the writer avoid these problems. For example, a software menu with labels of *Users*, *Roles*, *Privileges*, and *Skills* must be addressed in the context of user tasks within the documentation. Without context, the user may not be inclined to read the documentation, as these labels do not necessarily inform. Conversely, the documentation can present these labels as *Administering User Accounts*, *Assigning Roles to User Accounts*, *Assigning Privileges to Roles*, and *Defining User Skills*. These labels are action-oriented and they inform the reader.

Framework. A framework to reinforce the schema includes headings that form a logical outline and reflect visual patterns in the page layout (Redish, 1993). Headings should be consistent from chapter to chapter. For example, a system administration guide may contain chapters about system components. The structure for each chapter should be identical, to help the user find and understand similar content pertinent to each component. Visual patterns should also be identical across chapters. For example, each system component may have unique characteristics. The component characteristics could be documented in a table that has a consistent look and feel across the chapters. Additionally, the placement of new and old information is critical to user comprehension. Old information must be presented first, and then followed with new information. This framework must be consistent throughout the document within paragraphs and tables. Tables should be constructed with familiar content in the left-hand column and new information in the right-hand column (Redish, 1997). Coherence and consistency are achieved through the document structure and visual patterns. Users that are only interested in topics such as *Recommendations* can easily locate content when it follows a consistent structure. Multiple pathways for navigating the document relate to cognitive styles (Redish, 1993).

Conceptual and procedural introductions. Chunking content into sections using structural or functional elaboration is more effective than no elaboration (Redish, 1993). Structural elaboration offers a brief procedural introduction to the section and functional elaboration offers a brief conceptual introduction to the section. Both approaches help the reader; however, Redish (1993) reported that structural elaborations were more useful than functional elaborations because users were able to complete the tasks more quickly.

Illustrations in text. When visuals are integrated with text, it gives the user choices and reinforces the material. Visuals can provide additional information about concepts and gives the visual learner an opportunity to grasp the new material. According to a study conducted by Van der Meij and Gellevij (1998), screen captures are the most frequently used illustration in software manuals, outnumbering other types by a factor of three to one. Screen captures can add value to documentation because in many scenarios they improve user cognition and can convey actions and concepts better than other types of illustrations. Van der Meij and Gellevij (1998) claimed that a screen capture can serve four cognitive roles and the design of the capture can vary in four design areas (Gellevij & Van der Meij, 2004). The four cognitive roles are: (1) switch attention, (2) develop a mental model, (3) verify screen states, and (4) identify and locate elements and objects. The four design areas are: (1) coverage, (2) position, (3) size, and (4) cueing. Coverage refers to how much is displayed: a full screen or a single object on the screen. Position refers to the placement of text and screen capture in relation to each other. Size refers to how much the capture has been reduced in relation to its actual size on the screen. Cueing refers to special elements such as colored lines, arrows, circles, or callout boxes with text.

Switching attention. Switching attention involves user management of the mouse, the manual, and the screen. Judicious use of screen captures can be beneficial; however, inappropriate switching of attention may contribute to cognitive load. Appropriate use of screen captures can signal the user when to look at the screen to monitor whether the step worked correctly (Van der Meij & Gellevij, 1998). The position of the capture is also important; captures that appear after the instruction may be overlooked. Captures of icons are best utilized as an integral part of the instruction. Rather than describe the icon, simply place it immediately after the word *Click*. Gellevij and Van der Meij (2004) determined that switching attention supports the learning process indirectly, as it "induces and facilitates interaction between the manual and the computer screen" (p. 236). The other screen capture functions support learning in a direct manner (Gellevij & Van der Meij, 2004).

Mental model. Screen captures can help convey a mental model of the software interface by introducing main screens, providing a spatial layout of screens, and showing the user how to navigate logically to accomplish a task (Van der Meij & Gellevij, 1998). It is important to convey a sense of continuity; therefore, a progression of screens should be used to help build a mental model of the program, as captures that do not show continuity may confuse the user.

Screen states. Screen captures can be very helpful for novice users to guide them through the program and to confirm progress (Van der Meij & Gellevij, 1998). For example, a software installation procedure may require multiple captures to support progress checks and indicate critical events in the install process. Captures are particularly helpful for problem-solving regarding responses to error or warning messages. Coverage is important for the design area, as it can show before and after images.

Identifying and locating elements. Screen captures can reduce task complexity by identifying and locating elements on a screen (Van der Meij & Gellevij, 1998). This is especially helpful for complex interfaces with many actions, commands, and elements. Cueing is very helpful in identifying and locating elements as colored lines, arrows, and circles may be used to help the user focus on a specific item on the screen.

Van der Meij (2000) conducted a study in which he introduced the minimalist approach in the form of instruction coupled with screen images. In his study, three design styles of instruction manuals were used: instruction with partial screen shots, full screen shots with instruction, and instruction with full screen shots. The first and third style place instruction first (on the page) followed by or adjacent to the screen shot. The second style places instruction to the left of the screen shot. Results of the experiment showed that the instruction with the full screen image was the most effective and efficient style. Users of the instruction with the full screen image completed the training 25% faster and showed 60% better retention than those of the other two design styles (Van der Meij, 2000).

Van der Meij (2000) contributed the findings to cognitive load theory. Instruction manuals that adopt the minimalist approach prevent short-term memory overload. If users are forced to read the manual and interact with the computer, short-term memory becomes taxed, with less capacity to learn the application. When screen images are imbedded in the text, it reduces or eliminates the split-attention problem, and allows the user to focus on learning through the manual (Van der Meij, 2000). It is important to note that the minimalist approach to documentation and the use of screen images works well for procedural guides where users must practice using the computer application.

Ganier (2009) observed the behavior of users as they interacted with a new appliance and the number of times the instruction manual was referenced. He found that the instructional format influenced the time needed to locate information. Instructions that incorporated pictures of the appliance enabled users to find information more quickly than text without pictures, as the search for information was facilitated by the pictures.

Mayer (1989b), and Mayer and Gallini (1990) conducted experiments of scientific text with and without illustrations. Students who received text with illustrations recalled more conceptual information and performed better than students with text that did not include illustrations. They determined that four criteria must be met for illustrations to be meaningful instructional methods: (1) explanatory text or labels must be included in the illustration, (2) the learner must be inexperienced in the subject matter, (3) the illustrations must help the learner build a mental model, and (4) the learner must be able to demonstrate conceptual knowledge after studying the text with illustrations (Mayer, 1989b; Mayer & Gallini, 1990).

Stull and Mayer (2007) conducted three experiments in which students read a passage from a biology text. One group was provided a graphic with the text (passive treatment) and the other group had to generate their own graphic to accompany the text (active treatment). The passive treatment proved more effective when students were tested on transfer of knowledge. The authors interpreted their findings based on the "triarchic theory of cognitive load in which deep learning occurs when the learner engages in generative processing and essential processing while not having to engage in extraneous processing" (pp. 816-817). Students who were asked to generate their own graphic engaged in critical thinking; however, the process created an extraneous cognitive load and resulted in less capacity for generative processing.

Implicature and pragmatics. An implicature is "that portion of the text that is left unsaid" (Wright, 2008, p. 47), in other words, unexplained phrases or terms that can confuse the reader. Pragmatics is the "study of language used in context" (Wright, 2008, p. 28), meaning phrases that are used in a context that would be foreign to a novice user.

Wright (2008) investigated two guides on the same topic for evidence of implicature and pragmatics in documentation. The two guides analyzed in the study were a "for Dummies" text and a Microsoft guide. Wright (2008) determined that the major differences between the two guides were the number of implicatures, as the "for Dummies" guide was easier to understand and use as compared to the Microsoft guide. The Microsoft guide "builds upon terms introduced in other chapters of the manual using them as implied background knowledge" (Wright, 2008, p. 42). The Dummies text introduced one new concept at a time, and any required references to comprehend concepts were within the same sub-section of the text. Wright concluded that this major difference between the two guides is the primary reason for the difference of implicatures between the guides, as the Dummies text scored 6 implicatures compared to 43 implicatures for the Microsoft text (Wright, 2008).

Defining terms and concepts are important to readers, to avoid placing a burden on the user. The unnecessary burden of implicatures and pragmatics disrupts the process of communication and increases cognitive load. Without an awareness of the principles of implicature and pragmatics, the writer will not be able to "define user context" and will be "unable to produce usable documentation" (Wright, 2008, p. 49).

Procedural and system knowledge. Procedural information explains the step-by-step instructions for accomplishing a task, and system information is about the inner workings of the product. Karreman and Steehouder (2004) studied the effects of system information when it is included with procedural information in instructional documents. The study measured the effects of system information on task performance, cognitive load, and self-efficacy, using a software simulation of licorice production. The participants were split into two groups, those with procedural instructions, and those with procedural and systems information. The study results "give partial support to the hypothesis that system information helps users to complete tasks where there is no procedural information available or when the procedural knowledge is insufficient" (Karreman & Steehouder, 2004, p. 40). Cognitive load measure showed no significant effects between procedural and system information; however, processing system information placed a burden on the cognitive load while the user practiced with the software in the production simulation. The results of the study revealed that adding system information to step-by-step instructions imposed an additional burden for the user.

Ummelen (1997) collected data about the selection and use of procedural information within software manuals to determine if the declarative information affected task performance. "Procedural information is defined as 'how-to-do-it' information: the actions a user has to perform to achieve his goals. Declarative information is 'how-it-works' information: background and explanations about tasks in general and about the system" (Ummelen, 1996, p. 475). She found that declarative information has a positive effect, as users "were able to build a more elaborate mental model" while working with the software (Ummelen, 1997, p. 289). The declarative information provided a solid foundation from which to work with the software and to move into solving complex problems. "They can infer procedures, whereas users who only received procedural information can only try to remember the procedures literally" (Ummelen, 1997, p. 289).

Cognitive load and document design. Carliner (2002) discussed the problem of overloaded readers in his article "Designing Better Documents." He contrasted the quantity of information to how much information is actually read and comprehended, and noted the problem of readers who ignore critical information on insurance forms, tax forms, and medical information. Carliner argued that such information must be simplified and made usable through his discussion of information design. Using examples, Carliner demonstrated the concepts of motivation and cognitive load (overloaded readers) using an institutional communication example about the purpose, membership, and responsibilities of a committee. The first example he provided proved difficult to read and was visually unappealing. The reader does not know what the document is about unless it is read from beginning to end. Therein lies the problem; there is no motivation upon the reader to read the boring institutional communication. This type of document does little to stimulate motivation and overloads the reader. The second example was an improved version of the document that illustrated how similar information can be conveyed with headings and bulleted content. The improved version is visually appealing, making it easier to read and understand. Carliner's exploration of motivation and cognitive load in the field of information design draws from the development of these concepts as learning theories.

Visual effectiveness and usable information are natural elements in document design. Content should center on the user, fully explain the action required by the user, and clearly identify how the user will interact with the object of the action (Coe, 1996). Content should afford access to meaningful information rather than confuse or frustrate the user, as content that does not yield effective use may require too much effort. The usefulness of content may be measured by the difference between what we want to accomplish and what we actually accomplish (Coe, 1996). The objective is to narrow the gulf of execution. An effective strategy to narrowing the gulf is through visual effectiveness. "Visual effectiveness is a measure of how the appearance of information and the user of visual elements within it affect the ease with which users can find, understand, and use the information" (Hargis et al., 2004, p. 277). A few of the primary guidelines for visual effectiveness are (Hargis et al., 2004, p. 278):

- use graphics that are meaningful and appropriate;
- use visual elements for emphasis;
- balance the number and placement of visual elements; and
- use visual cues to help users find what they need.

Visual cues are particularly important when documenting procedural steps. According to Barker (2003), there are various accepted formats for procedures: standard, prose, parallel, and embedded. The standard format is recognizable and familiar because steps are clearly identified using numbers or bulleted lists. The prose format puts the steps in paragraph form, which makes it difficult for users to find the information. The parallel format is best for forms and complicated dialog boxes. However, this format does not present the information in a step-by-step manner and may be confusing for users. The embedded format is used for interactive assistance.

Information salience is another important factor in document design in which cause and effect relationships are conveyed. Albers (2007) defined salience as the "prominence given to an information element. The most important information should have the highest salience" (p. 81). When the proper level of salience is provided, it is easier to support relationships, which makes it easier for the user to apply in the workplace. To avoid overloading readers, some of the factors that can impede reader comprehension are incorrect information, redundant information, excess information, irrelevant information, and ambiguous information. Additionally, salience depends on time as Albers (2007) observed,

> For best comprehension, information needs to be provided only when a person needs it. Presenting it too early or too late is a distraction and what could have been valuable information is simply reducing the signal to noise ratio by adding to the noise. (p. 83)

Major factors that aid in building information relationships include prominent cues, design and presentation, order, comfort level of topic, familiar terms, and emotional appeal (Albers, 2009).

Cognitive psychology and minimalism. Minimalism is a design approach that addresses user cognition and motivation toward the use of documentation (Van der Meij, 2008). It was born out of observing the difficulties experienced by users of software documentation (Carroll, 1998; Van der Meij, 2008). The time was the 1980s, with a growing user population of personal computers. The user population changed from computer specialists to secretaries and business professionals without adequate documentation to support the new type of user. At the forefront of the computer industry, IBM commissioned a task force to characterize the problems of new computer users in hopes of designing direction for user interfaces, training, and documentation (Carroll, 1998).

> We observed incredibly complex attributions, elaborately reasoned abductive inferences, and carefully performed, ritual behaviors. People were not so much being merely stumped by this learning task as being drawn into a nightmare in which things frequently made a little bit of sense but generally ended in disaster. This was unpleasant to watch and intriguing to ponder. But what could we do about it?
>
> Our interpretation of our subjects' struggles was that they were actually making rather systematic attempts to think and reason, to engage their prior knowledge and skill, to get something meaningful accomplished. They did not seem to be getting appropriate guidance and feedback from the systems and documentation they were using, even though they were being presented with a huge amount of information through these channels. For example, although they often tried to attempt real tasks, their training materials did not support this. Although they made a great variety and number of errors, their materials did not support error recognition, diagnosis, or recovery, and the systems did not provide general undo functions. (Carroll, 1998, pp. 2-3)

John Carroll was one of three team members on the IBM task force, and became the leading designer and spokesperson for minimalism.

The minimalist design promotes working on real tasks, learning by doing, error handling, and modular instructions. Minimalism directly contrasts with the pervasive systems approach to documentation, which emphasizes sequencing of steps, hierarchically detailed models, and structured methods (Carroll, 1998). A systems approach is a highly integrated set of components that are interdependent and synergistic, whereas, minimalism promotes an iterative design process using modular components. It is the iterative design that differentiates minimalism, as the objective of the process is to include content that is required to make the user successful, and nothing more. The design process must be carefully managed through usability specifications that indicate the objective for each topic or module. For example, a topic about creating a one-page memo using word processor software might indicate the objective as the user will be able to "type, edit, format, and print a one-page memo after two hours of instruction" (Carroll, 1998, p. 7). Carroll (1998) also disclosed that usability trade-offs were to be expected and should be part of the overall design process. The design rationale for these trade-offs have become the view of minimalism.

> 1. Working on a realistic task provides the learner with an appropriate framework for integrating and applying learning experiences, but realistic tasks may be too difficult, and there may be too many kinds of task settings to support.
>
> 2. Working on a familiar task orients and motivates learners by engaging prior knowledge, but it may encourage task-specific learning and engage inappropriate prior knowledge.
>
> 3. Incorporating planning and acting throughout the learning experience helps orient the learner to applying knowledge and supports skill transfer, but it increases task complexity.
>
> 4. Retrieval, elaboration, and inference making engage and sustain learner attention and make skills more robust and accessible, but learners might not have access to enough information to reason successfully and may be anxious about bearing such responsibilities.
>
> 5. Diagnosing and recovering from errors focuses and motivates learners and helps sharpen a concept of correct performance, but errors can be frustrating and disrupt task goals. (Carroll, 1998, pp. 11-12)

As Carroll (1998) indicated, there are usability trade-offs with a minimalist approach to technical communication. A minimalist approach may be more difficult to design and develop because the technical writer must understand the subject matter well enough to realize the right amount of information to include, not too little and not too much (Carroll, 1998). Additionally, the design "hinges on making just the right assumption about the prior knowledge and skills of the intended audience" (Carroll, 1998). This approach requires more analysis to design and develop less documentation.

Minimalist documentation is user-centered; it focuses on the user and pushes the writer to consider what the user needs and wants (Redish, 1998). It requires the writer to consider when do users reference a manual, what do users want in reference manuals, how much do users want to explore in reference manuals, and who is most likely to explore (Redish, 1998). The objective of minimalism is to engage the user early in the process, avoiding the problem of alienating the user in lengthy discourse. The principles of minimalism stress (1) an action-oriented approach, (2) use real-world examples, (3) support error recognition and recovery, and (4) support reading for action (Canzoneri & Van Tiem, 2005). The critical issue is to focus on the business tasks, as this allows the user to become more productive in less time and enables problem solving (Canzoneri & Van Tiem, 2005).

Context and a user-centered focus are major elements of minimalism. As computers have become more user-friendly over the decades, documentation must follow suit and afford learning and doing. Documentation must model the "natural cognitive processes of users who are seeking to fill knowledge gaps through the right information, presented at the right time, and in the right place to meet task goals" (Anson, 1998). The challenge for technical communicators is to focus on a learner-centered approach that aligns with actual user tasks, which will provide "efficient and effective learning" (p. 93). To accomplish this, writers must understand the principles for developing minimalist-based documentation. Carroll (as cited in Anson, 1998) identified nine principles that documentation must provide. Among the nine principles, a few of the significant principles include: afford a quick start to using the software, train users on real tasks, exploit prior knowledge, utilize a training design, provide opportunities to learn how the system works, and promote reasoning that increases comprehension, retention, and active involvement in the learning process (p. 95). These are tall orders for writers of every level of experience, as it requires understanding how to apply these principles.

Documentation must model the "natural cognitive processes of users who are seeking to fill knowledge gaps through the right information, presented at the right time, and in the right place to meet task goals" (Anson, 1998, p. 92). A learner-centered approach that aligns with actual user tasks provides "efficient and effective learning" (p. 93).

Constructivism

Much of the software documentation in use today adopts a task-oriented style that originates from the early 1980s with the rise of cognitive psychology (Mirel, 1998a). Previously, documentation was system-oriented, based on behaviorist views, where the user had to learn the inner workings of the system and perform "rote, mindless interactions" that "failed to help them develop transferable knowledge and skills" (Mirel, 1998a, p. 9). The change from behaviorist to cognitive principles engaged the user and influenced documentation designers to adopt a format that was oriented to users' tasks and goals within the workplace (Mirel, 1998a). The transition allowed the user to step out of the inner workings of the system, and to think about how to use the software to accomplish work. The behaviorist image of the "human-as-cogs" (p. 9) changed to a cognitive perspective that stressed "information interchange between external and internal realities" (Mirel, 1998a, p. 9). In other words, the change in perspective engaged the user to draw from prior knowledge, envision the new relationship in the form of mental models, assess the meaning of the new information, and turn the new knowledge into "decisions and actions for specific purposes and conditions" (Mirel, 1998a, p. 10).

Unit tasks and complex tasks. The cognitivist perspective provided more control, allowing the user to think about tasks and work (Mirel, 1998a). Cognitive theories, such as information processing, have had a strong influence on documentation design, specifically designs for user actions that instruct users to select information and act on knowledge (Mirel, 1998a). These user actions are defined as *unit tasks*, and are documented with little or no context or relevance to the user's specific environment. Unit tasks focus on rule-driven steps, such as how to generate a financial statement, an approach known as instruction by informing (objectivist in nature). In contrast, *complex tasks*, such as how to analyze financial statements each month to determine if projects are within budget, will vary from month to month (Mirel, 1998a). The variables in complex tasks are difficult to document, as they do not fit the model of the unit task. Mirel (1998a) reasoned that when work is documented as unit tasks this "assumes that the whole of a user's activity is equal to the sum of its parts" (p. 11). Specifically, this means activity that is not considered a unit task is ignored. Mirel's point is pivotal in the challenge of designing documentation for complex tasks, because complex work requires "choices and actions" (p. 11) and documenting complex tasks as unit tasks does not allow for contingencies. For complex work, in which the "choices and actions depend on situational circumstances and coordinated efforts—the whole is likely to be greater than the sum of its parts" (Mirel, 1998a, p. 11). Therefore, the design for complex tasks does not fit into that of the unit task; it would be analogous to pouring a gallon of water into an 8-ounce glass. There is no consideration for the overflow of complex information and relationships in this structure.

Task-oriented instructions provide an active role for the user because the user is engaged in following the instructions and interacting with the software (Mirel, 1998a). In contrast, system-oriented documentation is not necessarily instructional, as the intent is to convey concepts and information about the software. System-oriented documentation does not engage the user in activity, but generally communicates important background information and concepts about the software. As Mirel (1998a) pointed out, task-oriented instruction typically mirrors the software interface and does not necessarily relate or convey the relevance of the task in the user's workplace.

A constructivist approach can bridge the gap that exists in the conveyance of complex information, as complex tasks are best conveyed through problem-based instruction (Mirel, 1998a). Mirel (1998a) argued that task-orientated documentation does not address the needs of the user as it ignores complex tasks and situational problems encountered in the workplace. Mirel examined how constructivism can address the areas that task-oriented models ignore. She took four themes from constructivism and related them to developing documentation: (1) apply context to the activity, (2) address problems experienced in the workplace, (3) highlight user knowledge, and (4) use case studies to emphasize problem-based instruction. Mirel offered an alternative perspective on developing documentation as she addressed a user-centered focus through constructivism.

Activities in context. When tasks are analyzed as activities in context, the writer attaches a "wider lens" (Mirel, 1998a, p. 19) to consider how software functions translate to workplace activities. In this process, the writer shifts the object of instruction from system tasks to user activities. The writer must broaden his or her view to include social factors in the workplace, as these are "structural dependencies that are crucial to people's work practices and knowledge" (p. 19). To illustrate this point, a task labeled 'Refreshing the System' may not indicate any relevance to a user. It introduces more questions such as What, Why, and When. However, the label 'Monitoring the System' is more descriptive, and may provide a clue to a relevant activity in the workplace, as *monitoring* connotes watching over something, whereas *refreshing* connotes to revive or restore (Visual Thesaurus). *Monitoring* is much more descriptive and applicable than *refreshing*. The challenge then, for the writer, is to use terms and phrases that are meaningful to the workplace, and to avoid using software labels that may be unsuitable for the user's situation. This is what a constructivist approach can do for user comprehension; the design must address and represent the variables and the relationships to provide the user with a context that fits the dynamics of daily workplace practices (Mirel, 1998a).

Address problems experienced in the workplace. Context should shape the instruction around problems experienced in the workplace, as the constructivist view maintains, "no element in an activity system has an individual existence outside of its relation to other elements" (Mirel, 1998a, p. 23). Context is particularly critical in the design of documentation for complex systems (Albers, 2002). Technical communicators must go beyond the step-by-step instructions and analyze how to address users' open-ended questions (Albers, 2009). This requires an understanding of the software product in terms of the users' wants and needs, as complex systems have many integrated parts and functions. The writer must be able to describe the parts and functions, but also show how they are integrated. Problems that can result from poorly integrated information include difficulty in understanding cause and effect relationships, ignoring information that is not present, and distractions by irrelevant but more visible information (Albers, 2002). Context is a critical factor, as it affects how the user processes and manages new information (Mehlenbacher, 2008).

Highlight user knowledge. Knowledge and work must be classified by the writer so it may be managed within the instructional content (Mirel, 1998a). One method of classifying knowledge may be as tacit (intuitive), versus explicit (articulated) (Mirel, 1998a). Tacit knowledge is unspoken, taken for granted; it is implicit basic knowledge, such as knowing how to use a mouse. Explicit knowledge consists of “rules, facts, heuristic strategies, procedures, and concepts that operate at a conscious level during activity” (Mirel, 1998a, p. 28). Explicit knowledge is passed on to users through training and books. The technical writer must understand what explicit knowledge the user will be consciously working with in performing the task, and the writer must have some insight into the users’ base tacit knowledge upon which to draw in performing the complex task (Mirel, 1998a). All knowledge is context sensitive, further complicating the writer’s work. The objective is to get the user to build knowledge and co-create the meaning, as “each new piece of data the user uncovers affects the path taken and the eventual outcome” (Albers, 2003b, p. 266).

Cases. The writer must determine what to make interpretable through context, to enable construction of knowledge (Mirel, 1998a). This can be done through cases that evoke situated context. Problems can be represented through cases, not to be confused with thinly defined scenarios. Cases should represent a “core problem situation that speaks to users’ actual work experiences, narrated and presented in ways that allow users to view problem situations and potential actions from many perspectives” (Mirel, 1998a, p. 26). Cases are multiple-dimensional rich descriptions with contextual situations that guide the user through types of activity, such as activities involved in strategic planning or in managing a budget (Mirel, 1998a). The writer must “recast instruction” into a problem-solving experience using cases to answer questions such as, "What can you do with X in situation Y?" (Mirel, 1998a, p. 33). It may even be possible to teach experience through cases (Mirel, 1998a). Each component of the framework culminates within the case: the object of instruction must focus on activities that are meaningful to the user, the activities must be characterized in the context of the workplace, and cases should exploit the users' tacit and explicit knowledge (Mirel, 1998a).

Task-oriented instruction and problem-based instruction differ in their assumptions of learning and how information is organized (Mirel, 1998a). Task-oriented instruction adopts an instruction-by-informing approach by presenting information, much like the objectivist approach to instruction. Conversely, problem-based instruction promotes learning and utilizes situated learning with multiple perspectives; it uses a constructivist approach to learning. Information organization and contrasting assumptions about learning differentiate these two approaches. Instruction-by-informing users are homogenous, "isolated program operators" (Mirel, 1998a, p. 33) that perform work the same way each time. In contrast, users in problem-based instruction are heterogeneous, in "contexts of flux and negotiation" (Mirel, 1998a, p. 33). The underlying social consequence for instruction-by-informing is that "users work alone" (Mirel, 1998a, p. 34). There is no room for question because there are no uncertainties. Instruction-by-informing is rigid and dictates how the user is to think about their work. In contrast, problem-based instruction uses cases that "create layers of meaning to engage users in naming the right problem and treat actions as desirable or feasible, not just as correct technically or logically" (Mirel, 1998a, p. 34). Problem-based instruction supports the user (Mirel, 1998a).

Albers (2009) continued this discussion in his articles about information relationships. Information must help the reader understand relationships to address questions such as "How are X and Y effecting Z?" (Albers, 2009, p. 171). A good document should help the user form a mental picture of the information relationships. "Without the relationships, a person learns about X and Y, but not how X and Y relate to each other or to Z in terms of their current problem or situation" (p. 172). Effective cases depend on prior knowledge, and if that is lacking then it must be supplied as part of the information.

Writer's worldview. The distinction between promoting learning (problem-based instruction) and presenting information (instruction-by-informing) begins with the writer's worldview of technical communication: positivism and constructivism (Hughes, 2002). The positivist view is singular and rigid, in which the writer describes the product's functionality. In this approach, the reader is treated as a repository for learning, because learning is acquired. The positivist view is more product-centered, in which headings are labeled with product terminology as opposed to workplace terminology. In contrast, the constructivist interprets "product functionality in light of both the user contexts and the developer's intentions" (Hughes, 2002, p. 277). The constructivist view moves beyond describing functionality to interpreting functionality in the construction of learning. For example, defining the steps to create a table using Microsoft Word is a positivist view, whereas, a discussion about presenting information in a tabular format that explains why the format is useful, is a constructivist view (Hughes, 2002).

Principles of knowledge. Mayer (1999) applied the principles of knowledge construction for designing text-based instruction. He emphasized that learning is dependent on cognitive activity and learning transfer is highly dependent on the design of the instruction. Mayer applied a model of learning based on cognitive processes: selecting, organizing, and integrating. The text design must encourage readers to select the material. Selecting information is supported through highlighting the most important information using headings, italics, boldface, bullets, font size, icons, repetition, captions, white space, instructional objectives, summaries, and concise information. Organizing information is supported through the structure of the text using outlines, headings, signal words, and graphic representations. The structure of the text must be understandable to accommodate information to address comparison/contrast, classification, enumeration, generalization, and cause-effect. An example of an understandable structure is text that states "There are five major steps in performing the software installation: (1) . . . (2) . . . (3) . . ., and (4). . ." The subsequent paragraphs would elaborate on the details for each of the five major steps. Each step warrants a separate paragraph or heading, with the repeated step number, to help the reader recognize the structure of the text. Integrating the material includes use of advanced organizers, illustrations, animation, worked-out examples, and elaborative questions. The objective of integrating material is to activate prior knowledge and foster knowledge integration (Mayer, 1999).

Conclusion. In view of technical documentation as a form of instruction, writers must engage readers and facilitate learning through metacognitive strategies such as constructivism (Iverson, 2009). Iverson (2009) acknowledged, "We give our readers the opportunity to construct their own understanding by first activating their prior knowledge and then involving them in meaningful tasks that are both intellectually and emotionally engaging" (p. 22). To accomplish this, writers must "do more than impart facts and figures" (Iverson, 2009, p. 22). Writers must create environments that will involve and engage readers, to show that there is important information within the documentation (Iverson, 2009).

Mirel (1998a) concluded, that users reference documentation "with the hope of finding explanations that fit their circumstances and contextual goals but instead find the instructions are silent about these situational aspects of work" (p. 44). Mirel's (1998a) inquiry into the practical implications of constructivist theory for documentation is a seminal piece with significant contributions to the field of technical communication. Technical writers can fill the need for context by applying constructivist principles to the documentation of complex tasks.

Software Documentation as an Instrument of Learning

According to Spyridakis and Wenger (1992), "reading is one of the most heavily researched of all human cognitive behaviors" (para. 6) because reading involves "nearly all the processes that interest cognitive scientists: perception; recognition; encoding; storing, and retrieving information from memory; use of the rules of language; and complex forms of reasoning and problem-solving" (para. 6). It is logical to expect that the development of documentation would be based on theory, a theory that supports cognitive processing.

Learning and doing are the primary objectives of the users of software documentation, as readers of documentation "read to do" and "read to learn" (R. R. Johnson, 1998a; R. R. Johnson, 1998b; Redish, 1989, p. 289; Van der Meij, 2008). The goal of *reading to do* is to "extract information for immediate action" (Redish, 1989, p. 289) and the goal of *reading to learn* is to "absorb information for future recall" (p. 289).

Just as *reading to do* and *reading to learn* have different aims for the user, the technical writer must approach each goal differently. Developing content for *reading to do* typically involves writing procedures or definitions, requiring lower-level cognitive skills to address unit tasks. On the other hand, developing content for *reading to learn* may involve higher-order cognitive skills to address complex tasks (Mirel, 1998b).

Whether the technical writer is developing content for lower-level or higher-order cognitive skills, a design approach or technique is required to convey the content. Theory provides the writer with a foundation upon which to base a technique and approach to the design and development of content (Hubbard, 2006). Theory gives the approach its credibility and it is theory that enables the writer to design content that will serve the user (Hubbard, 2006).

Software documentation is a form of instruction where learning occurs (Lohr, 2000). In fact, according to Coe (1996), the responsibility of technical communicators is to help users learn; “users want to learn from what you write” (p. 33). The technical writer is the creator/developer of software documentation, and performs a function that is related to the role of an instructor or teacher. Additionally, the writer may also be considered an author, as this recognition extends the meaning of the creator/developer, to one that contributes to the “articulation and rearticulation of meaning” (Slack, 2003, p. 193; Slack, Miller, & Doak, 2003). The role of author places a responsibility on the writer, a responsibility that may go beyond that of a transmitter and translator of technical information. Technical communicators are more than scribes; they create meaning in complex contexts in which declarative knowledge is transformed into procedural knowledge (Hovde, 2010).

Software documentation has evolved over the past thirty years from voluminous boxes of documents into a "multimedia, multichannel support system for multiple audiences" (Van der Meij, Karreman, & Steehouder, 2009, p. 287). In a historic overview of research on software manuals, Van der Meij et al. guided the reader through the evolution of software manuals as three phases.

> The first phase, which we define roughly as spanning the years from 1980 to 1990, can be labeled as a transitional period in which the traditional expository approach, which gave us tutorials as textbooks, slowly gave way to an instructional approach, in which tutorials were produced as sets of procedural instructions. In the second period, from 1990 to 2000, research contributed much to refining and perfecting this instructional approach. In the last decade, from 2000 onward, research has become increasingly focused on supporting the user's experience, attending to that experience, and fostering motivation. (Van der Meij et al., 2009, pp. 265-266)

This evolution of software documentation design and development has "significantly raised the bar for the technical communicator" (Van der Meij et al., 2009, p. 287).

> A high level of expertise is needed to create products whose foundation is science based and that meet the customer's needs and expectations. This expertise is much broader than the traditional "canon" that technical communicators used to learn and be concerned about. The professional demands placed on the technical communicator have significantly deepened and broadened. (Van der Meij et al., 2009, p. 287)

These challenges require knowledge of cognitive psychology, human-computer interaction, information science, information design, and graphic design (Redish, 2002).

Content Analysis as a Tool to Evaluate Software Documentation

Research methodologies employ two types of reasoning in educational research: inductive reasoning and deductive reasoning (Lodico, Spaulding, & Voegtle, 2006). Inductive reasoning is determined through observations, as it is a process of discovery. Deductive reasoning seeks specific evidence to support or negate a claim. Inductive reasoning is considered a bottom-up approach and deductive reasoning is considered a top-down approach (Lodico et al., 2006). The two types of reasoning are generally associated with two methodologies in educational research; inductive reasoning is employed in qualitative approaches and deductive reasoning is employed in quantitative approaches (Lodico et al., 2006). Each methodology takes the researcher along a distinct path of discovery.

The qualitative methodology ascribes to the following characteristics: examine or generate theory, conduct the research in the setting to be studied, observe and interview, use descriptive statistics, and generate hypothetical propositions. The goal of qualitative research is to generate understanding and produce thick rich descriptions. A quantitative approach may indicate trends through a survey, on the other hand, a qualitative approach provides context about a trend, to reveal why or how something has changed (Simon & Francis, 2001).

The methodology employed for the study of learning and doing through software documentation is a qualitative methodology using a technique known as *content analysis*. Traditionally, content analysis has been used for quantitative studies; however, over the past few decades, content analysis has been adapted and employed in both quantitative and qualitative approaches (Huckin, 2004). A quantitative approach counts words or phrases without any analysis of the text. A qualitative approach examines the content for the presence of concepts, which requires the researcher to use his or her judgment to determine the applicability of the content (Huckin, 2004).

The history of content analysis dates back to the 17th century when the Church used the technique as a method for inquisitorial pursuits (Krippendorff, 1980; Thayer, Evans, McBride, Queen, & Spyridakis, 2007). During the Great Depression of the 1930s, content analysis emerged as a research method for newspaper analysis (Thayer et al., 2007). Dating back to the 1950s, content analysis established its roots in the study of mass communication, using the model of sender / message / receiver to make inferences on text content (White & Marsh, 2006; Titscher, Meyer, Wodak, & Vetter, 2000). Content analysis has a long history of use in communication, healthcare, journalism, sociology, psychology, and business (Neuendorf, 2002). The number of content analyses published in *Journalism & Mass Communication Quarterly* went from 6.3% in 1971 to 34.8% in 1995 (Neuendorf, 2002). In the healthcare industry, content analysis has a long history as a method of studying nursing records; its use has increased 70% with most papers published in the 21st century (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005).

Content analysis is an investigative study about "shaping" (Grbich, 2007, p. 109) and how events have shaped what is written and said. Content analysis studies conversations, stories, forms, notes, interviews, transcripts, diaries, and documents for the presence of certain influences (Grbich, 2007; Kohlbacher, 2006). The objective is to focus on the "characteristics of language communication with attention to the content or contextual meaning of the text" (Hsieh & Shannon, 2005, p. 1278). Hsieh and Shannon (2005) summarized three distinct approaches in the application of content analysis to include *conventional*, *directed*, and *summative*.

> In conventional content analysis, coding categories are derived directly from the text data. With a directed approach, analysis starts with a theory or relevant research findings as guidance for initial codes. A summative content analysis involves counting and comparisons, usually of keywords or content, followed by the interpretation of the underlying context. (Hsieh & Shannon, 2005, p. 1277)

This study of software documentation is a directed approach because the data are viewed through the lens of learning theory. Open questions will guide the research and influence the data, which will render a humanistic context (White & Marsh, 2006).

There are many variations of analyzing text to include content analysis, conversation analysis, critical analysis, discourse analysis, ethnographic analysis, functional pragmatics, interpretive analysis, narrative analysis, rhetorical analysis, and semiotic analysis. Each of these approaches varies depending on the questions asked and the design methods (Neuendorf, 2002; Titscher et al., 2000; White & Marsh, 2006). Content analysis has various definitions; however, White and Marsh (2006) offered a definition that suits this study.

> Content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (Krippendorff, 2004, p. 18). The notion of inference is especially important in content analysis. The researcher uses *analytical constructs*, or rules of inference, to move from the text to the answers to the research questions. The two domains, the texts and the context, are logically independent, and the researcher draws conclusions from one independent domain (the texts) to the other (the context). (White & Marsh, 2006, pp. 23-24)

The analytic constructs for this study were derived from existing theories and practices, based on principles of learning. Additionally, the other meaningful matter is the relationship between visual images and text.

Analytical constructs are the essence of a content analysis approach. Without an analytical construct, the method is an "empty concept to the extent that [its] characterizations give no guidance on how to proceed and what kind of results should be sought" (Titscher et al., 2000, p. 213). A qualitative content analysis method includes sampling, units of analysis, categories and coding, and analysis and evaluation. For qualitative content analysis, the sampling should be "theoretical and purposive" (White &

Marsh, 2006, p. 36). "The units of analysis are the basis for reporting analyses" (p. 29). In this study, the units of analysis are the matrices that list categories based on principles of learning. The analysis is iterative, as the researcher must constantly compare the categories and constructs that emerge from the data (White & Marsh, 2006).

Conclusions

Cognitive principles are important to the design and development of software documentation as their objective is to reduce the load on working memory and to provide the reader with a schema upon which to build new knowledge. These principles contribute toward user centric or usable documentation. Usability can be enhanced by considering the user context in design. Morgan (1995) declared, "Usability is really the *raison d'être* of our profession" (p. 303). Additionally, Weiss (1991) reasoned that documentation has its own usability, and if poorly designed it "restricts the usability of the computer system" (p. 25). Usable documentation can enhance reader comprehension and enable learning.

The literature review provided background information about the field of technical communication to include a brief history, the cross-disciplinary nature of technical communication, the active theories that are promoted by researchers, and the application of the principles of cognitive load and constructivism to software documentation. While the literature included studies of applying cognitive and constructivist principles to technical communication, these studies do not indicate the prevalence of these principles nor do they indicate broad awareness on behalf of the technical communicator.

CHAPTER 3. METHODOLOGY

Introduction

The scope of the methodology chapter encompasses the research design that was used for the study. This chapter includes the theoretical framework, the research design strategy, sample, method of data collection, data analysis, limitations of the methodology, and the potential and anticipated results.

Philosophical Underpinning

The decision to adopt a quantitative, qualitative, or mixed methods approach requires a careful analysis of three factors: match the approach to the research problem, fit the approach to the audience, and relate the approach to experiences (Creswell, 2008). Quantitative research is best suited for analyzing trends, providing explanations for relationships, and predicting tendencies. Qualitative research is best suited for exploring a problem for deep understanding. The study is more meaningful to the researcher when the approach relates to the researcher's personal skills, training, experiences, and philosophical perspective (Creswell, 2008).

Both quantitative and qualitative methodologies possess philosophical foundations of positivist, interpretative/constructivist, critical, and postmodern (Creswell, 2009; Merriam, 2009). Each perspective has a distinct purpose, a unique design, and outlook of reality (Merriam, 2009). Quantitative research falls primarily into the positivist view, while qualitative research falls into the interpretative/constructivist, critical, and postmodern perspectives (Merriam, 2009). These views are important, as the researcher must understand how each perspective influences the research methodology and design. A qualitative study can bring forth many truths, which may be reflected in a constructivist philosophical underpinning that meaning is constructed through experiences (Gay, Mills, & Airasian, 2006). The underlying philosophical perspective of this dissertation is interpretative/constructivist. Interpretive/constructivists hold that meaning is constructed through experiences and is an interpretation of the individual (Creswell, 2009).

This study is very meaningful to the researcher as it relates to the researcher's personal skills, training, experiences, and philosophical perspective. The researcher has a background in software programming, training, instructional design, and technical writing. Experiences from each of these fields have contributed to the researcher's view of technical writing through a creative lens that incorporates learning theory in the design and development of software documentation. The purpose of this study was to discover the extent to which characteristics of cognitive and constructivist principles of learning have been applied toward designing and developing software documentation.

Chosen Methodology

The chosen methodology for this study is a qualitative content analysis. A content analysis can provide evidence about how theory is applied in the design and development of software documentation (Grbich, 2007). This approach is interpretive, based on the researcher's analysis of how the documentation affords learning and doing. It examined many aspects of writing, such as style, tone, formality, organization, logic, flow, transition, and subject matter knowledge. The analysis considers the human experience; therefore, it may disclose multiple issues about the style, structure, and overall benefit to the reader. Analysis of the documentation indicates how learning theory has shaped the material and how well it affords learning to the reader. Therefore, the analysis is a theory directed approach (Grbich, 2007), where the data are viewed through the lens of principles of learning. The design embodies the features of interpretative content analysis and qualitative comparative analysis.

Content analysis is the most suitable research design because it is an analytic study of written documents that seeks to determine the presence of influences that have shaped the content (Labuschagne, 2003). In this study, the researcher sought to determine how characteristics of cognitive load and constructivism have shaped the design and development of the selected documentation. The reliability of the design focused on identifying and documenting recurrent characteristics in terms of tasks, procedures, headings, and visuals (Labuschagne, 2003). The quality of the study is reflected in how well the research design is documented and supported through the literature. The investigator is central to the study, drawing on her understanding and experiences of learning theory and its application. The methodology is reflexive, oriented toward "constant discovery and constant comparison of relevant situations, settings, styles, images, meanings, and nuances" (Altheide, 1996, p. 16). In this study, the researcher sought to determine how cognitive and constructivist characteristics may have shaped the design and development of the selected guides. The study reflects the researcher's interpretation of theory and its application, through interpretative analysis (Potter, 1996). The analysis is based on the evidence of characteristics and the degree to which the researcher is objective. Objectivity is based on the researcher's epistemological view of the world, and the extent of meaning making. In this study, the researcher applied her understanding of cognitive and constructivist principles, her experience as a technical writer of software documentation, her interpretation as to the existence of artifacts demonstrating the application of specific principles of learning, and of how meaningful and effective the analyzed content is for the targeted user. The nature of the evidence includes subjective valuation (Potter, 1996).

Abductive Reasoning

Research methodologies typically employ two types of reasoning in educational research: inductive reasoning and deductive reasoning (Lodico, et al., 2006). Inductive reasoning is determined through observations, as it is a process of discovery. Deductive reasoning seeks specific evidence to support or negate a claim. Inductive reasoning is considered a bottom-up approach and deductive reasoning is considered a top-down approach (Lodico, et al., 2006). The two types of reasoning are generally associated with two methodologies in educational research; inductive reasoning is frequently employed in qualitative approaches and deductive reasoning is typically employed in quantitative approaches (Lodico, et al., 2006).

This study employs a qualitative methodology; however, it does not adopt inductive or deductive reasoning, as inductive and deductive reasoning are not central to content analysis. Content analysis is inferential in nature; it employs abductive reasoning because it "proceed[s] across logically distinct domains, from particulars of one kind to particulars of another kind" (Krippendorff, 2004, p. 36). Inferences are extracted from the text based on the analytical construct. For example, political affiliations of citizens may be inferred from the TV shows they watch, or the religious affiliations of political leaders may be inferred from the metaphors used in their speeches (p. 37). In these examples, the constructs are not necessarily natural pairs; however, it is logical to connect them. In this study, the presence or absence of certain characteristics were analyzed to infer if principles of cognitive load and constructivism were utilized in the design and development of software documentation.

Theoretical Framework

This study answers the following questions in the context of cognitivism and constructivism:

1. What characteristics of cognitive load and constructivism will be identified in the analysis of selected documents?
2. How prevalent are the characteristics of cognitive load and constructivism in the selected documents?

Research Design Strategy

The design strategy for this study is a qualitative analysis of software documentation. This study analyzes software documentation for evidence of how the characteristics of cognitive load and constructivism have been applied in the structure, format, design, and content. The characteristics, as they pertain to cognitive load theory and constructivism, have been extracted from the literature review in chapter 2 and listed in Table 3. The characteristics have been grouped into the following categories:

- Framework of the Document;
- Organization of Procedural Information;
- Visuals;

- Instructional Format; and
- Examples that Reflect User Experiences.

Each characteristic is identified as attributable to cognitive load and/or constructivism, as a function of working memory and/or schema. These characteristics serve as a heuristic in the data analysis phase of the study, as the analytical construct for the study. The characteristics were derived primarily from the literature of the authors listed in Table 2 from chapter 2.

Table 3. Characteristic Relationship to Cognitive Load and Constructivism

	Cognitive Load		Constructivism
Characteristics	Working Memory	Schema	Schema
Framework of Document			
Headings are consistent		✓	✓
Document structure is consistent		✓	✓
Table of Contents displays a logical outline		✓	✓
Organization of Procedural Information			
Headings are meaningful in context of the workplace		✓	✓
Headings are task-oriented	✓	✓	✓
Introductory paragraph before procedural steps	✓	✓	
Paragraphs structured with known material first		✓	✓
Procedural steps are clearly identified through formatting		✓	✓
Information organized into structurally similar lists	✓		
Information organized into tables	✓		
Descriptions accompany tables		✓	✓
Appropriate use of bold, italics, font size		✓	✓
Ample white space		✓	✓
Visuals			
Use of diagrams		✓	✓
Use of screen captures		✓	✓
Screen captures are sized and placed appropriately		✓	✓
Screen captures show screen states and elements	✓	✓	✓
Visuals match content	✓	✓	✓
Captions accompany visuals	✓	✓	✓
Diagrams have explanatory text	✓	✓	✓
Diagrams present system topology	✓	✓	✓

Table 3. Characteristic Relationship to Cognitive Load and Constructivism (continued)

Characteristics	Cognitive Load		Constructivism
	Working Memory	Schema	Schema
Diagrams present component relationship	✓	✓	✓
Instructional Format			
Conceptual information introduces topic		✓	✓
Low level of element interactivity	✓		
Terminology is defined	✓	✓	✓
Content is chunked into manageable topics	✓		
Examples Reflect User Experiences			
Provides realistic scenario to illustrate real world use		✓	✓
Uses real world examples		✓	✓

Framework of Document

The characteristics for the Framework of Document category apply to schema. Consistent headings in a document provide signposts, and act as a guide for the reader. For example, headings such as Recommendations, Summary, and Benefits when used consistently, help the reader to locate specific material. Document structure is a similar characteristic, as it helps the reader locate specific material and provides a reasonable expectation for navigating the document. The table of contents is an important tool for the reader and it should display multiple levels of sub-headings in a consistent manner.

Organization of Procedural Information

For sections that provide procedural information, the headings should be meaningful and task-oriented versus mimicking the software interface. Introductory information should precede the actual steps, to prepare the user for what will happen and why it is important. Procedural steps should be labeled as such to signal the user that the content is procedural. Each step should be clear and the sequence of steps must be explicit. Known information should precede new information, to provide a foundation for the material. As appropriate, information should be organized into tables or lists to document definitions and terms. Format and style should use ample white space, bold, and italics as appropriate.

Visuals

Visuals can serve working memory and add value by helping users understand schemas. As appropriate, diagrams should accompany content that discusses relationships amongst entities. System topologies and component relationships should be presented in diagrams when material discusses these relationships. Explanatory text should be present in diagrams and should relate to the content. Interaction with the interface should present screen captures to orient the user. Screen capture placement, size, and highlighted states are important characteristics to enable working memory and schema. Descriptions and captions should accompany all visuals, as they reinforce the presence of visuals and direct the reader's attention.

Instructional Format

Conceptual information contributes to schema building for the user. Conceptual information may be provided in an introductory chapter or within sub-headings prior to the actual procedures. Chunking content into manageable topics is an effective approach to reducing cognitive load. Information should be grouped into manageable topics that are meaningful and directly related to the task.

Examples Reflect User Experiences

The material should contain examples that reflect real world application. For example, content that discusses defining users and groups within a security system should use names and labels that are meaningful. Group names of GROUP1, GROUP2, and GROUP3 do little to help the user build a schema, as they are too abstract. Content should reflect real world examples that help users relate to their immediate tasks.

Sampling Design

The sample for the study was purposely selected based on the researcher's background as an information security specialist for enterprise server operating systems. The sample was taken from software companies that publish large volumes of documentation for their respective products. The targeted companies included EKC, IBM, and Ventyx. The documentation guides published by these companies are written for various user levels, multiple operating environments, and many business applications. The study was limited to six guides that address a specific user group: information security administrators for large enterprise-wide systems.

The guides were selected for their application of information security. As a previous information security subject matter expert, the researcher was able to comprehend the selected subject matter; therefore, the likelihood of relevance afforded a uniform study. Other topics were considered for analysis; however, the researcher preferred to analyze like subjects to maintain a level field of analysis. Furthermore, analysis of a familiar subject can avoid the risk of failing to observe evidence of the characteristics of cognitive load and constructivism.

The guides that were used in this study are listed in Table 4. The general focus of each guide is one of the following:

- administration of information security software for large enterprise systems;
- migration from one information security product to another; and
- administration of information security for a business application.

Five of the guides address information security administration for the enterprise and one guide applies to a specific business application named *Asset Suite*. Analysis of the business guide was limited to chapter 9, as it applies to information security.

Table 4. Guides Selected for Analysis

Title of Guide	Software Vendor
ETF/A Security Administrator's Guide	EKC
E-SRF Event System User Guide	EKC
z/OS Security Server RACF Security Administrator's Guide	IBM
CA-ACF2 to OS/390 Security Server Migration Guide	IBM
Tivoli Identity Manager	IBM
Asset Suite System Administration Guide	Ventyx

Twelve chapters were analyzed from six guides. The specific chapters targeted for each guide are listed in Table 5.

Table 5. Chapters Selected for Analysis

Title of Guide	Chapter Number and Title	
ETF/A Security Administrator's Guide	2	Rule Test Facility
	6	Rule Aging Facility
E-SRF Event System User Guide	6	How Reports are Produced
	11	Event System Reporting
z/OS Security Server RACF Security Administrator's Guide	1	Introduction
	3	Defining Groups and Users

Table 5. Chapters Selected for Analysis (continued)

Title of Guide	Chapter Number and Title	
	6	Protecting Data Sets on DASD and Tape
	7	Protecting General Resources
	11	Operating Considerations
CA-ACF2 to OS/390 Security Server Migration Guide	6	Database Migration
Tivoli Identity Manager	1	Administering
Asset Suite System Administration Guide	9	Asset Suite Security Administration

Chapters were divided into sections, breaking the material into manageable units of content for analysis. Thirty sections were analyzed from six guides. Each section of content was analyzed according to the characteristics identified in Table 3. Sections that contain procedural information were fully analyzed. Sections that contain conceptual information were analyzed if the content pertained to any of the procedural sections. Procedural topics were the primary target of the analysis. However, when conceptual information that pertained to the analyzed topic was located elsewhere in the guide, then that information was included in the study. Only one characteristic applies to conceptual information in the Instructional Format category. The chapter sections that were analyzed are listed in Table 6.

Table 6. Chapter Sections Selected for Analysis

Title of Guide	Chapter and Number of Sections	
ETF/A Security Administrator's Guide	2	2 sections
	6	2 sections
E-SRF Event System User Guide	6	2 sections
	11	2 sections
z/OS Security Server RACF Security Administrator's Guide	1	1 sections
	3	2 sections

Table 6. Chapter Sections Selected for Analysis (continued)

Title of Guide	Chapter and Number of Sections	
	6	1 section
	7	3 sections
	11	1 section
CA-ACF2 to OS/390 Security Server Migration Guide	6	4 sections
Tivoli Identity Manager	1	6 sections
Asset Suite System Administration Guide	9	4 sections

Data Collection

The characteristics of learning, which apply to cognitive load and constructivism, were grouped into five categories: Framework of Document, Organization of Procedural Information, Visuals, Instructional Format, and Examples. Each category is listed in a matrix as shown in Table 7 and Table 8. The matrix for the Framework of Document is listed in Table 7. The matrix for the four categories of section analysis is listed in Table 8. Together, these matrices served as the instrument for evaluating the extent to which the characteristics were applied in the design and development of the documentation.

Table 7. Matrix for Framework of Document

Framework of Document	Quality Rating			
Characteristics	-1	0	1	2
1. Headings are consistent				
2. Document structure is consistent				
3. Table of contents displays a logical outline				
SUB TOTAL				

Note: -1 = Not met 0 = Not applicable 1 = Partially met 2 = Largely met

As an instrument for evaluating the content, the matrices contain a quality rating associated with a characteristic. The quality rating ranges from -1 to 2, with -1 to indicate *not met*, 0 to indicate *not applicable*, 1 to indicate *partially met*, and 2 to indicate *largely met*. The rating indicates how the characteristic was applied in the documentation. *Not met* indicates no presence of the characteristic, *partially met* indicates a partial application, and *largely met* indicates the characteristic is present and complete. *Not applicable* indicates that the characteristic was not used as it depended on the presence of other characteristics.

For each section of content that was analyzed per chapter, four of the categories were applied and rated: Organization of Procedural Information, Visuals, Instructional Format, and Examples. The category named Framework of Document was applied once per guide, as it requires an evaluation of the entire guide versus a section within a chapter. The data for the five categories was collected in an Excel spreadsheet. There are 30 spreadsheets for the 30 sections. The data for Framework of Document was maintained in a separate spreadsheet as it applies to the entire guide. There are six spreadsheets for this category, to match the number of guides.

Table 8. Matrix for Section Analysis

A. Organization of Procedural Information	Quality Rating			
Characteristics	-1	0	1	2
1. Headings are meaningful in context of the workplace				
2. Headings are task-oriented				
3. Introductory paragraph before procedural steps				
4. Paragraphs structured with known material first				
5. Procedural steps are clearly identified through formatting				
6. Information organized into structurally similar lists				

Table 8. Matrix for Section Analysis (continued)

A. Organization of Procedural Information	Quality Rating			
Characteristics	-1	0	1	2
7. Information organized into tables				
8. Descriptions accompany tables				
9. Appropriate use of bold, italics, font size				
10. Ample white space				
SUB TOTAL				
B. Visuals	Quality Rating			
Characteristics	-1	0	1	2
1. Use of diagrams				
2. Use of screen captures				
3. Screen captures sized and placed appropriately				
4. Screen captures show screen states and elements				
5. Visuals match content				
6. Captions accompany visuals				
7. Diagrams have explanatory text				
8. Diagrams present system topology				
9. Diagrams present component relationship				
SUB TOTAL				
C. Instructional Format	Quality Rating			
Characteristics	-1	0	1	2
1. Conceptual information introduces topic				
2. Low level of element interactivity				
3. Terminology is defined				
4. Content is chunked into manageable topics				
SUB TOTAL				
D. Examples Reflect User Experiences	Quality Rating			
Characteristics	-1	0	1	2
1. Provides realistic scenario to illustrate real world use				
2. Uses real world examples				
SUB TOTAL				

Note: -1 = Not met 0 = Not applicable 1 = Partially met 2 = Largely met

Data Analysis

Five Step Process

The researcher followed a five-step procedure to analyze the content: (1) read the topic, (2) describe and summarize the topic, (3) re-read the topic and make notes, (4) analyze the topic, and (5) formulate the interpretation and record the results in a matrix (Figure 1). The data analysis strategy involved reading selected chapters and sections from the guides. In the initial phase, the content was read for comprehension of the subject matter. Content that stands out was identified through notes in the margin and in a comment section of the matrix. The notes indicate what is and is not easily understood about the topic. The next phase identified the absence or presence of the characteristics within each category. Further analysis identified specific characteristics of each category, indicating the quality rating in the matrix. In this phase of the study, it is important to analyze what is present and absent (Rapley, 2007). For example, if a discussion of widgets does not include evidence of why widgets are important, this may indicate that the characteristic for conceptual information is not met. If visuals are absent and would have been helpful to the reader, this may indicate that the characteristic is not met. The researcher recorded the quality ratings and documented her observations related to the characteristics.

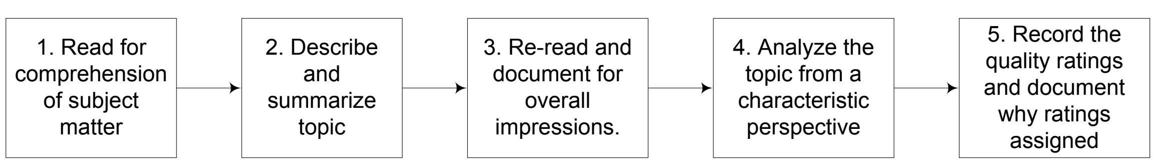

Figure 1. Data analysis steps

Analysis of Quality Ratings

Once the analysis was complete, the quality ratings were reviewed and reported. Quality ratings were reported for each category and each characteristic. The analyzed content was rated for how well the characteristics have been applied for each category. Each characteristic within each category has a possible quality rating of -1 to 2. Ratings for each characteristic were totaled to show a summarized rating for each category. For example, the highest rating for the category Organization of Procedural Information is 20, and the lowest rating is -10. A summary graph is presented for each category and individual graphs are presented for each characteristic. A spreadsheet is included to show all sections and the rating assigned for each characteristic, per category. The data is presented as a graph, similar to the example in Figure 2. The published data and graphs do not reflect the vendor name, chapter, or section title.

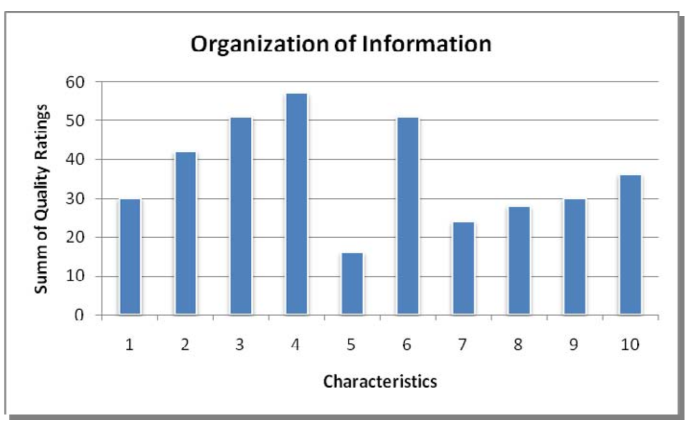

Figure 2. Sample graph for depicting ratings

Researcher Notes

The researcher's notes are documented for each analyzed section and category and recorded in the matrix as shown in Table 9. These notes are the core of the thick, rich description to follow in chapter 4 of this study. The spreadsheets were carefully documented, to inform the reader of how the content was analyzed and why it received a particular rating.

Table 9. Researcher Notes

Examples Reflect User Experiences Characteristics	Quality Rating -1	0	1	2	Researcher Notes
1. Provides realistic scenario to illustrate real world use					
2. Uses real world examples					
TOTAL					

Note: -1 = Not met 0 = Not applicable 1 = Partially met 2 = Largely met

Validity

Validity of each finding is documented in a rich, thick description of the section ratings (Creswell, 2009). Within the description, the researcher's bias is clarified to highlight how her background, education, and experience have shaped the study. The researcher spent a prolonged amount of time analyzing the documentation to convey the appropriate level of detail in the analysis.

As a rule, qualitative research is not generalized because it is an exploratory process, particular to a specific context (Creswell, 2009). However, if the research methodology is well documented it may be appropriate to position the study as repeatable. It is feasible to expect that this study of software documentation may be replicated using the matrix of categories and ratings.

Limitations of Methodology

The limitations of the methodology include the limited sampling, validity of the instrument, and personal bias.

The sample is limited to three software vendors and six guides. Across the six guides, thirty units of content have been identified for the study. The research results cannot be generalized to all enterprise-wide software documentation; but it can certainly suggest the inclinations of how cognitive and constructivist characteristics may be applied. The results could suggest what other large companies may have accomplished with their documentation.

The validity of the instrument developed for this study is another limitation. The researcher developed the instrument through the analysis of the literature. It is based on characteristics of cognitive load and constructivism that enhance working memory and schema building to facilitate instructional text. The instrument has not been tested or authenticated.

Finally, personal bias may play a role in the study. The researcher is an experienced technical writer and applies the principles of learning theory in her work of designing and developing software documentation. The researcher has also held positions as an information security administrator for enterprise-wide operating systems. Her knowledge and experience as an information security professional is expected to add value to the study; however, her knowledge of the subject matter may inadvertently cause her to overlook areas of content that are missing definitions that would benefit a novice. To minimize the possibility of bias, the researcher maintained a heightened self-awareness of the needs of a novice reader.

Potential and Anticipated Results

The purpose and benefit of the research was to determine the extent to which the characteristics of cognitive load and constructivism are applied by technical communicators in designing and developing software documentation. The research shows how writers adhere to specific characteristics of cognitive load and constructivism in their published documentation. The study may imply that practitioners publish documentation with a minimum to an exemplary use of these characteristics. The results could suggest that software companies should reevaluate employee screening and develop training for technical communicators. The study could also highlight the need for the technical communication profession to expand certification and standards requirements or guidelines to consider applicable tenets of learning theory.

CHAPTER 4. DATA ANALYSIS AND RESULTS

Introduction

The results of this study are presented in response to the research questions and the data analysis of the selected documents. The findings are accompanied by graphs that illustrate the variations of ratings, the results of each category, the significant characteristics of the categories, the significance of the characteristics that are limited to working memory and those that are limited to building mental models or schema. This chapter concludes with an overall summary of the findings.

The research questions and data analysis are discussed from the perspective of the characteristics of working memory and schema that relate to technical communication, and specifically to software documentation. These characteristics were introduced in the literature review from chapter 2 and then compiled into a table in chapter 3. The characteristics and their relationship to cognitive load and constructivism have been repeated in this chapter for ease of reference and are listed in Table 10.

Table 10. Categories and Characteristics

	Cognitive Load		Constructivism
Characteristics	Working Memory	Schema	Schema
Framework of Document			
Headings are consistent		✓	✓
Document structure is consistent		✓	✓
Table of Contents displays a logical outline		✓	✓

Table 10. Categories and Characteristics (continued)

Characteristics	Cognitive Load Working Memory	Cognitive Load Schema	Constructivism Schema
Organization of Procedural Information			
Headings are meaningful in context of the workplace		✓	✓
Headings are task-oriented	✓	✓	✓
Introductory paragraph before procedural steps	✓	✓	
Paragraphs structured with known material first		✓	✓
Procedural steps are clearly identified through formatting		✓	✓
Information organized into structurally similar lists	✓		
Information organized into tables	✓		
Descriptions accompany tables		✓	✓
Appropriate use of bold, italics, font, size		✓	✓
Ample white space		✓	✓
Visuals			
Use of diagrams		✓	✓
Use of screen captures		✓	✓
Screen captures are sized and placed appropriately		✓	✓
Screen captures show screen states and elements	✓	✓	✓
Visuals match content	✓	✓	✓
Captions accompany visuals	✓	✓	✓
Diagrams have explanatory text	✓	✓	✓
Diagrams present system topology	✓	✓	✓
Diagrams present component relationship	✓	✓	✓
Instructional Format			
Conceptual information introduces topic		✓	✓
Low level of element interactivity	✓		
Terminology is defined	✓	✓	✓
Content is chunked into manageable topics	✓		
Examples Reflect User Experiences			
Provides realistic scenario to illustrate real world use		✓	✓
Uses real world examples		✓	✓

For brevity and convenience, the characteristic categories, as listed in Table 10, are referred to as Framework, Organization, Visuals, Format, and Examples throughout this chapter. The analyzed content comprises 30 sections or units of material from six guides. Additionally, the rating levels for the characteristics are *not met*, *partially met*, and *largely met*. During the data collection, these levels were assigned a rating of -1, 1, and 2, respectively. The ratings and rating levels are referenced throughout this chapter.

Dependencies between Characteristics

Some of the characteristics in the Organization category and most of the characteristics in the Visuals category have dependencies. For example, if no tables were utilized then descriptions about the tables are not applicable. The same applies to visuals. If no diagrams or screen captures were utilized, the characteristics that relate to diagrams and screen captures did not apply. Yet, if screen captures were utilized and the dependent characteristics were absent, the -1 rating was applied to those dependent characteristics. The dependent characteristics are listed in Table 11. It is important to understand that all *not applicable* ratings were removed from the rating distribution, as consideration was only given when the characteristic was applicable.

Table 11. Dependencies between Characteristics

Category	Primary Characteristic	Dependent Characteristic
Organization of Procedural Information	Information organized into tables	Descriptions accompany tables
Visuals	Use of diagrams	Diagrams have explanatory text
		Diagrams present system topology
		Diagrams present component relationship
		Visuals match content
		Captions accompany visuals
	Use of screen captures	Screen captures are sized and placed appropriately
		Screen captures show screen states and elements
		Visuals match content
		Captions accompany visuals

Results – Research Question 1

What characteristics of cognitive load and constructivism will be identified in the analysis of the selected documents?

The purpose of Research Question 1 was to determine if the characteristics that relate to cognitive load and constructivism (Table 10) would be identified in the selected documents. All characteristics were identified across the selected documents. However, no single section contained evidence of all characteristics. The highest percentage of characteristics that were not present in a single section is 42%. The lowest percentage of characteristics that were not present in a single section is 4%.

Not present indicates a rating of -1, as *not met*. The percentage of characteristics that were not present for each section is listed in Table 12. The data (Table 12) represents the quality rating -1, *not met,* and includes four of the five categories. The Framework category is not included, as it was not rated for each section; the Framework category was rated for each guide.

The lowest percentage of characteristics that were not present was observed in sections 17, 25, and 26. These sections represent the highest occurrence of characteristics of cognitive load and constructivism, as only 4% of the characteristics were not present. Additionally, in section 26 only 5% of the characteristics were not present.

The highest percentage of characteristics that were not present is represented in section 4, with 42% of the cognitive load and constructivist characteristics rated as *not met*. Sections 5 and 6 have the second highest percentage of characteristics that were not met, with 39%. The percent and number of characteristics that were not present for each section are listed in Table 12.

Table 12. Percentage of Characteristics Not Present for Each Section

Section Number	Percentage of Characteristics that Were Not Present	Number of Characteristics that Were Not Present
Section 1	35%	7
Section 2	29%	5
Section 3	29%	6
Section 4	42%	8
Section 5	39%	7
Section 6	39%	7
Section 7	38%	8
Section 8	38%	8
Section 9	18%	4
Section 10	28%	5
Section 11	14%	3
Section 12	24%	5
Section 13	14%	3
Section 14	25%	5
Section 15	18%	4
Section 16	10%	2
Section 17	4%	1
Section 18	9%	2
Section 19	18%	4
Section 20	35%	6
Section 21	25%	4
Section 22	25%	4
Section 23	28%	5
Section 24	15%	3
Section 25	4%	1
Section 26	5%	1
Section 27	23%	5
Section 28	23%	5
Section 29	23%	5
Section 30	17%	4

The number of characteristics that rated as -1, *not met*, for each section, is shown in Figure 3. For example, sections 17, 25, and 26 had only one characteristic that rated as *not met* and sections 4, 7, and 8 had eight characteristics that rated as *not met*.

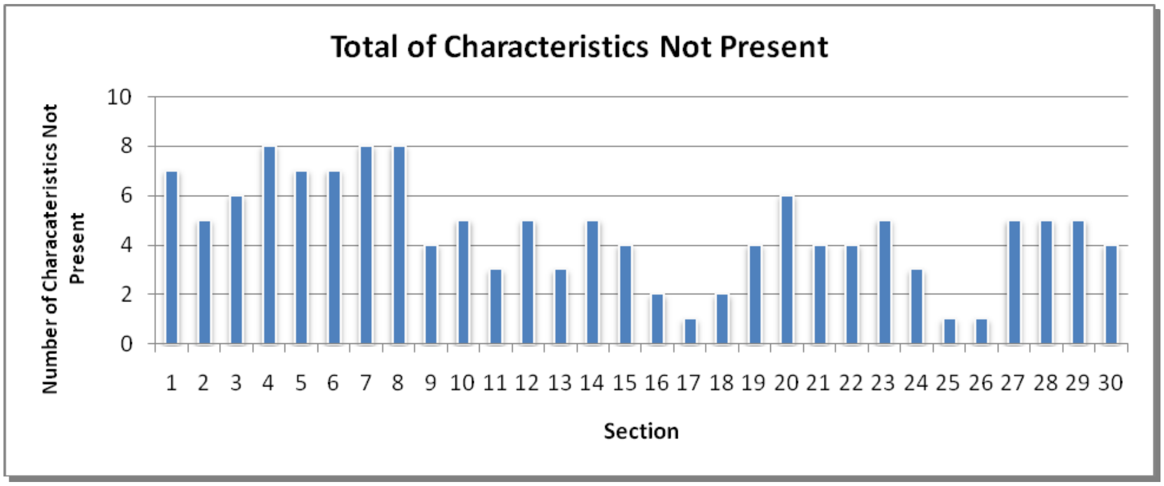

Figure 3. Total number of characteristics not present for each section

For all sections, the number and percentage of characteristics that were not present are also listed in Table 13. Note that 10% of the examined sections rated with only 1 characteristic that was not present and 26% of the examined sections rated with 5 characteristics that were not present.

Table 13. Percentage of Characteristics Not Present Across All Sections

Number of Characteristics Not Present	**Percentage of Examined Sections**
1	10%
2	6%
3	10%
4	21%
5	26%
6	6%
7	10%
8	10%

A macroscopic view of characteristics that were not present is illustrated in Figure 4. The highest percentage of characteristics not met accounts for 26% of the examined sections with 5 characteristics not present. The lowest percentage of characteristics not met accounts for 10% of the examined sections with 1 characteristic not present.

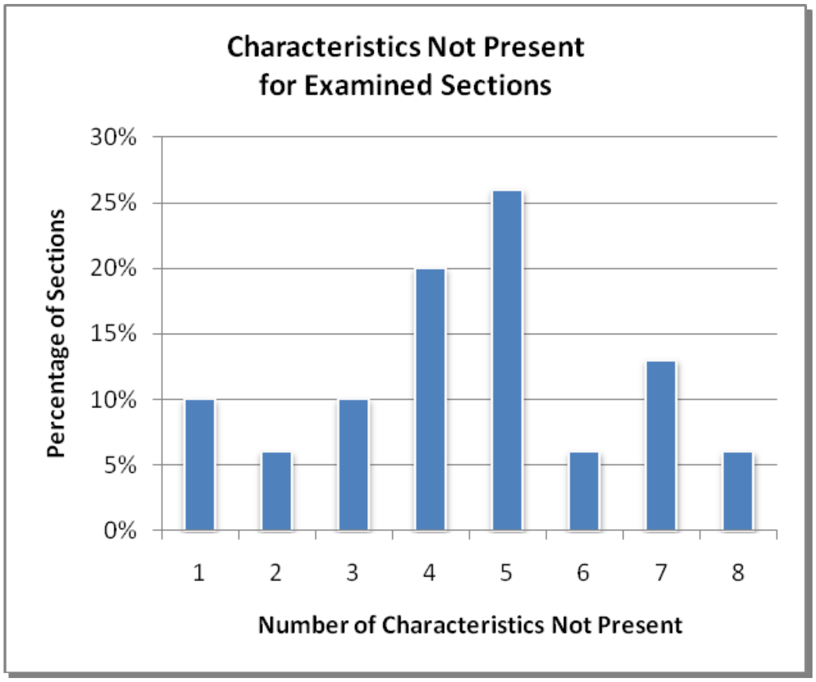

Figure 4. Percentage of sections with not present characteristics

Another view of how the characteristics rated across all sections is displayed in Figure 5, which shows the relationship between the sections and guides. The dark cells represent *largely met*, the gray cells represent *partially met*, the dotted cells represent *not applicable*, and the white cells represent *not met*. The dark cells are more prominent in guides 3, 4, and 5 and are more prevalent in the first and third categories, Organization and Format, respectively. The categories are denoted with a double line across the table.

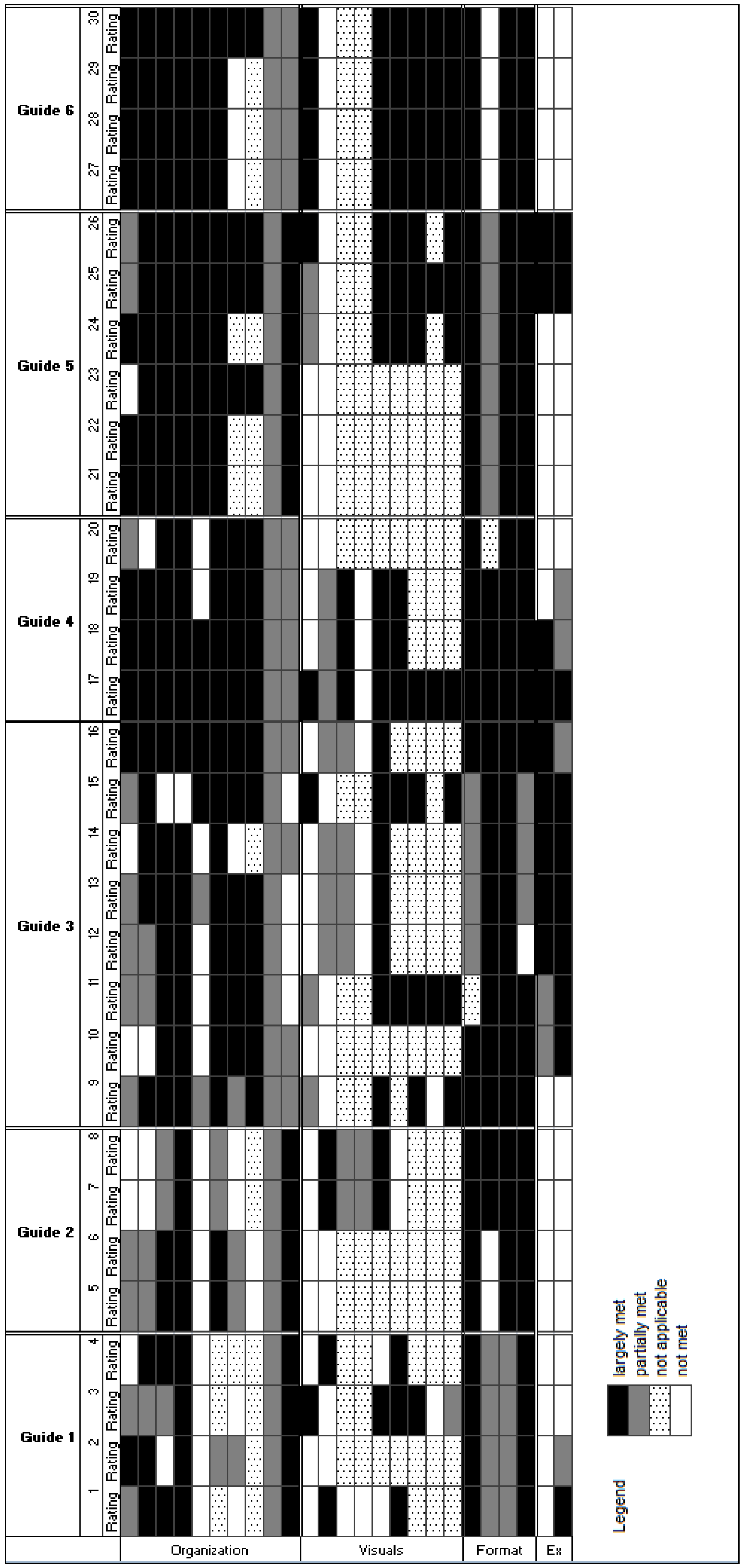

Figure 5. Relationship of characteristic ratings for all sections

A comparison of the characteristics that are present and not present is illustrated in Figure 6.

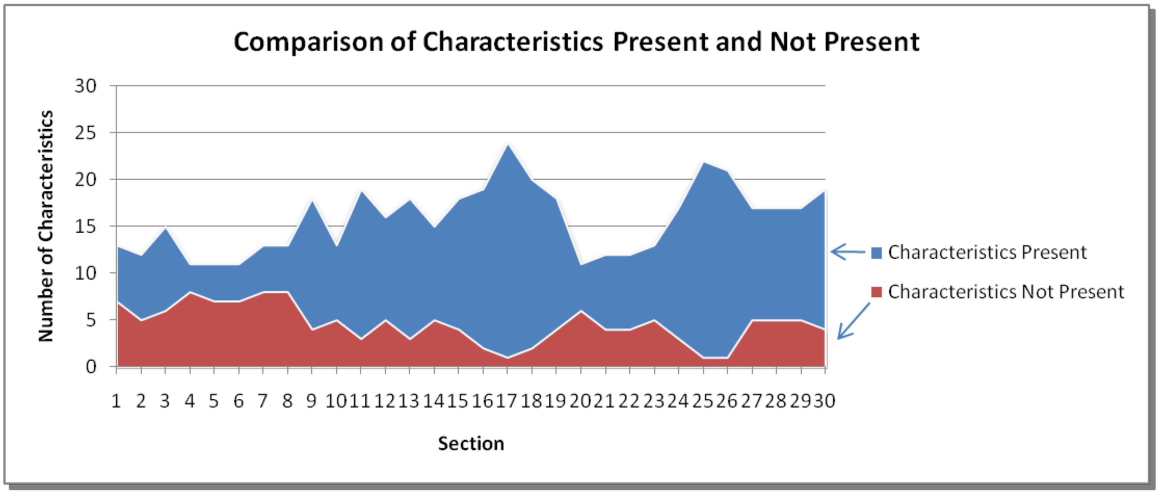

Figure 6. Comparison of characteristics present and not present

Results – Research Question 2

How prevalent are the characteristics of cognitive load and constructivism in the selected documents?

The purpose of Research Question 2 was to determine the extent of the application of the characteristics listed in Table 10. The results of Question 2 are discussed in this section by prevalence of the category, prevalence of individual characteristics, prevalence of characteristics related only to working memory, prevalence of characteristics related only to schema, average characteristic rating by vendor, and lastly from a broad view of all characteristics.

Prevalence by Category

As introduced in chapter 3, and listed in Table 10, categories of characteristics were segregated into Framework of Document, Organization of Procedural Information, Visuals, Instructional Format, and Examples Reflect User Experience. The characteristic ratings for prevalence by category are displayed using two analytical views: the sum of ratings by category per section and the characteristic rating distribution across rating levels (not met, partially met, and largely met) for each category.

Sum of characteristic ratings by category per section. The sum of characteristic ratings by category per section shows that the analysis of the Framework, Visuals, and Examples categories rated much differently than the Organization and Format categories. The ratings in the Organization and Format categories were generally higher. The sum of the characteristic ratings by category is a summary of the total rating for a characteristic per section. The -1, 1, and 2 quality ratings were totaled for each section.

Framework. The Framework category has three characteristics, with the lowest possible rating of -3 and highest possible rating of 6. Ratings for the sum of characteristics ranged from -1 to 6 as shown in Figure 7. Prevalence of characteristics varied from guide to guide; however, guides 1, 5, and 6 scored similarly.

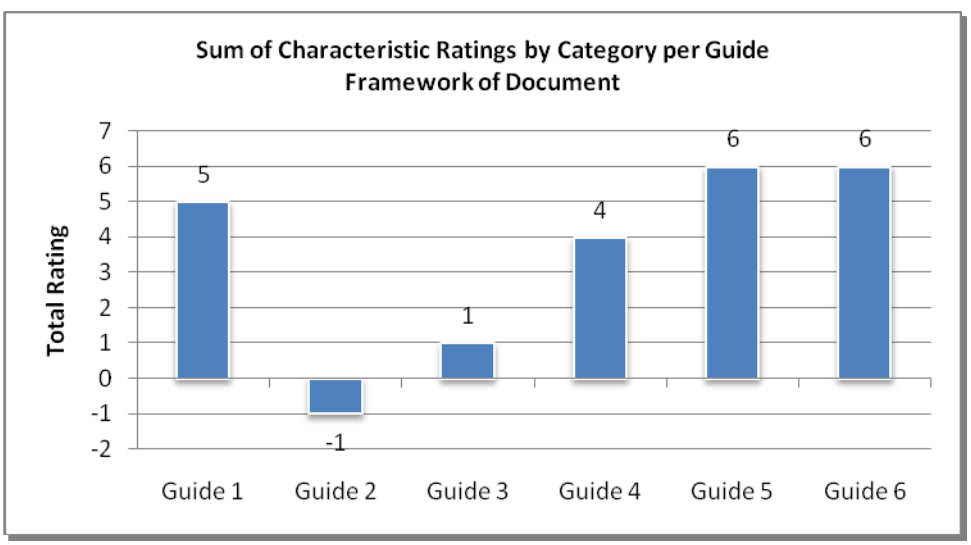

Figure 7. Sum of characteristic ratings – framework of document

Organization. The Organization category has ten characteristics, with the lowest possible rating of -10 and the highest possible rating of 20. Ratings for the sum of characteristics ranged from 3 to 18 as shown in Figure 8. Prevalence of characteristics in this category varied moderately, with sections 7 and 8 showing a lower rating.

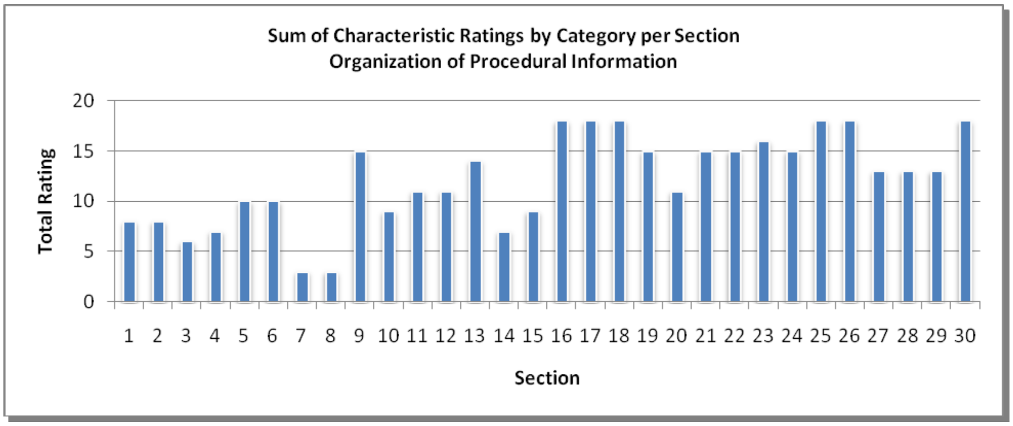

Figure 8. Sum of characteristic ratings – organization of procedural information

Visuals. The Visuals category has nine characteristics, with the lowest possible rating of -9 and the highest possible rating of 18. Ratings for the sum of characteristics ranged from -2 to 14 as shown in Figure 9. Prevalence of characteristics in this category varied significantly. Note that eight sections show ratings less than zero and four sections show ratings slightly greater than zero.

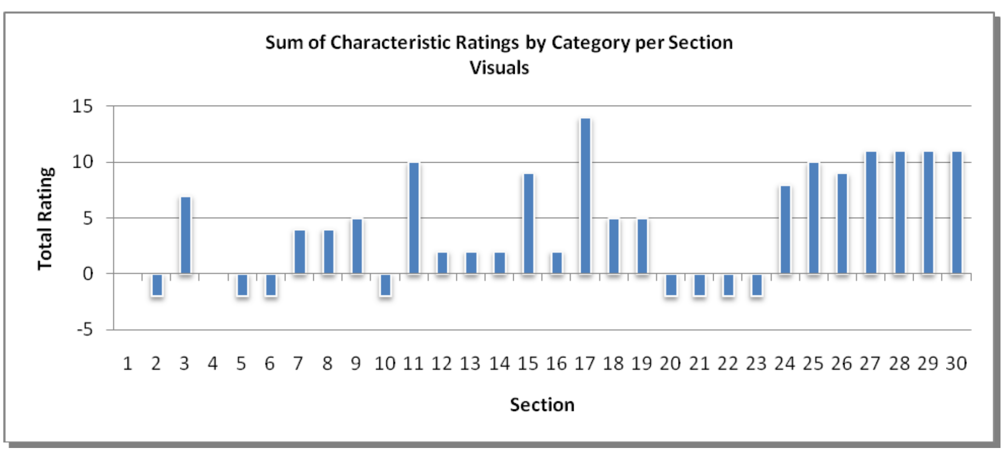

Figure 9. Sum of characteristic ratings – visuals

Format. The Format category has four characteristics, with the lowest possible rating of -4 and the highest possible rating of 8. Ratings for the sum of characteristics ranged from 4 to 8 as shown in Figure 10. There is more uniformity of characteristic ratings in this category.

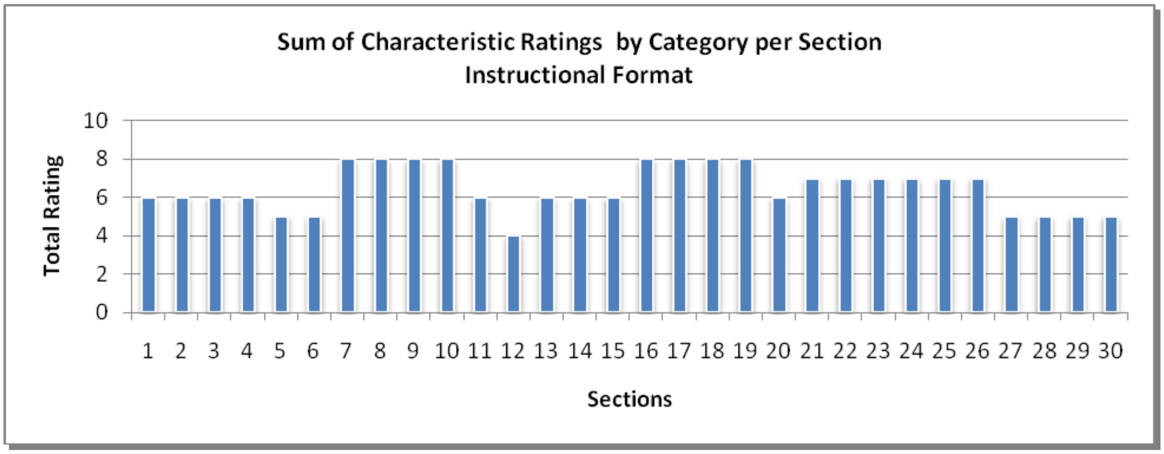

Figure 10. Sum of characteristic ratings – instructional format

Examples. The Examples category has two characteristics, with the lowest possible rating of -2 and the highest possible rating of 4. Ratings for the sum of characteristics ranged from -2 to 4 as shown in Figure 11. There is a wide variation of characteristics in this category. Some content rated poorly and some content rated very well. The sum of ratings for section 2 and section 19 are both 0 (zero), as one characteristic rated a 1 and one characteristic rated a -1, which calculates to 0. Note that in over half of the sections, the characteristic ratings are less than zero.

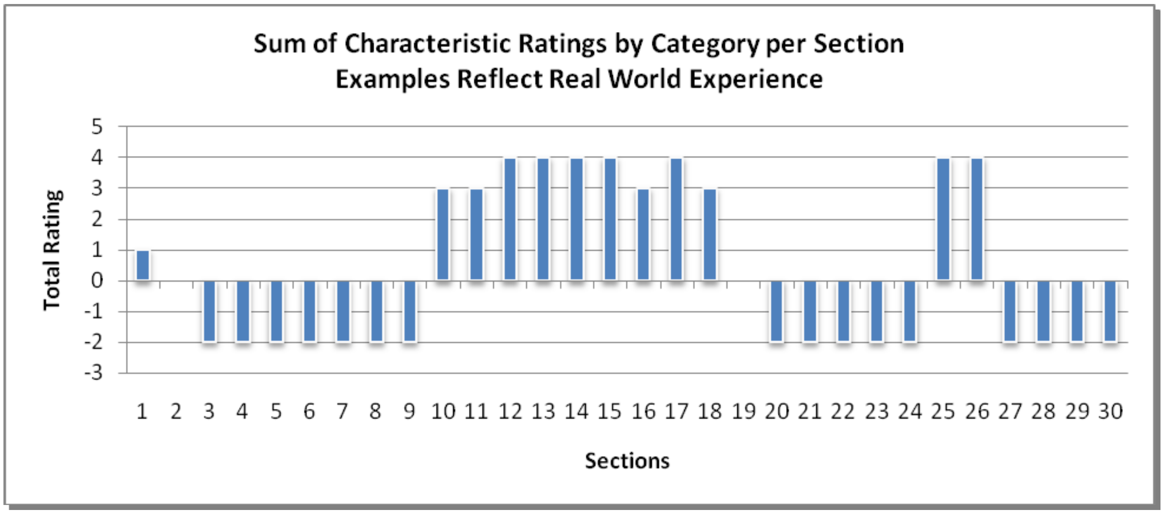

Figure 11. Sum of characteristic ratings – examples reflect real world experience

Characteristic rating distribution by category. The rating distribution of characteristics by category provides another view of the prevalence of the characteristics of each category in the analyzed documents. The least prevalent category is Examples, with Visuals as the second lowest in ratings.

Framework. In the Framework category, 50% of the characteristics as evaluated across all guides rated as *largely met*, 33% rated as *partially met*, and 17% rated as *not met,* as shown in Figure 12. Generally, the characteristics in the Framework category are well represented.

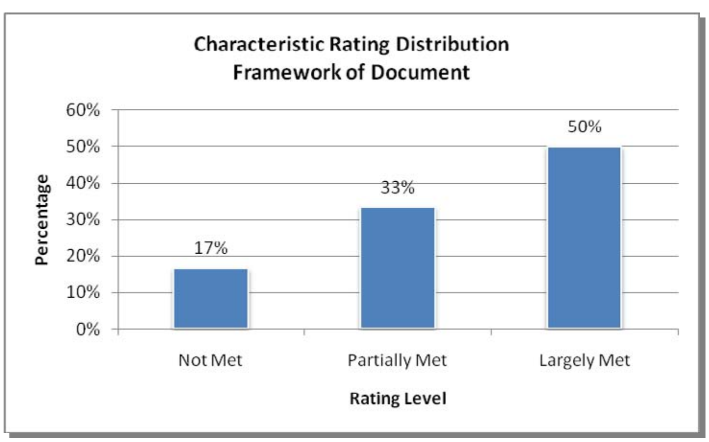

Figure 12. Characteristic rating distribution – framework of document

Organization. In the Organization category, 60% of the characteristics as evaluated across all guides rated as *largely met*, 26% rated as *partially met*, and 15% rated as *not met,* as shown in Figure 13. Generally, the characteristics in the Organization category are well represented.

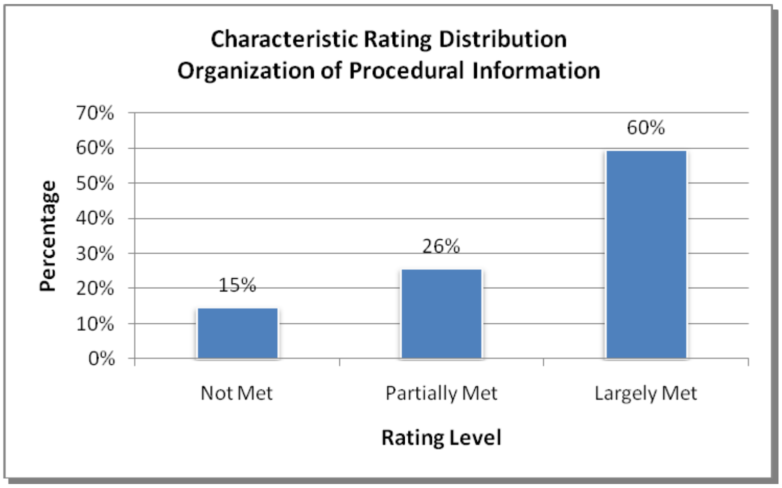

Figure 13. Characteristic rating distribution – organization of procedural information

Visuals. In the Visuals category, 52% of the characteristics as evaluated across all guides rated as *largely met*, 13% rated as *partially met*, and 35% rated as *not met,* as shown in Figure 14. Characteristics in the Visuals category are not as prevalent as in other categories.

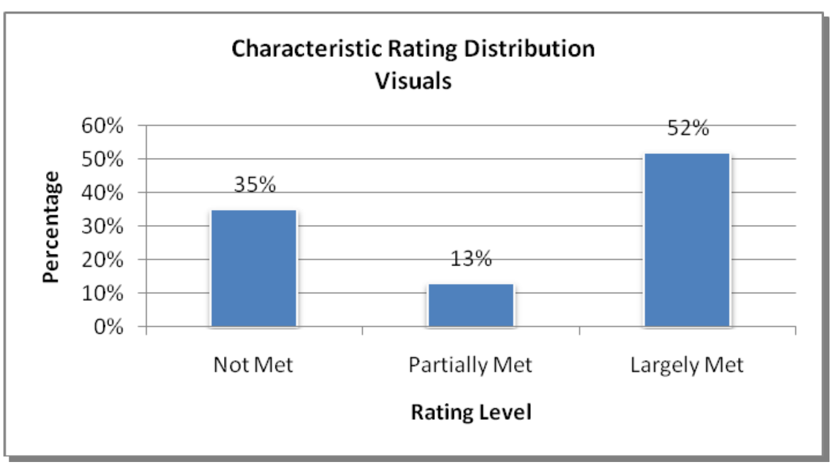

Figure 14. Characteristic rating distribution – visuals

Format. In the Format category, 76% of the characteristics as evaluated across all guides rated as *largely met*, 18% rated as *partially met*, and 6% rated as *not met* as shown in Figure 15. The characteristics in the Format category are well represented.

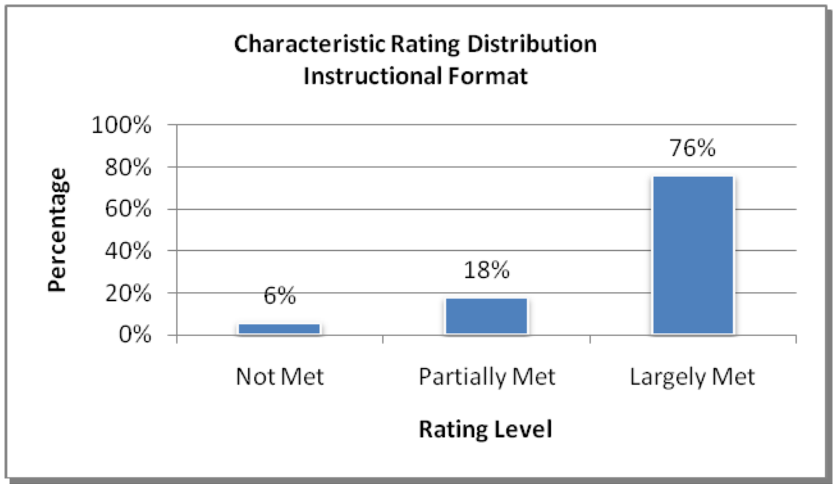

Figure 15. Characteristic rating distribution – instructional format

Examples. In the Examples category, 32% of the characteristics as evaluated across all guides rated as *largely met,* 10% rated as *partially met*, and 58% rated as *not met* (Figure 16). The characteristics in the Examples category are somewhat absent.

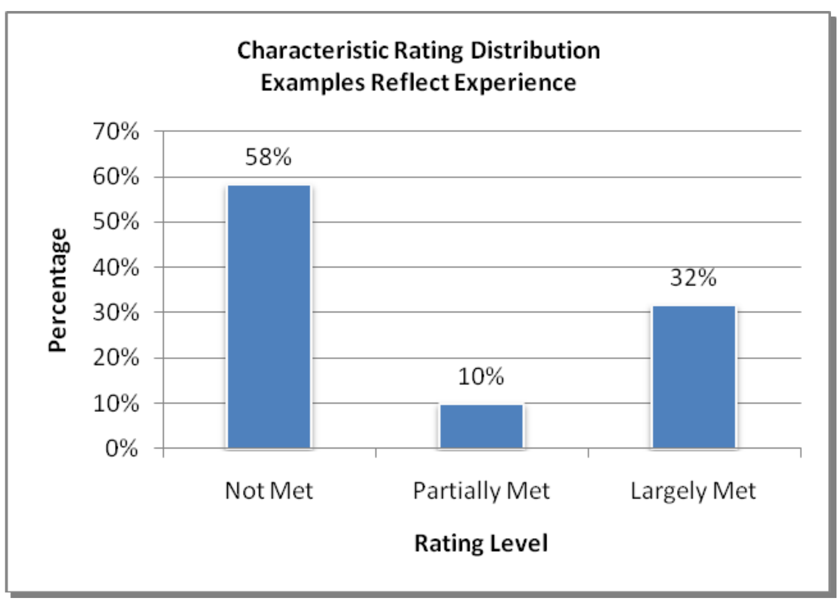

Figure 16. Characteristic rating distribution – examples reflect experience

Prevalence by Characteristic

Prevalence of the individual characteristics was examined using two analytical views: the average rating and the percentage of rating distribution. The average rating reflects the average quality rating levels of -1, 1, and 2. The percentage of rating distribution highlights the most prevalent or noteworthy characteristics in each category.

Framework. In the Framework category, there are three characteristics; the average rating of the characteristics as evaluated across all guides was 1.17 (Figure 17). This indicates a high level of evidence of the Framework characteristics.

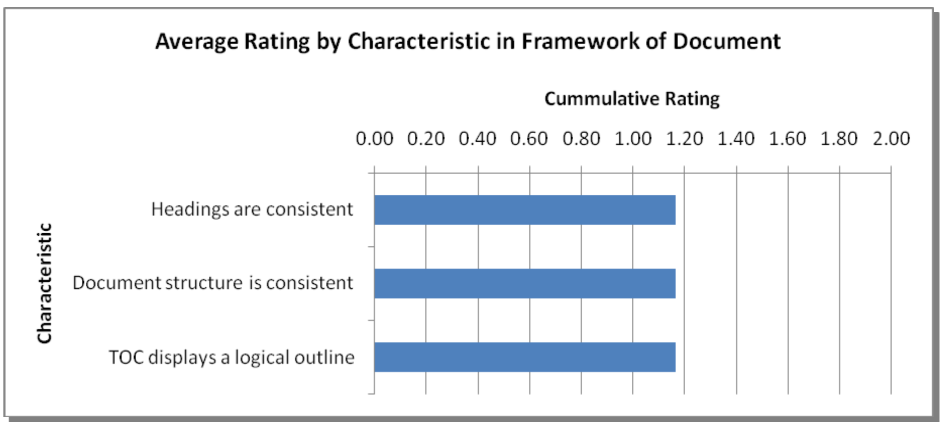

Figure 17. Average rating by characteristic – framework of document

The distribution of the rating levels across all guides was examined for the three characteristics in the Framework category. The rating distribution was identical for each characteristic, with 50% *largely met*, 33% *partially met*, and 17% *not met*. The graphic (Figure 18) illustrates one of the characteristics in the Framework category.

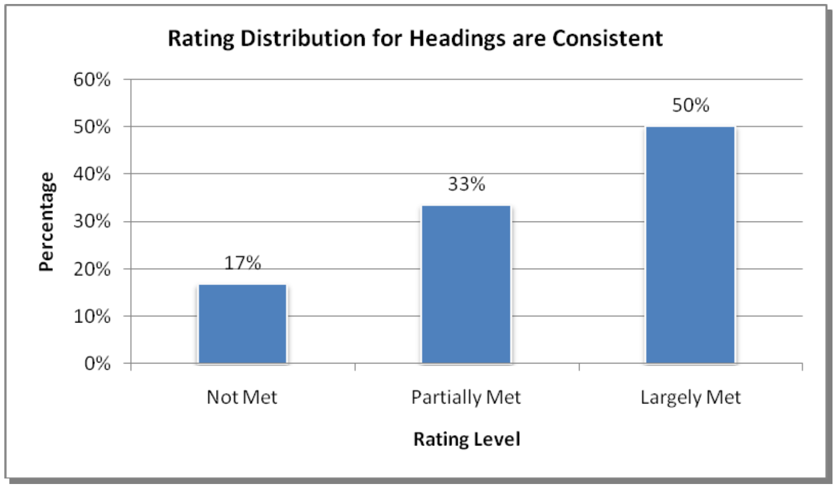

Figure 18. Rating distribution – headings are consistent

Organization. In the Organization category, three of the ten characteristics were rated as moderately not prevalent: *headings are meaningful*, *procedural steps are clearly identified*, and *information organized into tables*. The average ratings of these characteristics are 1.00, 0.53, and 0.92 respectively, as listed in Table 14.

Table 14. Average Rating – Organization Characteristics

Characteristic	Average Rating
Headings are meaningful in the context of the workplace	1.00
Procedural steps are clearly identified through formatting	0.53
Information is organized into tables	0.92

The average rating of these characteristics is clearly distinguishable from the other characteristics in this category as illustrated in Figure 19. These characteristics are critical in documentation, particularly for documentation of complex systems. The analyzed content in which these characteristics rated low was more difficult to navigate. The ratings for the two characteristics *use of bold, italics, font size* and *ample white space,* were primarily affected by one guide.

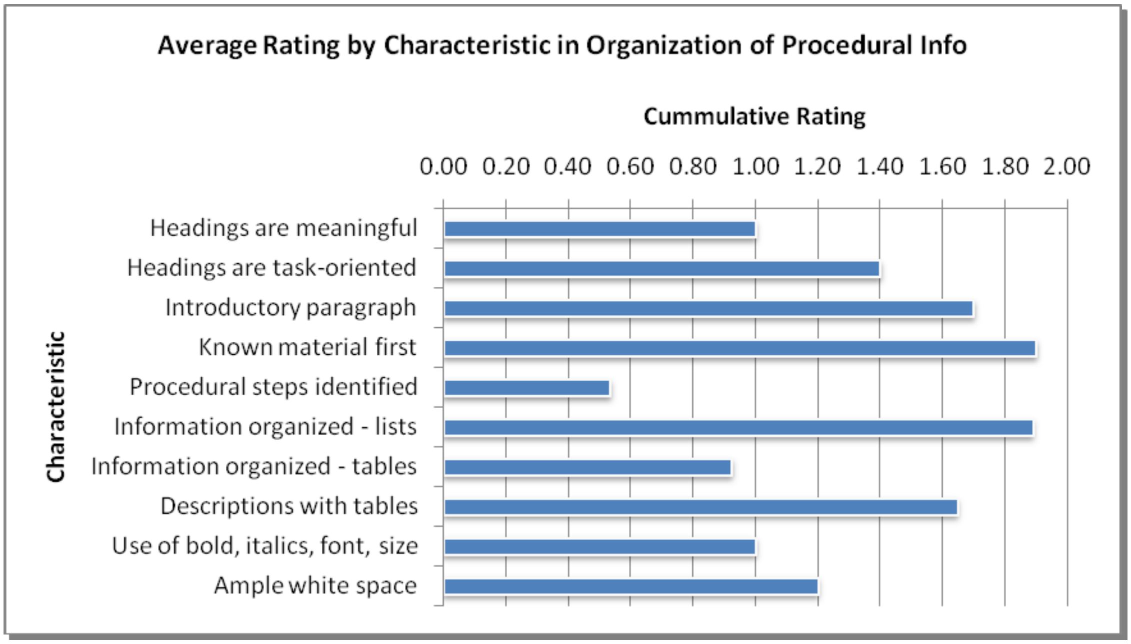

Figure 19. Average rating by characteristic – organization of procedural information

Headings are meaningful. The *headings are meaningful* characteristic is critical toward helping the user build a mental model of how the content can help them accomplish a task. This characteristic was rated as 40% *largely met*, 40% as *partially met*, and 20% as *not met* (Figure 20). Many headings mimicked the labels of the software interface, which were inadequate to gain an understanding of the topic. The researcher had to read for comprehension to understand the topic.

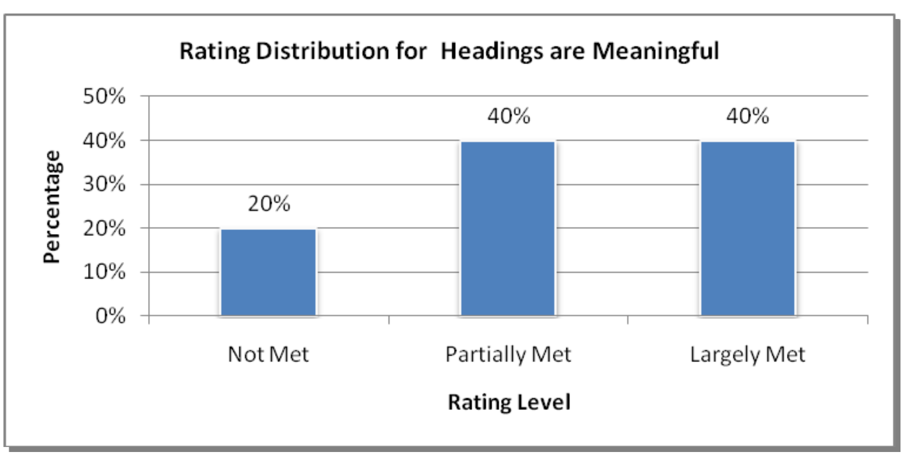

Figure 20. Rating distribution – headings are meaningful

A sample of suggested headings from the evaluated guides is listed in Table 15. In the suggested heading column, the acronyms have been removed from the headings and benefits/reasons have been added to further explain and illustrate meaningful headings.

Table 15. Meaningful Headings – Current and Suggested

Current Heading	Suggested Heading
Listing RAF Expiration Dates	Listing Expired Rule Lines
Modifiable Reports	Modifying Reports to Meet Your Specific Needs
Defining RACF Variables	Protecting Multiple Resources With One General Resource Profile
View Management	Managing Views to Control Tasks Available to the User

Procedural steps are clearly identified. A critical characteristic of document usability is visual effectiveness. Procedural steps that are buried in paragraphs using a prose format are not easy to locate. This characteristic was rated as 47% *largely met*, 7% as *partially met*, and 47% as *not met* (Figure 21). The *not met* instances were written in paragraph format, which does not provide the user with any visual cues that a procedure exists. Readers who browse documents for visual cues would likely overlook procedural steps in paragraph format.

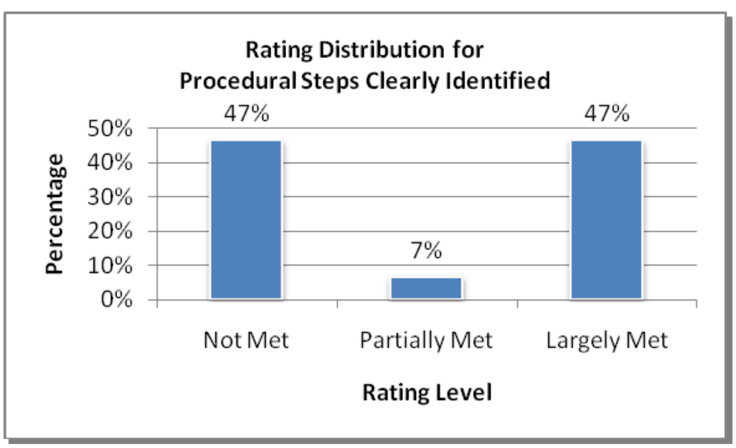

Figure 21. Rating distribution – procedural steps clearly identified

Information is organized into tables. This characteristic is very important for complex information in which relationships must be conveyed. There were many instances in the analyzed content in which a table would have served the reader rather than discussing the relationships through bulleted items. In fact, in one of the guides the bulleted list was overused to the point that the researcher struggled to focus on content. Generally, tables are much better for presenting relationships and help to break up paragraphs and bulleted lists. This characteristic as evaluated across all guides was rated with 54% as *largely met*, 15% as *partially met*, and 31% as *not met* (Figure 22).

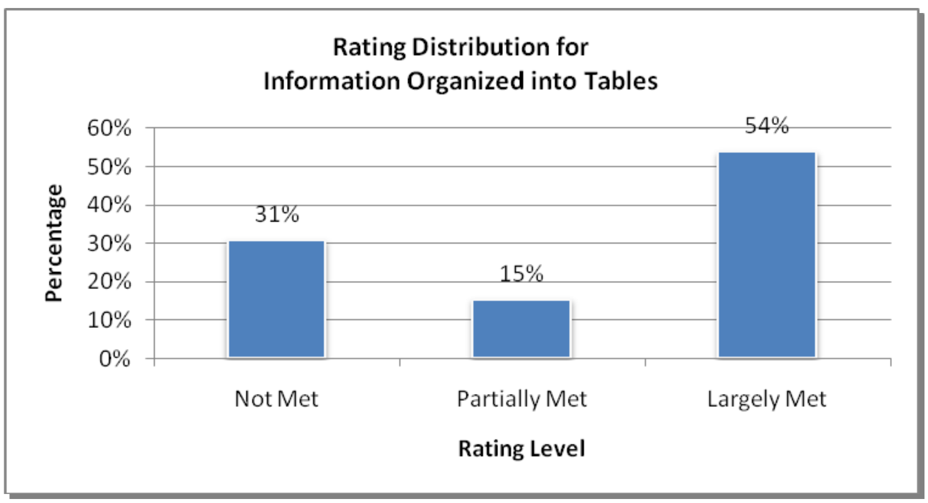

Figure 22. Rating distribution – information organized into tables

Visuals. In the Visuals category, two characteristics were identified as largely absent: *use of diagrams* and *use of screen captures*. The average ratings are 0.07 and -0.13 respectively, as listed in Table 16.

Table 16. Average Rating – Visuals

Characteristic	Average Rating
Use of diagrams	0.07
Use of screen captures	-0.13

The other characteristics in the Visuals category are dependent on the use of screen captures or diagrams. With this in mind, the average ratings of the characteristics listed after the first two, diagrams and screen captures, reflect how well the characteristic was applied when screen captures or diagrams were present. When screen captures were present, the *sized/placed* and *screen states* characteristics were applicable. When diagrams were present, the *explanatory text*, *system topology*, and *component relationship* characteristics were applicable.

Of the 270 ratings applied in the Visuals category, 116 ratings were assigned as *not applicable*, which is 43% of the count by value. The *not applicable* rating was removed from the rating distribution graphs to eliminate confusion. The average ratings by characteristic in the Visuals category are shown graphically in Figure 23.

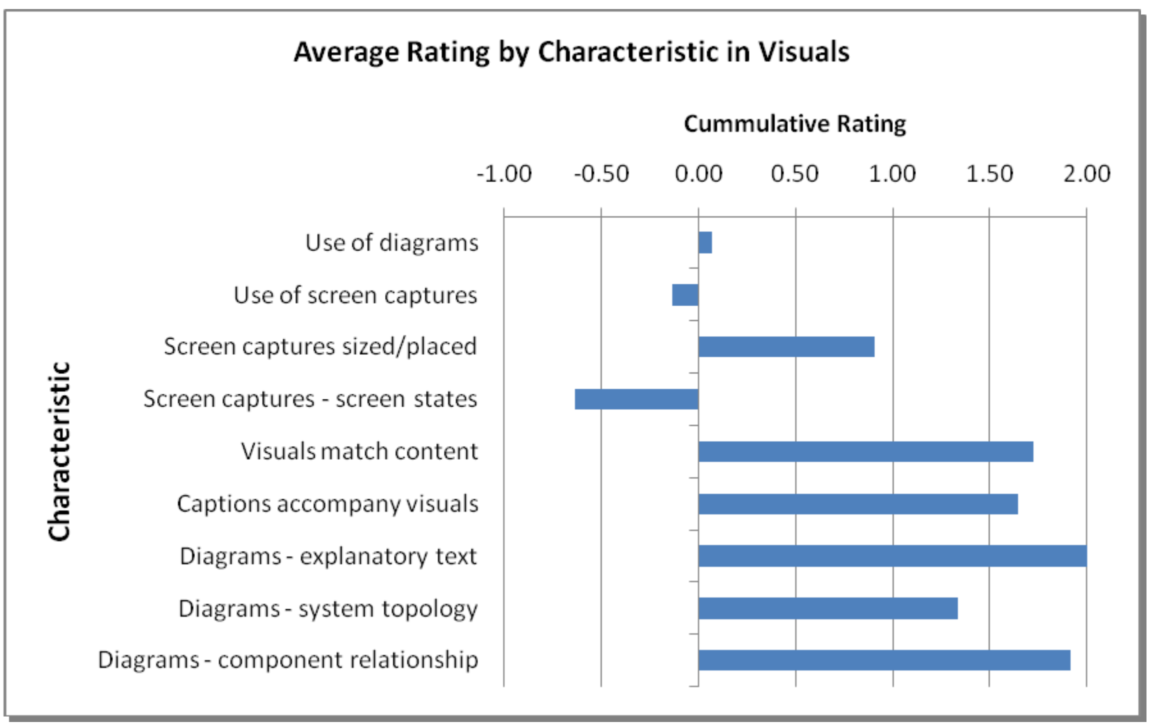

Figure 23. Average rating by characteristic – visuals

Use of diagrams. Diagrams are instrumental in building mental models. This characteristic was rated as 27% *largely met*, 13% as *partially met*, and 60% as *not met*. Over half of the analyzed sections did not provide diagrams (Figure 24).

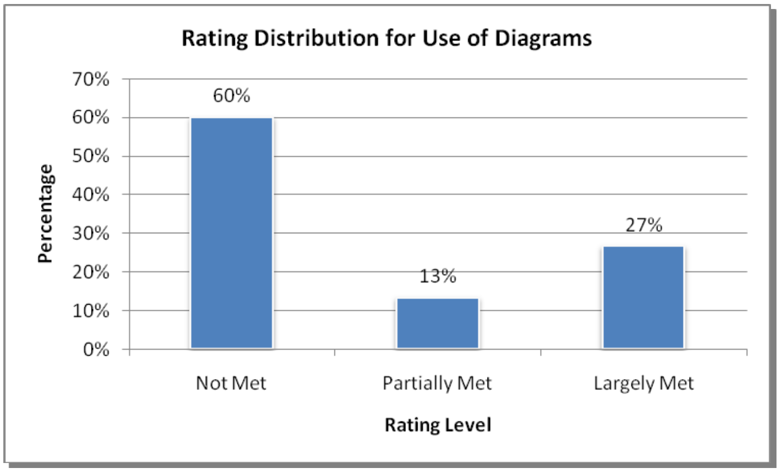

Figure 24. Rating distribution – use of diagrams

Use of screen captures. Screen captures are the most widely used graphic in software documentation. However, more than half of the content did not provide screen captures. This characteristic was rated as 13% *largely met,* 23% as *partially met*, and 63% as *not met* (Figure 25). Many areas of instruction could have benefitted from associated screen captures.

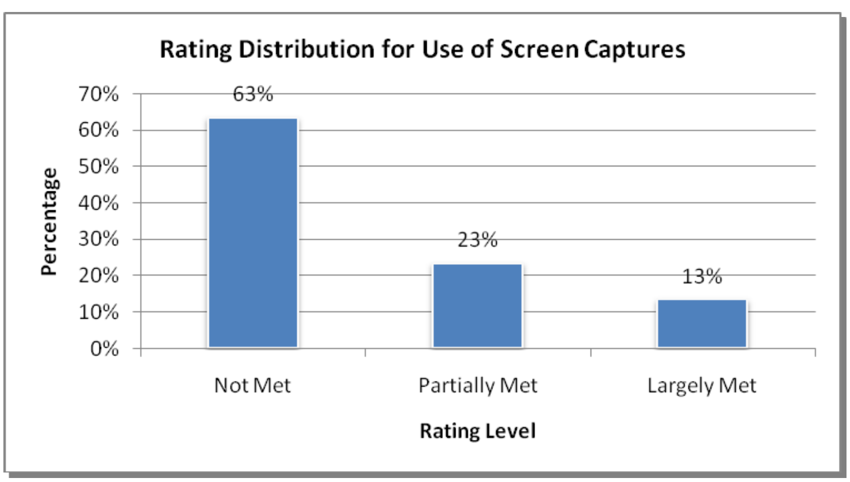

Figure 25. Rating distribution – use of screen captures

Format. In the Format category, the ratings associated with the characteristic *low level of element interactivity*, rated 1.03 compared to 1.86, 1.87, and 1.80 for the other characteristics in the category, as listed in Table 17.

Table 17. Average Rating – Format

Characteristic	Average Rating
Conceptual information	1.86
Low level interactivity	1.03
Terminology is defined	1.87
Content chunked	1.80

The average ratings for the Format characteristics are shown in Figure 26.

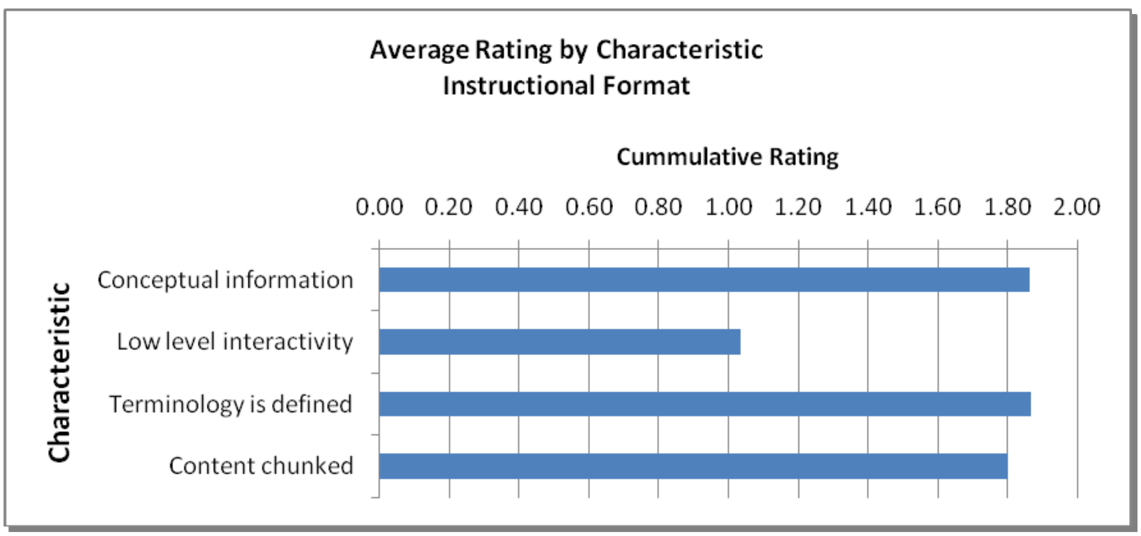

Figure 26. Average rating by characteristic – format

Low level of element interactivity. Ratings for this characteristic suffered due to procedural steps that were buried in paragraphs and the lack of screen captures. In one instance, the lack of screen captures forces the user to shift between pages in the documentation to reference commands. It was frequently difficult to discern interactivity from explanations. In other instances, the lack of screen captures may increase interactivity as the user reads the instructions and follows the interface. Without the screen captures to confirm screen states, there could be increased activity to confirm success or failure of a procedural step. In the Format category, the low level of element interactivity characteristic was rated with 45% as *largely met*, 34% as *partially met*, and 21% as *not met* (Figure 27).

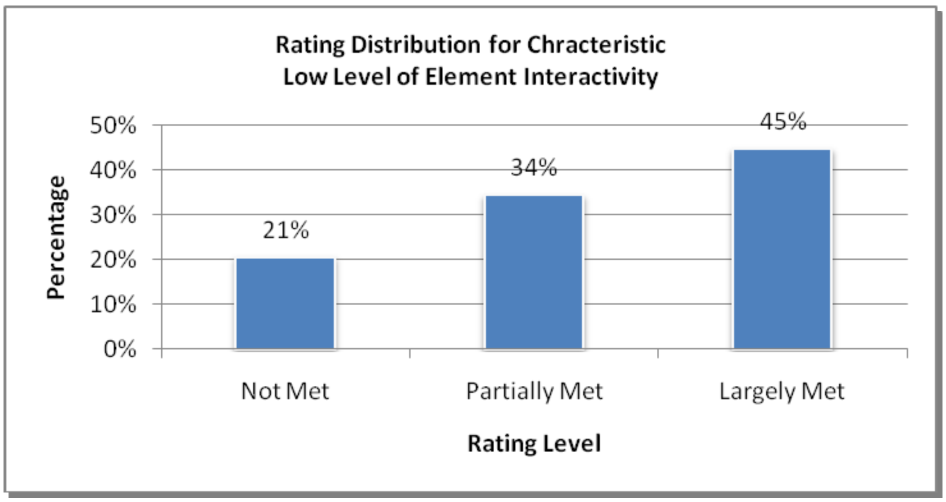

Figure 27. Rating distribution – low level of element interactivity

Content is chunked. Chunking content helps to reduce the load on working memory. In the Format category, this characteristic was rated with 87% as *largely met*, 10% as *partially met*, and 3% as *not met* (Figure 28). The ratings for this characteristic were very high; however, 4 of the 30 sections that were analyzed scored low. All four of these low-scoring sections occurred in the same guide and had a similar design. Additionally, conceptual information was not separated from the procedural information. There were numerous warnings, notes, and caveats interspersed with the steps, which acted as a deterrent to learning how to administer the product due to an excess of information. Topics such as these should be presented in layers, to allow the user to build knowledge as he or she progresses through the material. Actual scenarios could illustrate the various conditions that can change the behavior of the system, which would have also raised the ratings for the Examples category.

Additionally, the instructional format in these four sections presented numerous points as bulleted lists, which when overused, can be overlooked by the reader. Approximately 50% of the content in two of the sections was presented in this manner. Tables would have been a better approach for presenting many of the lists, which would have also raised the ratings for the Organization category.

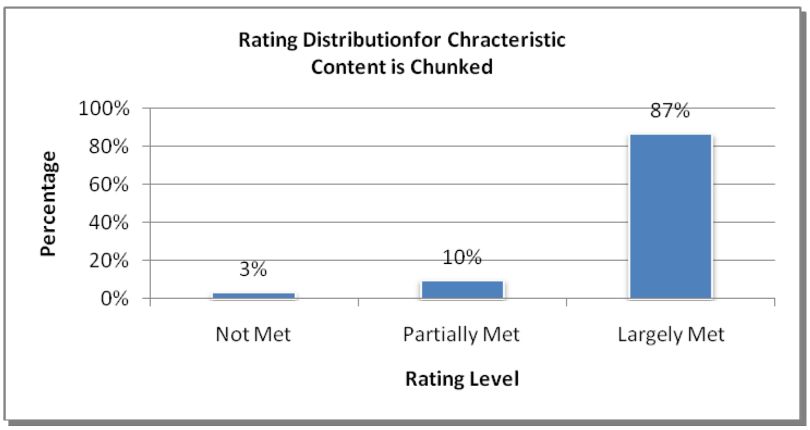

Figure 28. Rating distribution – content is chunked

Examples. The Examples category has two characteristics, *provides realistic scenario* and *uses real world examples*. Both characteristics scored low with 0.03 and 0.27 as average ratings respectively as shown in Figure 29.

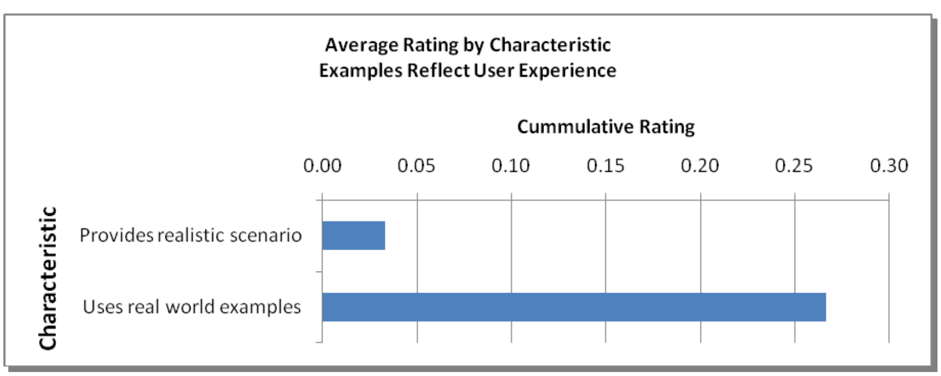

Figure 29. Average rating by characteristic – examples

Provides realistic scenario. The characteristic *provides realistic scenario,* was rated with 30% as *largely met,* 7% as *partially met*, and 63% as *not met* (Figure 30). Over half of the sections did not provide the user with scenarios to illustrate real world use. This can be problematic when the interface is very complex, as scenarios can help the user build mental models to relate the topic to the user's environment.

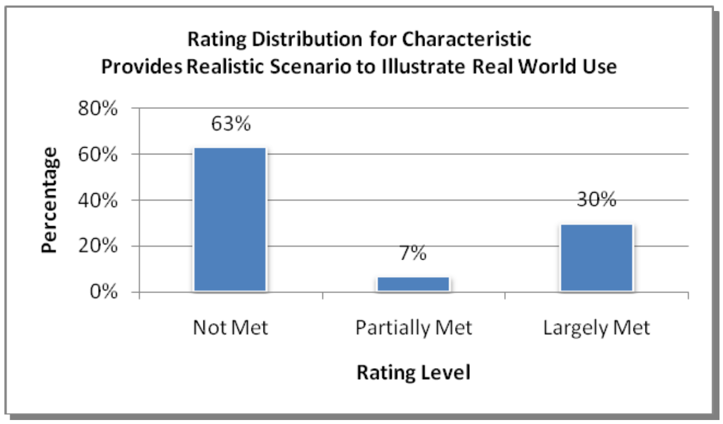

Figure 30. Rating distribution – realistic scenario to illustrate real world use

Uses real world examples. The characteristic *uses real world examples* was rated with 33% as *largely met,* 13% as *partially met*, and 53% as *not met*, Over half of the sections did not provide real world examples as illustrated in Figure 31.

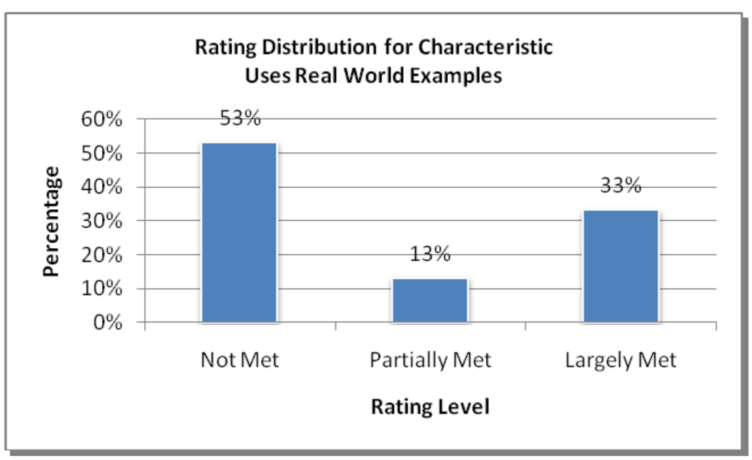

Figure 31. Rating distribution – uses real world examples

Prevalence by Working Memory

Generally, the average ratings of characteristics specifically related to working memory were very good, as listed in Table 18. The material in which these characteristics rated poorly contained paragraphs of content that would have been easier to read and understand had it been presented in tables, as the content discussed relationships of attributes to commands.

Table 18. Average Rating – Working Memory

Characteristic	Average Rating
Information organized into structurally similar lists	1.89
Information organized into tables	0.92
Low level of element interactivity	1.03
Content is chunked	1.80

Prevalence by Schema

Fifteen characteristics are specifically related to schema. Five of the characteristics as evaluated across all guides revealed low average ratings as listed in Table 19. These characteristics are important to building mental models.

Table 19. Average Rating – Schema

Characteristic	Average Rating
Procedural steps are clearly identified through formatting	0.53
Use of diagrams	0.07
Use of screen captures	-0.13
Provides realistic scenario to illustrate real world use	0.03
Uses real world examples	0.27

Average Rating Characteristic by Vendor

The average characteristic rating per vendor is displayed in Figure 32. The average characteristic rating for vendor 2 is 0.50, which is approximately less than half of the average ratings for vendors 1 and 3. Vendors 1 and 3 have very similar averages for characteristic ratings, with 1.13 and 1.04 respectively.

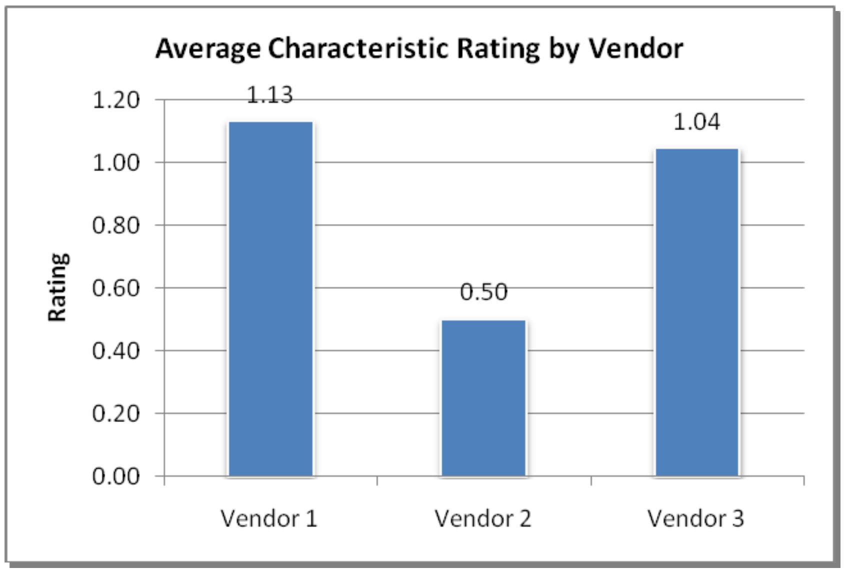

Figure 32. Average characteristic rating by vendor

Visuals. The variance is striking when viewing the average characteristic rating for the Visuals category. The average rating for vendor 1 is over 4 times that of vendor 3 as illustrated in Figure 33.

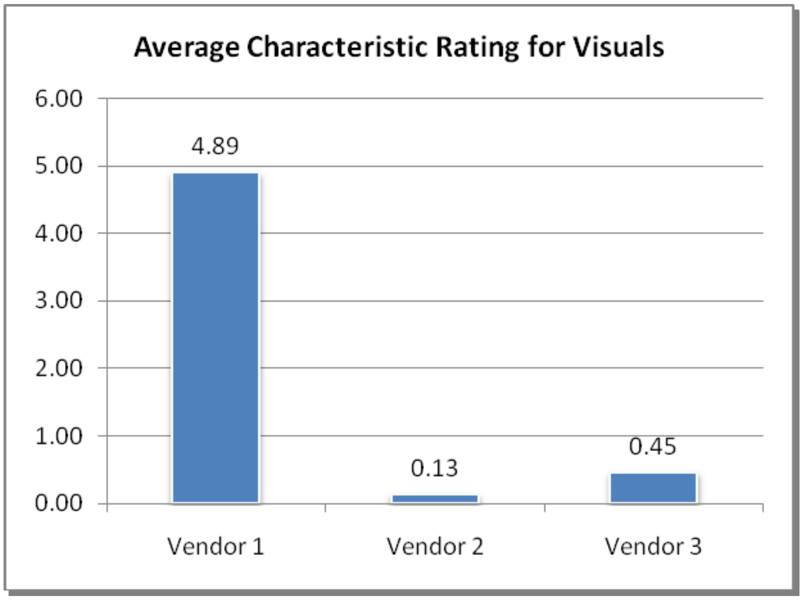

Figure 33. Average characteristic rating for visuals

Examples. The variance in the average characteristic rating for the Examples category is also significant between the vendors. The average rating for vendor 3 is less than 1; however, it is significantly higher than that of vendor 1 and 2, which are both less than zero.

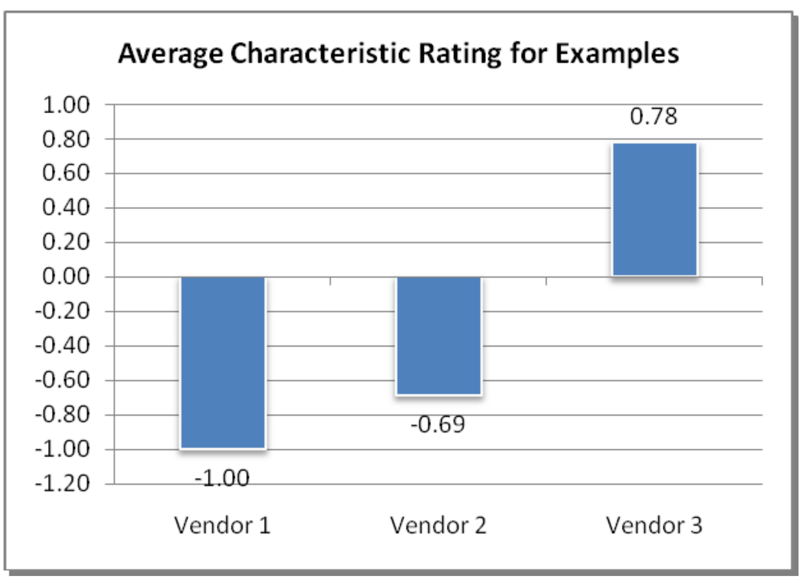

Figure 34. Average characteristic rating for examples

Broad View of All Characteristics

The data analysis shows that most of the characteristics were applied to a large degree in the documents. For the 28 characteristics and 5 categories that were studied, the average rating for each characteristic is shown graphically in Figure 35.

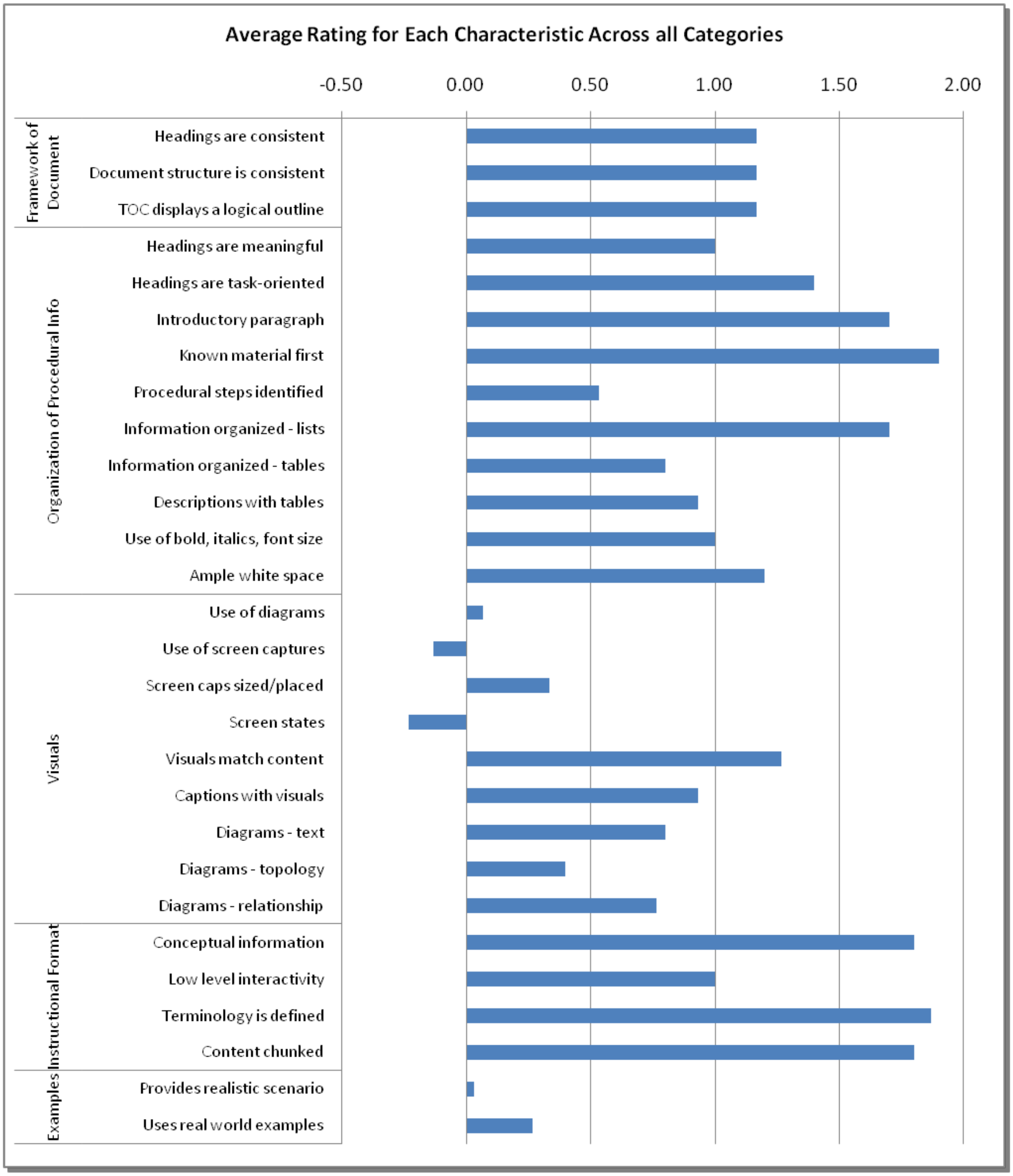

Figure 35. Average rating for each characteristic across all categories

The average ratings range from a low of – 0.23 to a high of 1.90 as listed in Table 20. Refer to the topic *Visuals* in the *Prevalence by Characteristic* section for an explanation of screen capture related characteristics.

Table 20. Average Rating – All Characteristics and All Categories

Characteristic	Average Rating
Headings are consistent	1.17
Document structure is consistent	1.17
TOC displays a logical outline	1.17
Headings are meaningful	1.00
Headings are task-oriented	1.40
Introductory paragraph	1.70
Known material first	1.90
Procedural steps identified	0.53
Information organized – lists	1.70
Information organized – tables	0.80
Descriptions with tables	0.93
Use of bold, italics, font size	1.00
Ample white space	1.20
Use of diagrams	0.07
Use of screen captures	-0.13
Screen caps sized/placed	0.33
Screen states	-0.23
Visuals match content	1.27
Captions with visuals	0.93
Diagrams – text	0.80
Diagrams – topology	0.40
Diagrams – relationship	0.77
Conceptual information	1.80
Low level interactivity	1.00
Terminology is defined	1.87
Content chunked	1.80
Provides realistic scenario	0.03
Uses real world examples	0.27

Summary

All characteristics were identified across the examined documents. However, no single section of content contained evidence of all characteristics.

The data analysis of the characteristics as evaluated across all guides revealed three results of particular note. First, the ratings of characteristics in the Examples category were very low. Over half of the analyzed sections did not provide examples and more than half did not provide realistic scenarios that illustrate real world use. The characteristics in the Examples category help the user build mental models. Software that is complex requires examples and scenarios, and much of the analyzed content in this study is documentation of complex systems.

Second, a very critical characteristic in the Organization category, *procedural steps are clearly identified*, rated low due to buried procedures within paragraphs. The researcher struggled to follow and comprehend the content.

Lastly, the use of diagrams and screen captures characteristics rated low in the Visuals category. Opportunities for helping the user understand complex content were missed throughout much of the analyzed content.

CHAPTER 5. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The conclusions and recommendations of the study are presented in this final chapter. This chapter includes a summary of the study and research questions, a discussion of the findings, implications for the practice of technical communication, and recommendations for future research.

Summary and Discussion of Results

Overview of Problem, Relevance, and Foundational Literature

Technical communication is a field that includes software documentation, which is written instruction that is instrumental in the workplace. Effective documentation must be accurate and definitive; it must be written in a clear and concise manner, and it must support the user's objective and be a useful learning tool. More now than ever, companies and individuals rely on documentation to aid in learning how to best use the software product. Additionally, for software companies, documentation can act as a financial risk mitigation tool and serve as an asset in the business strategy. As an important part of the product, the design and development of documentation are critical to the vendor and the user.

This study examined the instructional aspect of technical communication as discussed in Moore's (1996a; 1997) articles "Instrumental Discourse is as Humanistic as

Rhetoric" and "Rhetorical vs. Instrumental Approaches to Teaching Technical Communication." Moore's position laid the foundation of the study and was the impetus for the researcher to add complementary layers that would further the instrumental perspective. Redish (1993; 1997), Mirel (1998a), and Coe (1996), to name a few scholars, applied cognitive psychology to technical communication, which in turn became the layer of the study that drove the design of the research instrument. The instrument contains characteristics of cognitive load and constructivism that support working memory and mental models for readers. Cognitive theories maintain that learning takes place when the student can apply newly acquired knowledge in different settings (Schunk, 2000). Both cognitive load and constructivism fall under the umbrella of cognitive theories, which are most appropriate for learning in complex situations such as using software to solve complex problems (Schunk, 2000).

In this study, characteristics that apply to working memory and schema were evaluated, as these are important facets of cognitive processing. Schemas are models or structures used by learners to relate the new information to their understanding of the world, in other words, how prior knowledge assists in learning new content. Working memory involves the concepts of cognitive load, which is concerned with the quantity of information presented, and how much information the user actually reads and comprehends. The purpose of this study was to determine the extent to which the characteristics of learning theory that apply to cognitive load and constructivism have been applied in the software documentation of large enterprise systems.

Methodology

The two research questions in the study asked what characteristics of cognitive load and constructivism would be identified, and how prevalent would these characteristics be in the examined documentation. These questions were answered using a qualitative content analysis structured around a specially developed matrix that served as the data collection and analysis instrument for the study. The matrix followed the principles from the Hargis et al. (2004) text and included a set of categories and characteristics distilled from the extensive literature review discussed in chapter 2.

Characteristics of cognitive load and constructivism were organized into five categories: Framework of Document, Organization of Procedural Information, Visuals, Instructional Format, and Examples Reflect User Experiences. In total, there were 28 characteristics; however, 25 apply to a specific section of documentation and three characteristics apply to an entire guide. The characteristics for the Framework category were evaluated for each guide as a whole and the characteristics for the other categories were evaluated for each section of documentation. For each guide, there were three characteristics (Framework category) in the matrix, totaling 18 quality ratings. For each section, there were 25 characteristics situated into a matrix with a column for recording the quality rating. Quality ratings were assigned for each evaluated characteristic for a section of documentation. Thirty sections were analyzed for each characteristic, totaling 750 quality ratings.

The quality ratings ranged from -1 to 2, with -1 to indicate *not met*, 0 to indicate *not applicable*, 1 to indicate *partially met*, and 2 to indicate *largely met*. The rating indicated how the characteristic was applied in the documentation. *Not met* indicated no presence of the characteristic, *partially met* indicated a partial application, and *largely met* indicated the characteristic was present and complete. *Not applicable* indicated that the characteristic was not used because it did not apply to the content or because it depended on the presence of other characteristics not found in the guide or section. In a few cases, the not applicable rating was assigned when the content did not require the characteristic. The *not applicable* ratings were removed from the data analysis to prevent skewing of the rating distribution.

Discussion on Findings for Research Question 1

> *What characteristics of cognitive load and constructivism will be identified in the analysis of the selected documents?*

All characteristics in the matrix were identified across the selected documents. However, no single section contained evidence of all 25 characteristics in the four categories that apply to sections of documentation. The highest percentage of characteristics that were not present in a single section was 42%. The lowest percentage of characteristics that were not present in a single section was 4%. The sections with the most prevalent number of evaluated characteristics were 17, 25, and 26 and the sections with the least prevalent number of evaluated characteristics were 4, 5, 6, 7, and 8. The findings suggest that software documentation is developed using many of the characteristics of cognitive load and constructivism; however, the degree of application is quite varied. The examined sections that reflect the most applied use of the characteristics are few in number, which suggests that characteristics of cognitive load and constructivism are not applied on a broad scale.

Discussion on Findings for Research Question 2

> *How prevalent are the characteristics of cognitive load and constructivism in the selected documents?*

The prevalence of the characteristics varied greatly across the 5 categories, 6 guides, and 30 sections. The characteristics in the Visuals and Examples categories generally reflect as the least prevalent. The characteristics in the Organization and Instructional Format categories were the most prevalent.

Framework. For the Framework category, all characteristics were identified; however, the total of the characteristic ratings for the individual guides varied from -1 to 6. The variance between two of the vendors is somewhat similar. This observation is significant, suggesting that documentation processes and resources are challenging for many software companies. In four of the guides, all characteristics were present and in two of the guides, some of the characteristics were present. Refer to Figure 7 in chapter 4 for a review of the Framework characteristics.

Organization. In the Organization category, the characteristic *procedural steps are clearly identified*, was rated low for many examined sections primarily because procedures were frequently buried within paragraphs. Buried procedures may indicate a lack of design standards or failure to follow design standards.

Visuals. In the Visuals category, approximately half of the characteristics rated as *not met* and the other half rated as *partially* to *largely met*. In this category, the ratings depend on the use of screen captures and diagrams and these two characteristics were largely absent. The findings for this category suggest that visuals were not uniformly emphasized in the documentation process and that perhaps their value is not understood by technical writers.

Format. The prevalence of characteristics in the Format category rated very high. Of particular interest is the characteristic *low level of element interactivity*, as this characteristic is dependent on the presence of screen captures. Ratings for this characteristic were more distributed with 45% largely met, 34% partially met, and 21% not met. Screen captures were not as prevalent as they should have been which affected the ratings for element interactivity. Again, this suggests that screen captures may not be emphasized in helping users follow and apply instructional material.

Examples. The prevalence of the characteristics in the Examples category was very low. Over half of the analyzed sections did not provide examples and more than half did not provide realistic scenarios that illustrate real world use. In many of the guides, the material is not presented in the context of workplace activities, which makes it difficult to comprehend how to apply the information to solve problems. Characteristics in the Examples category were primarily absent, which indicates that examples are not emphasized.

Overall Observation. One of the examined guides had excellent content, but because many of the characteristics were not evenly applied, it was difficult to realize the depth of the content on the initial review. If the guide had been designed by applying the matrix used in this study, it is expected that the characteristic ratings would have been largely met. The point is that content was not the issue, in this case it was about presentation. Had the guide been developed using clearly identified procedural steps, usable screen captures, and conceptual diagrams, it would have been a more usable document, and therefore a more meaningful learning tool.

Conclusions

The absent characteristics across the examined documents raises questions about documentation standards, available resources, user needs analysis, documentation processes, and subject matter knowledge. These areas of concern are discussed in the following sub-topics.

Standards

Standards can address form, style, consistency, terminology, and organization of content. Do the software companies have established standards for the design and development of software documentation? Do the standards address task-oriented headings, clearly identifiable procedural steps, use of visuals, and the requirement to relate the software functions to the user's workplace tasks? If there are standards, do the standards address writing style or presentation style?

Documentation that is developed using standards achieves consistency. Standards that address design and style require awareness, education, and a commitment to the resources required for developing such standards. Is documentation perceived as a learning tool for users by management? Is management aware of learning theories? Is documentation perceived as a learning tool by writers?

Resources

Standards require adequate resources, which include experienced and knowledgeable staff, adequate time devoted to the project, and a commitment to producing a quality product. Is documentation reviewed internally for quality assurance?

User Needs Analysis

A needs analysis is critical to delivering a quality product. Are users consulted about their documentation concerns? Are customer support calls logged and analyzed to determine if documentation is a root cause of customer calls? Do users consult documentation as a training tool?

Documentation Process

Just as any other project, documentation projects are best conducted using a process that dictates how the writer gathers information to develop content. The process may include learning how to use the software, understanding how users apply the software in the workplace, developing content, reviewing content with subject matter experts, conducting a quality analysis of the content, and an approval process before the content is published. Is a process in place to ensure that the content is complete? Does the documentation meet the users' needs? Are the requirements known by the writers? How are documentation requirements derived? How does management know if the publication is accurate and meaningful?

Business Tool

Is documentation used as a selling tool? Are prospective customers allowed to review the documentation prior to purchasing the software? Documentation is part of the product and reflects on quality of the product. Do software companies buy into this fact?

Implications of Study

The implications of this study indicate that visuals and examples may be the least prevalent characteristics in software documentation. The low ratings may indicate that the writer made assumptions that the reader would understand the narrative without the need for screen captures, or the writer may have tailored the content for advanced users, assuming that advanced users do not require screen captures. The lack of diagrams may indicate that the writer had no contextual experience with the subject matter. In the experience of the researcher, properly designed diagrams indicate a deep understanding of the subject by the writer and a propensity to visualize and demonstrate concepts. The lack of diagrams may indicate the writers are inexperienced with graphical software and are not comfortable in demonstrating concepts. It could also indicate that writers do not have an extensive understanding of the subject, which is typically a requirement for developing diagrams.

Additionally, the results imply that documentation standards may be limited for some organizations, or may simply not exist. Standards can open doors to many opportunities to improve the documentation process, which leads to enhanced content that can improve the user experience. According to Novick and Ward (2006), users want "documentation that is easy to navigate, provides explanations at an appropriate level of technical detail, enables finding as well as solving problems through examples and scenarios, and is complete and correct" (p. 84). Organizations may benefits from reevaluating what is being produced and recognizing the need to incorporate cognitive principles of learning theory in the practice of technical communication.

Indeed, this is what Iverson (2009) proposed in her learner-centered writing model, which draws from cognitive science, creative writing, learning theory, and technical writing. Iverson's model focuses on components that help the learner such as activating prior knowledge, writing with a purpose, the proper use of headings, and information design. Iverson's learner-centered model applies to technical writing that engages readers, enables learning, and facilitates cognitive strategies. The model is listed in Table 21.

Table 21. Theoretical Components of Learner-centered Writing

	Cognitive Neuroscience	Creative Writing	Learning Theory	Technical Writing
Engage Readers	✓	✓		
Make a Connection		✓	✓	
Facilitate Metacognitive Strategies			✓	
Enhance Learning and Memory			✓	✓
Practice and Apply	✓			✓

The characteristics of cognitive load and constructivism apply to the practice of technical communication. Learning theory is critical to instrumental writing. Cognitive principles support learning; technical writing supports practice and application, and provides valuable information such as presentation, context, and graphics (Iverson, 2009).

There is a need for learner-centered writing methodology that merges cognitive and learning theory with writing practice to create a new reader-centric method of imparting information and learning through either written or digital material. (Iverson, 2009, p. 25)

There is limited discussion in the academic community relating learning theory and technical communication. As a genre of technical communication, software documentation has a unique role as an instructional medium. Documentation is a product of the whole system: industry, subject matter knowledge, standards, writer's background and experience, available resources, best practices, time, priorities, and culture of the organization. If learning theory were incorporated into technical communication as a practice, the Visual and Example characteristics may become a part of best practices, as a natural part of designing and developing instructional material. Documentation that incorporates these concepts into software documentation is an important method to enhance the mediation of knowledge.

Rude (2009) posed the question of "How do texts (print, digital, multimedia, visual, and verbal) and related communication practices mediate knowledge, values, and action in a variety of social and professional contexts?" Rude mapped the research questions in technical communication into four areas: discipline, pedagogy, practice, and social change. In the area of practice, Rude asks questions such as "How should texts be constructed to work effectively and ethically? . . . What are best practices of text development and design?" Rude's questions strike at the core of this study.

Recommendations for Future Research

This study could be expanded to include interviews of the technical communication groups involved in the production of the documentation. A natural extension to this study could include inquiries about best practices, standards, knowledge of learning theories, educational background, professional experience, management oversight, available resources, and needs analysis. Additional information about how documentation is developed and how priorities are established could have helped to fill in the gaps of why certain attributes are present or missing from the examined guides. A study encompassing a larger set of vendors could reinforce the results of this study and perhaps reveal slightly different findings.

Additional research could benefit the field of technical communication to include topics such as:

- the feasibility of introducing learning theory into the curriculum for technical communication,
- survey of technical communication faculty and their views of introducing learning theory into the curriculum,
- survey of technical writers who develop documentation, about their views of the practice, their knowledge of learning theory, and their views of incorporating learning theory in their practice,
- study of rewriting documentation using the matrix characteristics and interviews of the writers during and after the process,
- study of how the revised documentation is received by users,
- usability tests of the documentation using the categories and characteristics from this study, to determine if the results of this study are confirmed regarding the Examples and Visuals categories, and a
- survey of how software companies view documentation.

Such additional studies could point to software documentation practices that produce documents that consistently help users learn and benefit from the product.

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