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Causal Factors for Web Site Complexity

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Abstract
The World Wide Web has become the medium of choice for the distribution and use of information by individuals, teams, organizations, and communities. Web sitesâ the collection of web pages that make up the World Wide Webâ are the fundamental means by which that information is retrieved and distributed. Understanding the factors that impact the complexity of a web site is a key step toward effective retrieval and distribution of information and its ultimate use in collaborative activity. This paper proposes three major dimensions of factors that impact the complexity of a web site: (1) cognition, (2) content, and (3) form. These three dimensions and their associated factors comprise how individuals perceive a web site, the content that is located at the site, and the manner in which the web site is constructed. A model and associated propositions are presented, and implications of this approach for research and practice are discussed. This multi-dimensional view of web site complexity provides a richer approach to understanding how complexity might be examined and, ultimately, reduced. This paper relates to collaborative work through individuals and their interaction with a web site. This interaction is, in fact, a communication between the individual using a web site and an individual, group, or organization responsible for the design of the web site. Additionally, the individual perspective is a necessary starting point for collaborative use between and among people.

Keywords: Complexity, Web Site Design, Cognition, Form, Content.

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Causal Factors for Web Site Complexity

Introduction

The World Wide Web (web) has become a tool for business, communication, learning, leisure, and a whole host of anticipated and unanticipated activities across a broad spectrum of the population. Use of the web, an inherently collaborative tool, has led to an enormous proliferation of data and information available to both the public and private sectors. Information on the web is different things to different people, relevant to some and not others, competitively advantageous to some, but not others, and so on. One critical aspect of whether a web site provides a benefit is whether it is easy to use, and in particular, how complex the web site is. The more complex a web site is, the less likely that relevant information can be obtained from the site or that the site can be used effectively, if at all (Hu et al., 1999; Shapira et al., 1999; Busy et al., 1999; Rumpradit and Donnell, 1999).

Considerable research has been conducted on web site design, information relevance, and intentions to use technology (see, for example, Bucy et al., 1999; Beach et al., 1978; Davis et al., 1989; Schubert & Dettling, 2002). As with any new field, the research has typically examined individual factors that provide insight into a single component of what causes a web site to be complex. Despite the numerous studies that deal with the exchange of information on the web, however, none have attempted to explicitly understand the intricate causalities of web site complexity in a holistic way.

An integrated understanding of the factors that define web site complexity is important for several reasons. Large information spaces, like a web site, are vehicles for the delivery and exchange of information (Comerford, 1999; Star and Ruhleder, 1996) and support an implicit communicative channel between the user of the technology and the individual, group, or organization responsible for its design (Reeves and Shipman, 1992). If individuals are unable to locate relevant information or become disoriented within a web site, they cannot receive or exchange information effectively (Thuring et al., 1995; Dillon et al., 1994). With a better understanding of the causal factors of web site complexity, web sites can be designed and managed to reduce user disorientation and improve relevant information retrieval. Furthermore, an integrated view of web site complexity that brings together several literatures can result in a richer foundation for further research. An integrated view also has the potential to incorporate both perceived and objective aspects of web site complexity, hence providing a broader foundation for the examination of web use in all types of interaction

This paper builds on several bodies of literature to develop a well-founded and logical understanding of the factors impacting web site complexity. The theoretical framework developed here is composed of three dimensions of web site complexity: (1) human cognition and how it influences an individual when retrieving and using information in a web site, (2) content of the web site and the amount of information that is available on it, and (3) the form of the web site with respect to user interface, navigation, and structure. The framework extends prior web site complexity research that focused only on structural dimensions of web sites (Stevenson et al., 2000; Geissler et al., 2001; Gehrke and Turban, 1999). Each dimension and its associated factors are discussed, and propositions for research are developed. The focus in the paper is on the development of the theoretical framework, as an important precursor to the empirical studies that can be built on and help evolve the theory.

An Integrated Framework

An understanding of the factors that contribute to web site complexity comes primarily from the following bodies of literature: information retrieval and relevance, largely focused on information that is available to individuals (Schneider, 1987; Borchers et al., 1998; O'Reilly, 1980); human cognition, focused on how individuals deal with information (Daft and Lengel, 1986; Shapira et al., 1999; Thuring et al., 1995); an individual's use of a communication technology (Fulk, 1993; Thompson et al., 1994; Poole and DeSanctis, 1990; Davis et al., 1989), and user-interface design, concerned with acceptable interface design issues to improve human-information interaction (Hu et al., 1999; Haas and Grams, 2000; Marshall and Shipman, 1995; Thuring et al., 1995). The three factors of content, form, and cognition are explored as an initial set of factors that may contribute to web site complexity. These factors represent a synthesis of prior web site complexity literature, providing a coherent and integrative base upon which to explore web site complexity.

Figure 1 presents the overall theoretical framework for the dimensions developed in this paper. Cognition, content, and form are all predicted to have a direct impact on web site complexity. In addition, cognition is expected to mediate content and form.

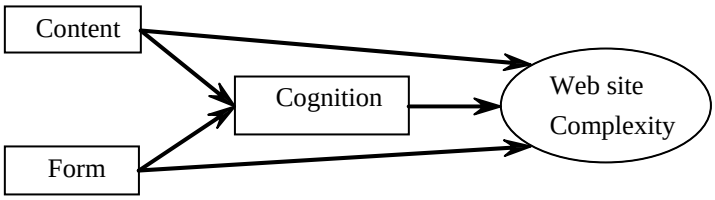

Figure 1. Causal Dimensions of Web Site Complexity

The dimensions of the framework suggest that web site complexity is both a perceived and objective construct. Web site complexity can be examined through such factors as the links between web pages and the structure of the information provided at the site (Bucy et al., 1999; Nielsen, 2000), but also through perceptions specific to an individual. Web site complexity can take on different levels for different individuals, based on how an individual ultimately perceives the web site or what the individual expects from the web site. This perception can mediate the effects that form and content have on the complexity of the web site (Te'eni, 1989; Cho and Kim, 2001). For purposes of clarity, web site complexity is represented as a single construct, consisting of both perceived and objective complexity. This does not imply that perceptive and objective measures are identical for web site complexity, but it does imply that they are interrelated. Various questions regarding web site complexity will still require an understanding of whether perceptive measures, objective measures, or a combination of both measures needs to be implemented.

Cognition Dimension

A number of studies help to define the cognition dimension of web site complexity. These studies have examined the importance of human cognition for maintaining orientation within a web site (Kahn, 1995; Thuring et al., 1995; Marshall and Shipman, 1995; Dieberger and Bolter, 1995), utilizing past experiences to determine how to interact with the current web site (Taylor and Todd, 1995; Thompson et al., 1994; Harrison and Rainer, 1992), and individual and organizational beliefs for web site use (Fulk, 1993; Daft and Lengel, 1986; Shapira et al., 1999). Each aspect of the cognition dimension is discussed below.

Mental Model and Orientation

The cognition dimension emphasizes the perceived nature of web site complexity, thus it is essential that an individual be able to develop a clear mental model of a web site. A mental model of a web site is a mental stage on which information is located, gathered, and examined. A mental model is used to identify situational relationships between units of information (Bower and Morrow 1990).

Tolman (1948) originally suggested the notion of a cognitive map to indicate routes, paths, and environmental relationships among concepts. Dillon et al. (1993) also suggested the use of cognitive maps when navigating hypertext. They discussed how cognitive maps are generally focused on navigating to a desired location rather than the value of the destination. Cognitive maps are often used to navigate a space, either physical or digital, through the use of landmarks, routes, or surveys that represent detailed spatial understanding (Cohen, 1989). All of this suggests that the formation of a clear mental model of a web site can provide better understanding and use of the available information at the site, thus reducing its complexity.

An important factor that contributes to the development of a clear mental model is web site coherence (Thuring et al., 1995). Web site coherence is the ability in a web site to provide a logical structure between nodes, i.e., web pages (Thuring et al., 1995). A logical structure is provided by useful hypertext cues in the form of hypertext links. These cues provide individuals with their current position within a web site, how they got to that position, and options for moving on from their current position (Thuring et al., 1995).

> Proposition 1: Increased web site coherence contributes to a clear mental model of a web site.

The effect of a mental model is mediated by orientation. It is through orientation that individuals know their location within a web site, how they got to that location, and where they can go from their current location. Orientation may also provide an individual with more effective information retrieval capabilities. That is, an individual who can form a mental model of the web site for navigation and searching purposes may be better equipped to locate relevant information within that site than someone who is unable to form a mental model of the site. Orientation in web sites is typically experienced in terms of the dimensions of forward/backward/up/down and an assumed node-link-node relationship between pages (Dieberger and Bolter, 1995).

> Proposition 2: The development of a clear mental model contributes to high orientation within a web site.

Proposition 3: High orientation within a web site reduces web site complexity.

Cognitive overhead can influence orientation of an individual within a web site. Dillon et al. (1994) examined prior studies that showed a relationship between comprehension and orientation. As the amount of information on a web site increases, cognitive overhead increases. This increased cognitive overhead may, in turn, result in an inability to orient within a web site or navigate through the web site (Thuring et al., 1995).

Proposition 4: Increased cognitive overhead reduces orientation within a web site.

Figure 2 summarizes the relationships for the effects and antecedents of mental models and orientation.

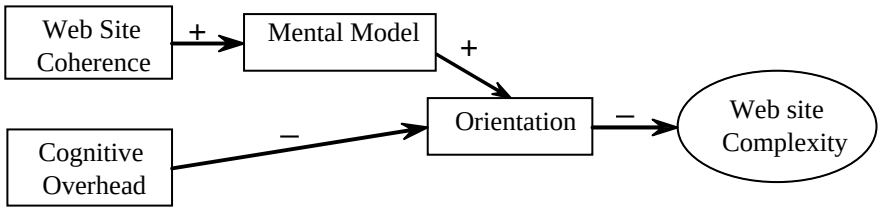

Figure 2. Effects and antecedents of mental models and orientation

Individual Beliefs

Individual beliefs play a key role in the motivation for action of an individual on various tools. Individual beliefs are influenced by many factors, including past experiences, societal influences, or organizational pressures. Fishbein and Ajzen (1975) suggest that individual beliefs are a key motivator in reasoned action. They break beliefs into two key components: descriptive and inferential. Descriptive beliefs are largely based on the acquisition of beliefs through observations. Inferential beliefs are founded on personal factors such as desires, attitudes, and personality characteristics. Beliefs play an important role in how individuals attribute observations, form attitudes, and facilitate change (Fishbein and Ajzen, 1975).

Davis et al. (1989) explore The Theory of Reasoned Action (TRA) as proposed by Fishbein and Ajzen (1975) and apply it to information systems. TRA is based on the notion that the beliefs about consequences and the evaluations of those consequences by an individual form an attitude toward a behavior. In addition, an individual's normative beliefs and motivation to comply form their subjective norms. Together, an individual's attitude toward a behavior and their subjective norms form their behavioral intention. In turn, this intention is often played out into an individual's actual behavior (Fishbein and Ajzen, 1975).

The model proposed by Fishbein and Ajzen (1975) was adapted by Davis et al. (1989) to specifically address individual beliefs and their relationship toward the use of information systems. In the adapted model, called the Technology Acceptance Model (TAM), they propose that two variables, perceived usefulness and perceived ease of use, play a key role in the use of an information system. More specifically, TAM examines individual attitudes toward an information system and their use of that system. TAM does not address the issue of subjective norms and how those may impact the use of an information system. Davis et al. (1989) found

that both perceived usefulness and perceived ease of use of an information system influenced an individual's intentions to use the system. In addition, actual use of an information system can be predicted by their intentions toward that system.

These findings apply to web site complexity because they address the issue of intent to use an information system by an individual and that individual's personal beliefs toward an information system. If an individual has high behavioral intentions to use a web site, the web site may be viewed as less complex. The findings of Davis et al. (1989) lead to two additional propositions.

> Proposition 5: Increased levels of perceived ease of use of a web site reduce web site complexity.
>
> Proposition 6: Increased levels of perceived usefulness of a web site reduce web site complexity.

While Davis et al.'s (1989) study was longitudinal, these propositions do not suggest the influence of time. That is, both perceived ease of use and perceived usefulness may change over time, as was the case with the original examination of TAM. However, these propositions suggest that an individual may have beliefs regarding a web site, regardless of time. For example, an individual may have perceptions toward a web site when faced with the task of managing a telephone account on-line. An individual may believe that the web site is not any easier to use than a telephone would be for accomplishing the same task. In this case perceived ease of use is low, resulting in higher web site complexity. An individual may also have beliefs about the telecommunications company that is managing the telephone account. If an individual's experience with the company has been poor in the past, the customer may not believe that the company web site will be more useful for managing a telephone account than how it is currently handled. In this case, perceived usefulness may be rated low, resulting in higher web site complexity. Figure 3 represents the relationships between perceived ease of use and perceived usefulness and web site complexity.

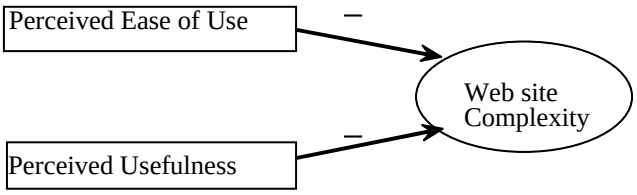

Figure 3. Impact of percevied ease of use and perceived usefulness on web site complexity

Group Affinity

TAM does not address the role that subjective norms play in the development of behavioral intentions (Davis et al., 1989). Instead, the model examines the beliefs and evaluations of an individual and how these translate to behavioral intentions. There may be

situations where technology use is not only determined by individual beliefs and voluntary actions, but by the group in which an individual works.

Stemming from influence that a specific group leader may have on an individual, Fulk (1993) proposes that the affinity of an individual toward one particular group will result in the development of individual technology usage behaviors. Fulk (1993) found that organizational group influence on an individual greatly impacted the way an individual gains meaning toward a communication technology, especially when the individual had a high affinity toward the group. If organizational groups are inclined toward specific web sites for information retrieval and exchange, individuals with high affinity toward those groups are likely to experience lower perceived web site complexity.

> Proposition 7: Increased individual affinity toward an organizational group reduces perceived web site complexity in sites often visited by that group.

An example of the effect of group affinity on web site complexity is the use of a corporate Intranet. An Intranet is a series of web sites internal to an organization. Members of particular departments within an organization often have web sites designed specifically to their needs for information exchange, information retrieval, and member communication. New members to a department may be inclined toward the normal practices of other department members. Van Aken et al. (1994) suggest an increase in shared information, problem solving, and trust can result though the development of teams solely based on members' affinity toward other members. Figure 4 depicts the effect of group affinity on web site complexity.

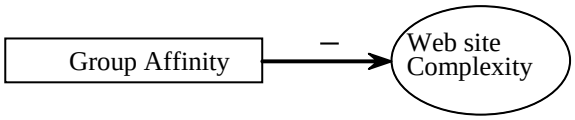

Figure 4. Impact of group affinity on web site complexity

Figure 5 represents all the factors in the cognition dimension of web site complexity, as developed in the previous sections.

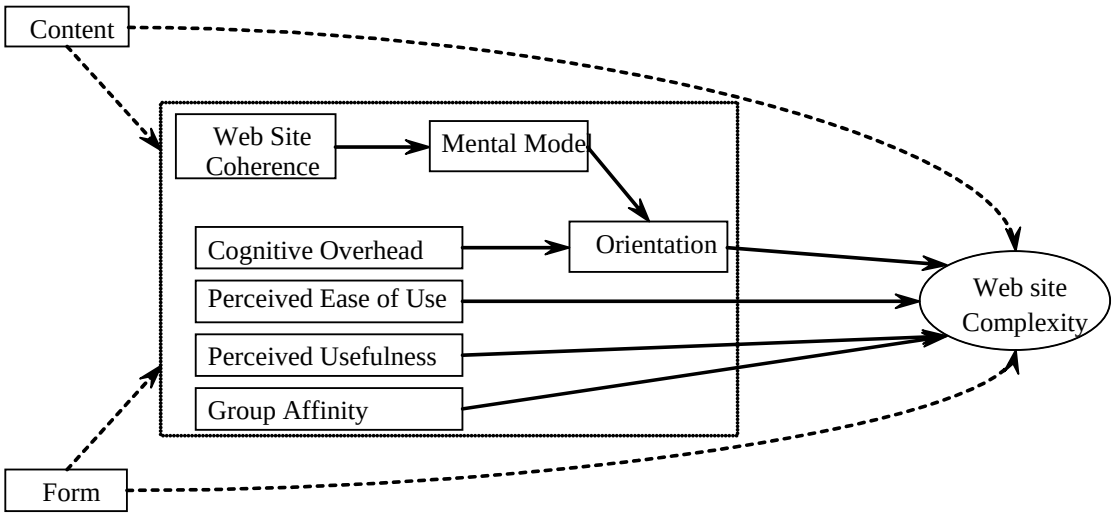

Figure 5. Factors in the Cognition Dimension of Web Site Complexity

Content Dimension

Web site complexity is not only the result of perceptions of an individual, but also of the information located on the web site. The nature of information is important, in that it is one of the causes of information overload (Thuring et al., 1995). Information overload is a complex set of components that include (1) the nature of the information, (2) organizational conditions, (3) environment, (4) symptoms, (5) adaptive processes, and (6) maladaptive processes (Schneider, 1987). In particular, the nature of information that is available at a web site can have varying certainty, ambiguity, novelty, complexity, and intensity (Schneider, 1987).

Information uncertainty is often referred to as the relationship between the amount of information needed and the amount of information available (Daft and Lengel, 1986). Information ambiguity is the number of ways that the same piece of information can be interpreted (Daft and Lengel, 1986). Information novelty is the ability (or inability) of information to fit a particular schema (Kiesler and Sproull, 1989). Information complexity refers to how a group of information is related to other groups of information (Driver and Streufert, 1969). Finally, information intensity is the rate at which information is available (Dutton et al., 1983).

For the purpose of web site complexity, information complexity and information ambiguity are the most important factors discussed by Schneider (1987). The other aspects of information are not as relevant because they are information characteristics that may represent functions of hardware components (information intensity), they are characteristics that have been discussed earlier in the development of cognitive factors impacting web site complexity (information novelty), or they relate more specifically to individual needs (information uncertainty). Thus, the focus in this model is on equivocality and ambiguity.

Kiesler and Sproull (1982) suggest that information ambiguity may result in the ineffective use of information. If information located within a web site does not have a clear purpose, the complexity of the web site increases. The impact that the addition of ambiguous information has on web site complexity is mediated through the cognition dimension. Information ambiguity may impact the cognitive overhead of an individual, thereby impacting web site complexity.

Proposition 8: Increased ambiguity of information increases web site complexity.

An example of information ambiguity would be the case of changing telephone service at a large telecommunications company web site. In this example, ambiguous information at the site may include information about accessories, wire-line services, or new product development. This information is not directly relevant to the task of changing services to a telephone account, and thus adds to the ambiguity, and ultimately, complexity of the web site.

In addition to information being ambiguous, information may be interrelated. By relating one item of information to numerous other pieces of information, the information complexity increases (Driver and Streufert, 1969). In the case of web sites, information can be extensively interrelated with other information, whether relevant or not. How information is interrelated across a web site is an objective characteristic of the site and therefore impacts web site complexity *directly*.

Proposition 9: Increased interrelatedness of information increases web site complexity.

In the telecommunications example, the information needed by a customer to make a change to telephone service is finite. By placing that finite—and related—information across multiple web pages in multiple locations, the complexity of the site increases.

In addition to information ambiguity and complexity as proposed by Schneider (1987), information equivocality may result in the inability to access information in order to use it effectively (Kiesler and Sproull, 1982). Information equivocality refers to the ability of information to have more than one interpretation. As information may have multiple interpretations, individuals may have difficulty interpreting the information for use within their schemas. An increase in equivocality of information may result in higher cognitive overhead, thereby increasing web site complexity, mediated through cognition.

Proposition 10: Reduced equivocality of information reduces web site complexity.

Returning to the example of making changes to a telephone account at a web site, this process requires navigating numerous web pages, each of which presents information that is intended to help the customer. The customer must interpret the information provided by the company in order to successfully navigate to the location that will allow for service changes. During the navigation process, information at the site is not always interpreted as intended by the company. Equivocal information, in this case, could be a web page that contains a form for service change requests. The information at this page may be specific to a business customer, but the form may be interpreted as handling all (business and private) change requests. While the customer may ultimately find the location within the web site that is capable of handling the private request, the form containing information with high equivocality has increased the complexity of the web site.

Form Dimension

In addition to the content of a web site influencing complexity, the structure of the web site can play a role. Numerous studies have been published on user navigation in computer applications (Ukelson et al., 1993), navigation though the web (Rumpradit and Donnell, 1999), interface designs for information retrieval systems (Hu et al., 1999), and infrastructure designs for large information spaces (Star and Ruhleder, 1996). These studies provide the relevant factors for the form dimension of web site complexity, including both direct effects and indirect effects as mediated by cognition.

Bucy et al. (1999) defined formal features of a web page that correspond to an increase in web site traffic. They examined such features as banners, page structure, dynamic elements, graphical elements, and interactive elements. The findings suggested that page structure (frames and page maps) were strongly correlated with the amount of traffic to a web site. As the web site structure improved by using frames and page maps, and by keeping page sizes small, the amount of traffic to the site would increase (Bucy et al., 1999). These findings suggest a relationship between web page structure and web site complexity. Similar to information interrelatedness,

web page structure is viewed as an objective characteristic of a web site based on design criteria (Bucy et al., 1999), not mediated by cognition.

Proposition 11: A well-designed web page structure decreases web site complexity.

Similar to web page structure, web site structure is an important objective characteristic in the definition of web site complexity. Web site structure is concerned with the objective characteristics of total number of a web site (Bucy et al., 1999), similar formatting between web pages, and consistent interfaces for similar tasks across the web site (Gehrke and Turban, 1999; Nielsen, 2000; Shneiderman, 1998).

Proposition 12: A well-designed web site structure decreases web site complexity.

In addition to site and page structure, hyperlinks can contribute to reduced web site complexity by having information within the hyperlink. Since people typically do not know the destination to which a link will take them, an intelligent link can provide previews of the destination, provide knowledge about interrelationships between information units, and increase coherence of the web site (Oinas-Kukkonen, 1998).

Proposition 13: Intelligent hypertext links reduce web site complexity.

Figure 6 summarizes the factors in the content and form dimensions of web site complexity.

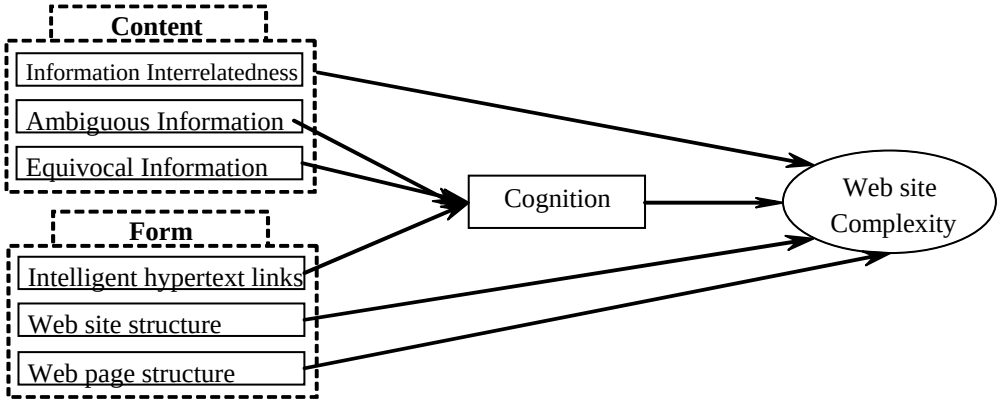

Figure 6: Factors in the content and form dimensions of web site complexity

Discussion and Conclusions

Table 1 summarizes the key causal factors that are used to define web site complexity, as developed in this paper. The table shows the dimensions that were proposed to represent the causal components of web site complexity, with examples of use of the factors in prior research. Further research is needed to determine whether the proposed dimensions are comprehensive

enough to define web site complexity, or whether a more parsimonious set would be just as useful.

Dimension	Examples of Use in Past Research	Related Propositions
Cognition	Cognitive maps for navigating hypertext (Dillon et al., 1993) Navigation through landmarks, routes, and surveys (Cohen, 1989) Relationships between hypertext pages (Dieberger and Bolter, 1995) Orientation as coherence and cognitive overhead (Thuring et al., 1995) Relationships between comprehension and orientation (Dillon et al., 1993)	1-4
	Beliefs as a key motivator of reasoned action (Ajzen and Fishbein, 1975) Perceived Ease of Use and Perceived Usefulness (Davis et al., 1989)	5-6
	Member affinity toward groups (Fulk, 1990)	7
Content	Information overload (Schneider, 1987) Information ambiguity (Kiesler and Sproull, 1989) Information complexity (Driver and Streufert, 1969)	8-10
Form	Web page structure related to web site traffic (Bucy et al., 1999) Web site design issues (Gehrke and Turban, 1999) Intelligent links to improve navigation (Oinas-Kukkonen, 1998)	11-12

Table 1. Summary of Causal Factors in Web Site Complexity

Some issues are not addressed in the framework, the most notable being time and its effects as well as the relative strength of the proposed dimensions and factors. Time can play a key role in how web site complexity is formed. The purpose of this paper was to propose causal factors that are not dependent on time, in order to provide a starting point for a rich examination of web site complexity. Such issues as experience and use may play key roles in determining how web site complexity evolves over time. These issues can be captured in future versions of the model, but they bear brief discussion here.

Beliefs and attitudes toward a technology will be more strongly correlated with behavior when an individual has direct experience with that technology (Regan and Fazio, 1977; Fazio and Zanna, 1981). Some studies have examined the application of the Technology Acceptance Model with inexperienced users (Taylor and Todd, 1995), the influence of experience on computer skill (Harrison and Rainer, 1992), and the influence of experience on computer utilization (Thompson et al., 1994). Experience had a direct effect on computer utilization as well as being a moderator for other factors (Thompson et al., 1994).

In addition to time and experience, the impact of the relationships between the dimensions may vary across contexts. The ties between the three dimensions, as well as the relative strength of an individual dimension in determining web site complexity likely varies across contextual settings. Web sites provide a broad range of interfaces to a broad range of information and how the relationships in the proposed framework are maintained across web sites likely varies. For example, the degree to which information interrelatedness (part of the content dimension) directly impacts web site complexity in a public forum web site versus a personalized medical history web site is probably different.

The task that a web site is used for may play an important role in complexity. If the

information provided on a web site is inappropriate to the task, web site complexity may increase. For example, search engines are often used to find information appropriate to a task; however, search results are rarely optimal and require further examination by the user. The less appropriate the resulting pages, the more complex the user may perceive the situation to be. On this issue, web sites are available, not only through traditional desktop web browsers but through a variety of handheld and wireless devices. The characteristics supported by the technology may also play a key role in the determination of web site complexity, particularly when those characteristics interact with a specific task (Zigurs and Buckland, 1998).

The theoretical framework presented in this paper makes several contributions. The framework provides a better understanding of the factors that are expected to contribute to web site complexity. While single factors may have been addressed independently in prior literature, this framework brings them together for the first time in the articulation of the web site complexity construct. Because the framework was developed from a variety of sources in the literature, it provides an integrated and more comprehensive view of complexity factors. That view takes into account both perceived and objective characteristics of web site complexity. There is ample foundation for testing the framework, as well as developing measures for the constructs. As the web becomes the communication channel of choice for a wide variety of collaborative activities, knowing what factors influence the complexity and hence use of web sites is a fundamentally important endeavor.

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