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Standards Directory: An Engineering and Technology Standards Digital Library and Information Retrieval System for The Walt Disney Company

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by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

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We hereby certify that this dissertation, submitted by Shawn O. Harrs, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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Walt Disney Company (Company) engineers and architects utilize engineering and technology standards in the design, development, and maintenance of its physical infrastructure worldwide. There was a need to improve the methods by which Company standards are organized and retrieved. While the leading commercial information brokers for engineering and technology standards provide standards search engines and online standards catalogs, these search services are poor in supporting standards seekers who have only a general understanding of their information needs because their searches only utilize a standard's document number, title, and keywords as metadata for searching.

In order to provide a tool for distributing and retrieving standards in an online environment that fulfilled the needs of Company engineers and architects, the Standards Directory, a digital library and information retrieval system, was developed with two main features in mind: categorization and search. First, the Standards Directory utilizes an engineering and technology taxonomy to provide grouping and classification of standards. Second, the Standards Directory supports various forms of search and improves the overall relevance of search results by, among other things, providing stem word full-text searching and browsing capabilities within disciplines.

A study was conducted to investigate the effectiveness of the Standards Directory compared with leading commercial information brokers of engineering and technology standards. The study found that the Standards Directory provided a higher level of relevance of search results as established by end-user relevance judgments made by Company engineers and architects seeking information for their actual information needs. Standards-based engineering, architectural, and other high technology organizations may benefit from the implementation of a Standards Directory as it can increase employee productivity, improve product quality, enhance the accuracy of organizational decision-making, and foster organizational learning.

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In Memoriam
Noel Kenneth Webster
* 9th September, 1915 † 28th June, 1997

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Chapter 1

Introduction

Leading management and organization theorists have established in the literature the concept of treating organizational knowledge as a valuable strategic asset (Brown & Duguid, 1991; Davenport, Jarvenpaa, & Beers, 1996; Drucker, 1991; Nonaka, 1994). In today's economy, organizations must efficiently and effectively create, locate, capture, and share their organization's knowledge and expertise, and have the ability to leverage that knowledge when solving problems and exploiting opportunities. As a result, the implementation of knowledge management processes and technologies has grown significantly, as organizations adopt knowledge management as part of their overall business strategy (Sunassee & Sewry, 2002, 2003).

Knowledge management (KM) focuses on connecting people with each other and people with information in an effort to achieve competitive advantage in business (Hoyt, 2002). The intersection of these connections is where creativity leads to innovation and thus establishes competitive advantage. Knowledge or expertise is contextual and ranges in form from tacit (experiential) knowledge to explicit (physical) knowledge. Polanyi (1958) introduced the notion of tacit knowledge, which is defined as knowledge that is difficult to document or convert into procedures because it is highly personal, gained from experience, not easily visible or expressible, and usually requires joint, shared activities in order to transmit it. Examples of tacit knowledge include techniques and insights gained from personal experiences and interactions. Nonaka and Takeuchi (1995) define explicit knowledge as knowledge capable of being articulated in formal language such as grammatical statements, mathematical expressions, specifications, and manuals. Such explicit knowledge, they conclude, is easily transferred between individuals. Choo (1998) suggests that explicit knowledge is knowledge that is made manifest through language, symbols, objects, and artifacts. Explicit knowledge can further be object based, that is, found as patents, software code, databases, technical drawings and blueprints, chemical and mathematical formulas, business plans, and statistical reports, or rule based, that is, expressed as rules, routines, and procedures (Stenmark, 2002). Choo observes that organizations tend to depend primarily on this sort of explicit and articulated knowledge, formalized in documentation and used in decision-making processes, or institutionalized as operating procedures.

Critical to successful employment of explicit knowledge is the provision of an effective means for its retrieval. To accomplish this, organizations utilize the lessons learned approach whereby knowledge is captured, codified, and subsequently incorporated into standards of practice aimed at improving the successful outcome of organizational objectives. Kruizinga, Heijst, and Spek (1996) assert that organizational learning should be a managed process aimed at knowledge creation, distribution, combination, and consolidation, as well as the application of knowledge. Further, Alavi and Leidner (1999) find that browsing and retrieval are one of three dominant technology tools to have emerged in the development of knowledge management systems (KMS) and that organizational intranets also play a dominant role in support of a business's internal KM activities.

The Walt Disney Company (Company) has developed several hundred internal standards that are used in the design, development, and maintenance of its physical infrastructure worldwide. All of the infrastructure the Company builds meets a stringent set of standards that reflect not only the Company's many years of theme park experience, but also state laws and standards set forth by some of the world's most respected standard setting organizations (Breitenberg, 1987), including the American National Standards Institute (ANSI), the American Society for Testing and Materials (ASTM), the National Electrical Code (NEC), the American Welding Society (AWS), the National Fire Protection Association (NFPA), the Society of Automotive Engineers (SAE), and the American Society of Mechanical Engineers (ASME).

Standards and laws address numerous aspects of the Company's engineering and technology design and development, from the materials selected for design and construction to an amusement ride's characteristics and safety features. The Company continuously develops new standards through processes designed specifically to help leverage the Company's collective knowledge and capture key learning from the work the Company does every day.

As early as the first century BC, Marcus Vitruvius Pollio, a Roman writer, architect, and engineer, documented architectural theory and practice in what are perhaps the first documented standards in the architectural discipline (Atkinson, 1995). The National Standards Policy Advisory Committee defines a standard as "a prescribed set of rules, conditions, or requirements concerning definitions of terms; classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices" (Cerni, 1984, p. 10).

A Company standard under consideration for use undergoes a rigorous peer review process. Once approved, Company-specific standards are archived electronically in the Company's electronic document management system (EDMS) in the standard's original file format, Microsoft Word, as well as Adobe's Portable Document Format (PDF). The Company developed the EDMS system in use specifically for the archiving of its engineering and architectural drawings. As such, the EDMS system's hierarchy for organizing documents focuses on property location, that is, to which facility or infrastructure within the Company a given document belongs. The EDMS system then organizes documents by document type or application for a given location, such as a themed illustration, an architectural rendering, or an engineering computer aided design (CAD) drawing.

As standards have Company-wide applicability and are used at multiple locations, the EDMS system has not provided a means for accessing standards that is congruous with the manner in which they are used. As such, the Company business units that design, develop, and maintain the Company's physical assets needed to improve the methods by which Company standards are organized and retrieved.

Many recent contributions to the literature propose generic methods for developing digital libraries (McCray & Gallagher, 2001) that utilize information retrieval and metadata schema standards, such as Z39.50 and Dublin Core (Bainbridge, Thompson, & Witten, 2003; Dushay, 2002; Hill, Janée, Dolin, Frew, & Larsgaard, 1999).

However, these methods do not provide a succinct means for grouping or classifying documents.

Matylonek and Peasley (2001) have proposed a Web-based database for tracking standards in a library due to their assertion that collections of engineering and technology standards are difficult to organize and manage in technical libraries. Libraries often catalogue standards from an issuing organization as a collection or document series, and, as such, provide no information about individual standards, an observation also made by Taylor (1999). However, in addition to a lack of classification of individual standards, Matylonek and Peasley's proposed approach fails to provide full-text retrieval capabilities. There has been no succinct contribution to the literature in which a digital library utilizes a taxonomy to provide grouping and classification of engineering and technology standards in an effort to augment full-text standards searches. This combined approach has improved the relevance of search results by increasing the relevance to end users of search results and by providing the ability to narrow searches to specific engineering and technology disciplines.

Problem Statement and Goal

Current methods used to organize engineering and technology standards within the Company's EDMS system are not congruous with the manner in which they are used in practice, which, in turn, was causing deficient retrieval for end users. Further, existing commercial engineering and technology standards search engines, such as Information Handling Services' (IHS) Global Engineering Documents, GlobalSpec's Engineering Search Engine, Thomson's Techstreet, and ANSI's National Standards Systems Network, only utilize a standard’s document number, title, and keywords as metadata for searching. As such, the ability to perform general and exploratory information searches for standards with these search providers is deficient due to a lack of full-text searching capabilities. The Standards Directory, an engineering and technology standards digital library and information retrieval (IR) system, that was developed for this study, utilizes the Company’s engineering and technology project-work-breakdown-structure (see Appendix A) as its taxonomy for the categorization of standards into appropriate engineering and technology categories and disciplines. Further, the Standards Directory has improved the overall relevance of search results of engineering and technology standards by, among other things, providing full-text searching capabilities.

Relevance and Significance

There were several reasons for developing the Standards Directory. For example, engineers and architects have used the Internet and commercial search tools as information systems for reference and research of engineering and technology standards. Interpreting and analyzing the deficiency of results these information systems provide aided in addressing the information retrieval needs of technical information users with specific needs. Furthermore, technical information users are called upon with increasing frequency to retrieve information quickly, offer information analysis, and provide searching expertise. In addressing these issues, the study analyzed user search behavior in the domain of engineering and technology standards in an effort to improve retrieval relevance, efficiency, utility, and user satisfaction (Su, 1998) as well as to provide an efficient, effective Web-based interface for user navigation and search results.

A user-based evaluation of search engine results also addresses the degree to which users' needs are met by the system (McClure, 1994, p. 594). Allowing searchers with varying levels of domain knowledge to search for work related information in an effort to determine the relevance of search results has provided a more accurate picture of how end-users view results, determine relevance, and use search engines. For example, the results that searchers with a high or low domain knowledge (Wildemuth, 2004; Zhang, Anghelescu, & Yuan, 2005) or the information retrieval system itself deems highly relevant may not be the same results a novice searcher might find highly relevant.

Because user relevance is subjective, the searcher is ultimately the best judge of his or her own needs and expectations (Schamber, Eisenberg, & Nilan, 1990). Jansen and Pooch (2001) suggest that information scientists are not certain how searchers conduct the search process. The observations gathered in this study on the characteristics of searchers can clarify how typical users search for information on the Web. With this knowledge, a better understanding of how engineers use this resource independently will aid computer scientists in designing retrieval systems that are more intuitive.

As global markets continue to grow, standards gain in importance as companies must ensure that their products comply with standards from foreign countries (U.S. Congress, Office of Technology Assessment, 1992). Nonetheless, as different market places adopt different standards, organizations are required to develop variations of its products to comply with the standards for each of the markets in which it operates. In order to reduce these barriers to trade, international standards have been developed for use throughout the world. This is particularly important for the Company, as efficiencies offered by standards reduce product development costs in the many countries in which it operates. However, where markets have adopted varying standards, the categorization of engineering and technology standards by discipline provides a method to evaluate comparable standards independent of the publishing organization, thus providing the ability to determine more easily the requirements needed to customize products for specific markets.

The engineering and technology taxonomy used in the Standards Directory addresses several issues related to IR in an, as yet, unaddressed domain and focused on the importance of providing high-quality IR capabilities to technical information users with specific needs. By addressing these issues, the Standards Directory provides an efficient method for retrieving information in a specific knowledge domain consisting of various engineering related disciplines. This was achieved by improving the relevance of search results over existing standards-based IR systems in addition to providing an efficient, effective Web-based interface for user navigation and search results.

The significance of providing improved retrieval capabilities to engineers and technical standards users stems from the importance of incorporating standards in product design and development. Standards aid organizations in the preservation of investments and enhance product development and service quality (Bergner et al., 2000). Engineering organizations are diverging from proprietary solutions as these strengthen the dependency on a single provider or process. In particular, the Company's operation in international markets requires cooperation with foreign firms in a coordinated effort to strive for standard solutions for new or existing technologies. The strong impact of standards to enhance interoperability also drive these activities. As the Company continues to seek interoperability as the answer to competitive advantage, standards gain a greater part of the solution. Further, beyond the Company's specific organizational needs, standards-based engineering, architectural, and other high technology organizations may also benefit from the implementation of a Standards Directory. A broader, more pervasive use of standards in an organization as well as the integration of standards into a product's design can increase employee productivity, improve product quality, enhance the accuracy of organizational decision-making, and foster organizational learning (Argote, 1999; Girczyc & Carlson, 1993; Rolfe, 1998; Rus, Lindvall, & Sinha, 2002). The Standards Directory can help accomplish this by providing a platform for the categorization of organizational knowledge that has been captured and codified, whether as standards, operating procedures, or best practices, and provides not only an effective means for their retrieval but also allows the organization to assess where additional knowledge may need to be captured.

Barriers and Issues

Information retrieval has provided academia and the information sciences with many challenging research tasks (Kobayashi & Takeda, 2000). Achieving high precision and accuracy in information retrieval is difficult, even for well-organized digital libraries. The combination of search methodologies, including the use of document metadata, document categorization, search algorithms, database thesauri, semantic analysis, and artificial intelligence aided learning have shown to improve free text retrieval precision and accuracy of unstructured documents (Boyan & Moore, 2001; Cutrell & Dumais, 2003; Guha, McCool, & Miller, 2003; Larkey, 1999; Lawrence & Giles, 1998). With this, the Standards Directory was developed with a focus on combining manual document categorization, metadata, and stem word full text search capabilities to achieve improved relevance for standards searches than currently available title searches provide. Kobayashi and Takeda assert that by using “a simple metadata standard (such as the Dublin Core), the precision of information retrieved by search engines is expected to improve substantially” (p. 155). However, limitations in the metadata capabilities employed by the Standards Directory may limit or prevent some forms of document information from being gathered and subsequently may be contribute to retrieval precision and accuracy levels that fall short of what could be otherwise achieved. Further, Sebastiani (2002) asserts that automated text categorization (TC) has reached effectiveness levels comparable to those of trained professionals and are growing at a steady pace while the effectiveness of manual TC is not perfect and, more importantly, it is unlikely to improve substantially by the progress of research. Nonetheless, having identified these possible limitations has provided the potential for future research and improvements to the system’s design.

Traditional measures for the evaluation of information retrieval systems, which are based on the relevancy of the retrieved output, may only be a partial match of users’ objectives and of the systems’ objectives (Johnson, Griffiths, & Hartley, 2003). Factors other than the recall and precision of output may influence a user’s judgment of search success. Such factors are likely to be related to the degree to which the system meets its objective to facilitate and maximize the value of a user’s search efforts. Johnson, Griffiths, and Hartley assert that users’ evaluation of a retrieval system is a multidimensional construct based on the user information searching process that the system seeks to support. As such, the ultimate test of success of an IR system must be the fulfillment of a user's information needs within a user's constraints (e.g. search time, cost vs. value, etc.). This means that a successful outcome is uncertain until a user's needs are met. Measurement of the utility or the subjective satisfaction of a user, the utility of the information gained, and a user's perception of informativeness must be considered due to the subjective nature of such judgments.

Finally, as the scope of applicable standards categories and subsequent subcategories had not been assessed previously, the study sought to determine whether there are additional categories that need to be added to the taxonomy. The system was designed sufficiently flexible to accommodate additional categories.

Research Questions to be Investigated

This study addressed the following research questions:

1. Can document categorization, the use of metadata for browsing, and document full-text searching improve the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines?
2. What are the strengths and weaknesses with respect to end-user searching of the Standards Directory compared with the commercial engineering and technology standards search engines utilized in this study?

Summary

This chapter introduced problems that stem from the ineffectiveness of engineering and technology standards search engines. Specifically, current commercial engineering and technology standards search engines and the Company's EDMS system do not meet the information-seeking needs of Company engineers and architects. An investigation was performed to determine how IR system design features such as document categorization, the use of metadata for browsing, and document full-text search can improve the retrieval effectiveness of engineering and technology standards in order to better support their standards seeking needs. This study also investigated how such IR system design features can be more effective in supporting standards retrieval for Company engineers and architects compared with current commercial engineering and technology standards search engines. Effectiveness was measured in terms of the relevance of search results as established by end-user relevance judgments made by Company engineers and architects seeking standards and related technical information for their day-to-day information needs. The preceding discussion of the problem, relevance, significance, and barriers and issues for this study lead to a review of related literature.

Chapter 2

Review of the Literature

Introduction

Over the past 20 years, the study of information retrieval has evolved beyond its primary goals of indexing text and searching for useful documents in a collection (Baeza-Yates & Ribiero-Neto, 1999). Today, research in information retrieval includes modeling, document classification and categorization, systems architecture, user interfaces, data visualization, filtering, languages, and many other areas of inquiry.

The Web has evolved into a ubiquitous, universal repository of human knowledge, providing a means for the rapid dissemination of ideas and information. Ease of access is based on the conception of a standard user interface that is always the same no matter what computational environment is used to run the interface. As a result, the user is shielded from details of communication protocols, machine location, and operating systems. However, the ease with which information can be published on the Web presents problems and frequently makes finding useful information a tedious and difficult task. For instance, to satisfy an information need, a user might search for information of interest using Web links. However, since the Web is vast, almost unknown, and not entirely connected, such a navigation task is inefficient. For technical information users, the problem becomes more cumbersome when the information sought cannot be defined in specific terms, which may cause their research efforts to be incomplete. The main obstacle is the absence of a well-defined underlying data model for most of the information accessed by information retrieval systems, which implies that organizing information, by providing mechanisms for definition and structure, can improve search engine effectiveness.

A review of current information system research on various topics related to the organization of, searching for, and finding information brings the literature concerning search engines and technical information users into focus. These topics are broad and encompass themes integral to information science itself, such as taxonomies, expertise, relevance of information, and information technology literacy. However, this body of literature will form the basis for understanding the interaction of technical information users and information retrieval technologies.

The following sections provide an overview of the theory and research literature specific to the topic, including the benefits of taxonomies, retrieval methods for high precision and accuracy, technical information and expertise in information retrieval, and end user search strategies. The chapter will conclude with a summary of the contribution this study will make to the field.

The Benefits of Taxonomies

Bruno and Richmond (2003) define taxonomy as “a hierarchical classification of headings constructed using the principles of classification, and a thesaurus supplies the commentary and links to navigate the taxonomy” (p. 45). Bruno and Richmond assert that taxonomies support information management and retrieval in the areas of identification, discovery, and delivery.

Taxonomies aid in controlling volumes of information by providing an association between information that is similar and support filtering, categorizing, and the labeling of information. Further, additional information on a topic can be inferred by determining where an entry is placed in context within the taxonomy. As such, a taxonomy built on a solid foundation can further serious investigation and learning. When a common language or terminology is employed, it facilitates communicating ideas, findings, discoveries, and events. Taxonomies provide this common language and allow new discoveries to be identified, catalogued, and mapped (Price, Small, & Baecker, 1993).

Taxonomies are also used to structure, organize, and classify related concepts. Taxonomies aid in identifying areas where a new discovery is, in fact, a repositioning of a current idea or a refinement or variation of an existing concept. For example, Dimitrij Mendelejeff (1869) published a table in which the elements that were known at the time were arranged by increasing atomic mass, and grouped into columns according to their chemical properties. In doing so, Mendelejeff demonstrated that the properties of the elements varied in a periodic way. He noticed that when the elements were grouped by their properties, there were some missing elements that he predicted would correspond to undiscovered elements. He was able to predict some of the properties for two of these, which corresponded to Gallium (discovered in 1875) and Germanium (discovered in 1886). Similarly, the use of an engineering and standards taxonomy can provide organizations with the ability to analyze the need for the adoption of standards in the development of its products. Finally, a taxonomy can improve the retrieval process using the taxonomy's controlled vocabulary by enhancing searching via browsing or by limiting searches to specific topics. The use of navigation paths, also known as breadcrumbs, based on a taxonomy's hierarchy provides context and enhances searching via free text. For example, if a free text search returns 100 results for the word "torque," the navigation path for each result provides the context required to show whether the record refers to engine torque, fastener torque, or torque wrenches. It is not necessary to open each returned record to determine the context in which the word torque is used. Similarly, some cases may require that the searcher perform "word sense disambiguation" (Sebastiani, 2002, p. 7), whereby the searcher must determine, given the occurrence in a text of an ambiguous (i.e., polysemous or homonymous) word, the sense of this particular word occurrence that is distinguishable from other meanings potentially attributable to that word. Document categories support the searcher with this task as categories provide a means to assign each occurrence of a word to the appropriate sense (Ide & Véronis, 1998).

Technical Information and Expertise in Information Retrieval

Expertise and its origin is a widely discussed topic in the literature (Olmstadt, 2000). It is widely understood in the literature that the development of expertise relies on previously acquired skills (Howe, Davidson, & Sloboda, 1998) that allow some subjects to be more successful. Ericsson and Charness (1997) define an expert as a subject whose usual tasks are representative of an activity, a function, or a domain. Duration and repetition of the tasks are two conditions of expertise building. As such, many years of performing an activity in a precise domain forms the main condition for a real expertise. Marchionini (1995) asserts that information seeking is a fundamental human process closely related to learning and problem solving. With this, Marchionini proposes that information retrieval system interface design should allow an information seeker to determine which strategy is most applicable to their information needs by providing information seekers with alternative interface mechanisms for displaying and manipulating retrieval results with multiple levels of representation. Further, Zhang, Anghelescu, and Yuan (2005) found that as the level of domain knowledge increases, IR system users tend to change their search behavior, such as using more terms in queries or using more query manipulation features to search for relevant documents. As such, the Standards Directory incorporates search manipulation features that, for example, allow users to limit their initial search or their search results to specific engineering disciplines.

Retrieval Methods for Improved Relevance

Text retrieval can be divided into conceptual, linguistic, and statistical approaches, each of them focusing on different parts of the same problem (Aronson, Rindflesch, & Browne, 1994). When combined, these approaches complement each other. The statistical approach is based on word frequencies and the statistical properties of those frequencies. The linguistic approach handles different levels of natural language, especially morphology and syntax. The conceptual approach draws attention to conceptual rather than morphological or syntactical relations between words. Typical problems of text retrieval caused by natural language are, for example, one concept that might be expressed by many different words (synonyms) and one word or expression that might refer to different concepts (homonyms). In order to improve low recall and precision due to issues that arise as a result of user vague or ambiguous search terms in relation to the actual information sought, free text searching requires that sufficient and appropriate synonyms, quasi synonyms, and antonyms are identified for the concepts describing the search topic. As Bates (1986) notes, “The variety of query formulation must be as great as variety of document description for successful search” (p. 362).

In developing a text-mining system for scientific literature, Müller, Kenny, and Sternberg (2004) utilized the full text of scientific articles and categories of terms against which articles and individual sentences can be searched. The authors found that limiting keyword searches to specific categories improves precision when searching for keywords in the full text of an article as opposed to searching its abstracts. Blaschke and Valencia (2001) also found that access to the full text of articles is important to searches, as they are critical to providing sufficient coverage of facts and knowledge in the literature and for their retrieval. Limiting keyword searches to abstracts reduces recall due to the constraints of the information concentration imposed by a word limit, which makes it unlikely for keywords for some specific types of data to appear in abstracts but in turn appear in a document’s full text.

Müller, Kenny, and Sternberg (2004) also found that the precision of a keyword search is reduced by almost 40% when searching full text compared to abstracts. The authors also note that searching of a full text corpus of documents utilizing a single keyword returns a large number of irrelevant results for most searches. They attribute this higher false positive rate to the writing style found in full text, where facts can be expressed within complex sentence structures (as compared to abstracts, where authors are forced to compress information), combined with the inability of a keyword search to capture context. However, the precision of a keyword search can be increased by searching for combinations (synonyms) of keywords, but since there are many potential ways to describe the same concept or entity, the authors suggest that a synonym search be used that automatically includes synonyms for a given term in a search.

End User Search Strategies

Based on analogies from Janes (1989) and Leimkuhler (1968), Meadow, Boyce, and Kraft (2000) define "the known item search, the specific information search, the general information search, and a search to explore" (p. 273) as four generic types of search used to retrieve information from a database. Knowledge of what is being sought range from specific, in the case of known item searches, to vague, in the case of exploration searches. The authors use the term record to denote a single document or entity of information retrieved from a search.

The known item search is used when a single entity of information is needed and a specific descriptor is available with which the needed entity of information can be uniquely defined. It is also used when the searcher knows of a particular information entity, but does not know where it is. Known-item searching is an important information seeking activity that has recently gained increased attention in the information retrieval community (Ogilvie & Callan, 2003). Known item searches are typically used in expert or topic specific information retrieval systems. For example, a standard number can be used to search an online standards library to retrieve a known standard. This type of search has the benefit that if a user is using the right information source it does not require the user to find more than a single result with the desired information and, as such, avoids the difficulty of finding the necessary information among a significant amount of unwanted or unnecessary information.

A specific information search utilizes one or more descriptors that define a specific or relatively narrow scope of needed information. While a user may not be certain which descriptors to use, some descriptive attributes or values about the needed information are available to the user. This type of search is also common in expert and topic specific systems as underlying metadata provide support for retrieval accuracy and efficiency (Zhang & Dimitroff, 2004). This type of search strategy can also be effective when content is categorized or associates self-describing metadata with full-text content. An example of a specific information search would be a search for a standard on a specific topic using the document title as the underlying metadata for the search.

A general information search is used when information on a general subject is needed, such as information about composite metals. There is neither a single way to describe the subject nor to represent the desired information. As such, a user may not recognize an applicable record even if it is part of the search result. Further, the user cannot expect to find all of the desired information in a single document or record. When performing these types of searches users often need to perform multiple searches to determine what information is available on a given subject. In doing so, a user should continually revise the attributes and values used in the search query.

The least specific of the four search strategies, in terms of information sought, is the exploratory information search. The goal of this search strategy is to find out what kinds of information are available in an IR system, similar to browsing a library or bookstore.

The first three of Meadow, Boyce, and Kraft's (2000) search strategies seek information on a specific item, a specific topic, or a specific subject, respectively. The authors note that, in particular, type two and type three search strategies may require commencing with an exploratory type four search to determine the availability of the information sought in the IR system. As such, the usefulness of each strategy is dependent on whether a user has knowledge of an information set's existence in a given IR system, the user's ability to describe the needed information in terms that explicitly describe the information sought, and a user's overall search objective.

As such, Meadow, Boyce, and Kraft (2000) suggest that an IR system should recognize that users may employ any of these search strategies and switch from one strategy to another at any time. While the specificity of known item and specific information search strategies can provide high relevance and accuracy in well-structured expert or topic specific IR systems, all of the search strategies have difficulty providing accurate or relevant results with Internet search engines due to the general lack of structure of WWW pages. This is because Internet query tools normally used for IR are poor at supporting exploration. This is not a problem in libraries, because the shelves of libraries are excellent for exploration due to their formal classification, but in purely digital collections of documents, such as the WWW, there are no shelves to explore and a lack of formal document classification makes it particularly difficult to satisfy the general information and exploratory search strategy needs. As such, the ability to support these two types of search strategies effectively may be an important omission in the development of Internet-based IR system capabilities, as exploration through browsing is an important supplement to querying when users discover items of additional interest (Hertzum & Frøkjær, 1996). In addition, as mentioned earlier, specific and general information searches often begin as exploratory searches in order to determine the availability of information in a given IR system.

Similar to Meadow, Boyce, and Kraft's (2000) four types of search, Salampasis, Tait, and Bloor (1998) assert that information seeking is possible using non-analytical, opportunistic, and intuitive browsing strategies. The authors argue that the retrieval effectiveness of information-seeking environments can be improved when information seekers can utilize arbitrary mixtures of browsing and query-based searching strategies. To support browsing effectively, the authors assert that information in digital libraries needs to be richly interconnected and organized using hierarchical or aggregation structures. The authors find that highly interconnected digital libraries can be used to increase information retrieval effectiveness by supporting across-document browsing, which has the goal of identifying relevant documents. Across-document browsing lies in contrast to within-document browsing which is concerned with locating a relevant passage within a document or extracting its gist. As such, across-document browsing can be used in conjunction with other on-line information-seeking strategies in order to solve, more effectively, an information problem.

Müller, Kenny, and Sternberg's (2004) text-mining system for scientific literature allows users to determine whether a query is to be met in the whole publication or in a sentence. When query terms are found in the whole article, the search has the function of text categorization, while finding them in a sentence or paragraph aims at extracting facts. The specification of co-occurrence determines the character of a search. If a combination of keywords and categories is found in a sentence, the likelihood that a sentence contains a fact involving the chosen categories and keywords is quite high. Choosing co-occurrence within a document indicates that a searcher is more interested in finding a relevant document.

Contribution of the Study

Information retrieval technologies are vital to finding information, in particular for professions concerned with complete coverage of a topic. Existing commercial engineering and technology standards search engines, such as Information Handling Services' Global Engineering Documents, GlobalSpec's Engineering Search Engine, Thomson's Techstreet, and ANSI's National Standards Systems Network, only utilize a standard's document number, title, and keywords as metadata for searching. As such, the ability to perform general and exploratory information searches with these search providers is deficient. The Standards Directory supports general and exploratory information searches by supporting full-text searching that automatically expands search terms with its stem words and that can be narrowed to specific topic categories. In addition, the Standards Directory provides search manipulation features that, for example, allow users to limit their initial search or their search results to specific engineering disciplines. Further, the Standards Directory supports across-document browsing by linking standards to other related and referenced standards as well as provides users with the ability to browse standards by category and sub-category. The employment of these information retrieval system design characteristics provides the field of information system research a model for supporting the development of effective digital libraries for engineering and technology standards.

Chapter 3

Methodology

This chapter presents the procedures and principles that were used in developing and conducting this study. It includes the method of research, specific procedures employed, resources utilized, a review of research precedents, a review of the instrumentation that was employed, and a discussion of reliability and validity.

Research Method

The study evaluated existing commercial engineering and technology standards search engines as they are used by technical information seekers and compared them with the Standards Directory. Specifically, Company engineers and architects with various levels of experience in searching for engineering and technology standards as part of their profession participated in the evaluation. Table 1 lists the major commercial engineering and technology standards search engines that were queried with terms and sets of terms chosen by Company engineers and architects who participated in the study, in addition to the Standards Directory.

Table 1. Major Commercial Engineering and Technology Standards Search Engines

Search Engine	Web Address
Information Handling Services' (IHS) Global Engineering Documents	http://global.ihs.com/
GlobalSpec's Engineering Search Engine	http://search.globalspec.com/Search/StandardSearch
Thomson's Techstreet	http://www.techstreet.com/
ANSI's National Standards Systems Network	http://www.nssn.org/search.html

Several sources were helpful in determining which commercial engineering and technology standards search engines to test. Duke University's library for engineering, mathematics and physics Web page on standards collections, Syracuse University's library Web page on engineering and computer science standards, the University of Kentucky's World Wide Web subject catalog Web page on standards, the University of Maine's Fogler library Web page on engineering standards and specifications, the University of Michigan's art, architecture, and engineering library Web page on engineering and related standards, the University of Rhode Island's library Web page on engineering standards, and the University of Washington's library Web page on standards information on the Web are all Web-based academic sources that recommend various commercial engineering and technology standards search engines (Duke University, 2005; Syracuse University, 2005; University of Kentucky, 2005; University of Maine, 2005; University of Michigan, 2005; University of Rhode Island, 2005; University of Washington, 2005). The four selected commercial engineering and technology standards search engines represent the leaders in the field (Taylor, 1999). For example, GlobalSpec's Engineering search engine is a specialized engine that provides access to 60 million product specifications, 1 million product families, 10,000 supplier catalogs, 5 million patents, 1 million technical standards, 50,000 application notes, and 40,000 material-property data sheets (Schweber, 2004).

Company employees in various engineering, architectural, and technical disciplines participated voluntarily in the study (see section titled Research Participants). The open invitation extended to research participants ensured that those participating fairly represent the Company's engineering population. The research participant population consisted of engineers and architects at all phases of their professional careers. In addition, the 61 Company employees in various engineering, architectural, and technical disciplines who participated in the study creates a statistically appropriate sample of the Company's total engineering employee body (about 12% of 500 full-time employees).

Specific Procedures

The research consisted of two main components: system development and system evaluation (i.e., the end user study). Each of these components was comprised of multiple phases.

System Development

The development of the Standards Directory consisted of four main phases: standards metadata definition, an evaluation of user navigation and interface requirements, document categorization and system population, and text query requirements. The approach used to develop the Standards Directory employed four major technology resources: full-text indexing and retrieval system resources, relational database resources, system code and Web application resources, and user interface and software development resources. The system was developed following system design methods proposed by Pfleeger (2001), relational database design methods proposed by Elmasri and Navathe (2000), user interface design methods proposed by Shneiderman (1998) and Belkin (2003), and principles of text information retrieval systems design proposed by Meadow, Boyce, and Kraft (2000). A high-level functional system design is available in Appendix B. A visual display of a document's metadata in a Web browser is available in Appendix C. A model of the system's search engine code is available in Appendix D. A visual representation of the system's database schema in Microsoft Access is available in Appendix E.

The goal of the standards metadata definition and document categorization phase was to determine what attributes associated with standards need to be incorporated into the database schema. Kobayashi and Takeda (2000) define the term metadata as "an invisible file attached to a Web page that facilitates collection of information by automatic indexers; the file is invisible in the sense that it has no effect on the visual appearance of the page when viewed using a standard Web browser" (p. 154).

The goal of the user navigation and interface requirements phase was to determine how standards information from the database should be organized visually in order to achieve effective means of user navigation that will allow users to navigate to standards in a manner congruous with their use. Further, the user interface requirements were used to develop a user interface that is now used to categorize standards and enter their associated metadata.

The goal of the document categorization and system population phase was to work with domain expert volunteers to categorize engineering standards into their respective categories based on the engineering and technology taxonomy as well as to populate the system's database with metadata and to upload full-text engineering standards to the Standards Directory. Related work by Paganelli and Mounier (2003) focuses on information retrieval of technical documents. Technical documents follow organization and structure rules that may be specific to a company that produces the documents and typically cover various procedures, processes, and technical requirements related to specific equipment. As such, technical documents tend to be strongly structured and relatively long. Conversely, engineering standards are codified guidelines that define how processes are to be performed or measured, or how products are to be designed. Businesses, industrial organizations, and government bodies usually author engineering standards, which serve to increase product quality and safety, and allow for interchangeability of parts. As such, engineering standards focus less on product specificity and more on process specificity. Engineering standards having a narrower subject specific focus than technical documents makes categorization of content in the Standards Directory more appropriate at the document level, versus Paganelli and Mounier's categorization of content components within documents in their technical document collection.

The final phase evaluated how searching for standards can utilize a combination of the metadata stored in the database and a stem word full text search of an engineering and technology standards collection to provide search results with higher relevance than current document title searches provide.

System Evaluation

The evaluation of the Standards Directory in the study consisted of two main phases. The first evaluation phase consisted of conducting a study using research participants. The second phase consisted of an analysis of study results and modifications to the Standards Directory based on study results. In this second phase, the following hypothesis was tested:

> The use of document categorization, metadata for browsing, and document full-text searching improves the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines.

The section titled *Research Participants* below provides details of the volunteering process for research participants as well as how the study was conducted. At the beginning of the study, the researcher introduced participants to the nature and goals of the experiment through a short (20 minutes) presentation (see Appendix F).

Each research participant was asked to choose an engineering or technology topic on which to search for information (Su, 2003a, 2003b) (see Appendix G). Research participants were predominantly practicing engineers, so the topics chosen stemmed from real information needs. Research participants were allowed to browse or use as many queries as needed on each search engine for the same topic until they believe they obtained the most relevant results possible with that tool. This approach allowed research participants to find the information sought using any of Meadow, Boyce, and Kraft's (2000) four types of search. On each of the four selected commercial standards search engines as well as the Standards Directory, research participants searched for their topics and analyzed the search results. Research participants then evaluated the search results for relevance. Research participants also noted why some results (if any) were most relevant to their information search on search forms for each search engine (Su, 2003a, 2003b) (see Appendix G).

The literature provided several sources of guidance for conducting information retrieval system evaluations. Meadow, Boyce, and Kraft (2000) define information retrieval as "finding some desired information in a store of information or database" (p. 2). The primary objective of the study was to improve the retrieval of standards by addressing issues related to what Meadow, Boyce, and Kraft assert are the two main areas of information retrieval problems: design and user behavior. Design considerations that were addressed include user interface organization, display, and navigation through categories of standards. User behavior considerations were addressed by evaluating the results of the user questionnaire that was given to a representative sample of 61 research participants during the search engine comparison study. Research participants were asked to evaluate the overall relevance of the search results of the Standards Directory in terms of their information needs compared with commercial standards search engines (Su, 2003a, 2003b) (see Appendix G). Research participants were also asked to evaluate and specify the strengths and weaknesses of the Standards Directory using responses to several Likert scale questions as well as open-ended questions. As such, the goal of the study was to determine how the information retrieval needs of technical users could be improved with respect to end-user relevance judgments.

The Standards Directory provides a retrieval interface that supports the customized retrieval of standards limited to specific engineering and technology categories before (see Appendix H) and after (see Appendix I) a search is performed to provide improved information retrieval results (Cutrell & Dumais, 2003). In addition, the Standards Directory utilizes the standards metadata stored in its database to support keyword searching. Combining a database query on the metadata with a full-text stem word search of a collection of full text standards can also improve retrieval relevance over the search capabilities available in the existing EDMS system as well as commercial standards search engines (Doan, Beigbeder, Girardot, & Jaillon, 1998). The Standards Directory's design has the ability to employ any suitable engineering and technology taxonomy, such as the taxonomy proposed by Pushpagiri and Rahman (2002) as well as Rahman, Teklu, and Wiesner (2002) (see Appendix J) that was developed for the content classification of engineering and technology related learning materials.

The data obtained from the research participants was used to assign relevance categories by conducting content analysis of open-ended responses on the overall relevance of search results from the IR systems evaluated. The Pearson Correlation Coefficient (Neuendorf, 2002; Su, 2003a, 2003b) was calculated using Microsoft Excel to ensure that the content analysis was valid and reliable. Results of the content analysis categorization were used to determine the participants' overall relevance ranking of the search engines used in the study. A statistical analysis was performed to determine whether there are any significant relationships among participants' overall relevance ranking of the search engines used in the study and were used to assist the researcher in determining the effectiveness of the Standards Directory search engine in returning results relevant to users' information needs.

Qualitative content analysis methods were used to determine the strengths and weaknesses of the various standards search engines utilized in the study (Krippendorf, 2004; Mayring, 2000; Neuendorf, 2002; Su, 2003a, 2003b). User feedback was compared and contrasted to the research participant's expected results and information need (obtained from the questionnaire in Appendix G). The results from the Standards Directory search engine were also compared to the results from each of the commercial standards search engines. These results were also examined with respect to the purpose, scope, and specializations of each search engine as determined by the literature (Davis, 1996; Feldman, 1998; Kingoff, 1997; Page, 1996).

Problems Encountered

Participants encountered two major problems during the study that were not experienced during the pretest. First, there was some ambiguity around the use of the *Save* feature in the online survey. Participants used the *Save* button after providing their demographic information and either closed the browser window with the online survey or opened a search engine in the browser window with the survey. When participants returned to the survey after conducting their searches, using the bookmark provided by the researcher, the participants proceeded to complete the online survey, skipping the demographic information. However, the *Save* button only repopulates a user's form if they bookmark the survey after the *Save* button is clicked. As such, some participants were contacted after the session ended to provide their demographic information. The researcher was able to identify these participants as they provided their contact information voluntarily at the end of the survey. Further, the Company's proxy settings prohibited participants from following links outside of the domains of the search sites. This problem was encountered when participants wanted to follow a link to determine the relevance of the search results on some of the commercial standards search engines. This problem, however, was not identified before the first session as these proxy settings were unique to the computer lab in which the surveys were conducted. These problems were all encountered in the first session and were rectified in subsequent sessions by instructing participants not to close their browsers with the search survey and by providing open proxy access to the computers in the lab. As such, all survey results were used in the final data analysis.

Presentation of Results

Research results presented in this report were compiled in Microsoft Excel and contain all relevant quantitative data and statistical analysis. Compiled questionnaire results, transcriptions of written responses used in the content analysis, and comparisons of the search results with the users' technical information needs used in the analysis are also available in this report.

Research Precedents

Several research precedents for the methods employed are available in the literature. In a ground breaking study, Cooper (1968, pp. 31-32) proposed the primary function of an information retrieval system is to save users as much effort as possible in the search for relevant documents. Yao (1995) as well as Tang and Sun (2003) employ measures of retrieval system performance that are based on Cooper's view and measure retrieval system's effectiveness as the difference between a user's and the system's rankings. These studies depart from the widely held dichotomous notion of relevance (a document is either relevant or it is not) and measure relevance based on an ordinal scale in which the user specifies whether a given document is more relevant than another. Several recent studies of search engines use human relevance judgments as the basis of evaluation whereby participants are asked to rank items retrieved by search engines based on each item's relevance to their information needs (Nowicki, 2003; Su, 1994, 1998, 2003a, 2003b; Su & Chen, 1999; Vaughan, 2004). These studies use the Pearson *r* or Spearman rho to determine the degree of association between the search engine's relevance ranking and the participant's relevance ranking. Su (2003b) proposed a comprehensive systematic model for the evaluation of search engines that measures the value and usefulness of search engine results to end-users, a method for collecting quantitative data and determining relationships between measures significantly correlated with search success. Vaughan (2004) proposed a set of measurements for evaluating search engine performance whereby the proposed measurements are calculated based on a continuous relevance ranking (from most relevant to least relevant) by human subjects. As the number of participants in this experiment was large (greater than 30), the Spearman rho was not computed (Gay & Airasian, 2002, p. 318; Gliner, Morgan, & Harmon, 2002). Oppenheim, Morris, and McKnight (2000) note that there is a need for research into the suitability of search engines to cover various subject areas and provide

15 criteria for performing tests on search engines, including relative recall. Oppenheim et al. also recommend that such research should be based on a limited number of records and include novice users. Agosti and Melucci (2001) assert that the notion of relevance must be considered in the evaluation of Web-based search engines, as the pervasive presence of links among Web pages can influence a user's perception of a retrieved document's usefulness. With that, Agosti et al. provide measures of effectiveness when evaluating the characteristics of search engines.

Resource Requirements

In the development of the Standards Directory, the researcher utilized several resource categories, which included development tools, domain experts, and research participants.

Development Tools

The tools utilized to develop the Standards Directory fall into four main areas, which are user interface design and software development resources, system code and Web application resources, relational database resources, and full-text indexing and retrieval system resources. Other support tools used during the development and evaluation of the research are listed in Table 2.

Table 2. Development Tools Utilized in the Research

Tool Description	Version/Model	Function
Macromedia Dreamweaver	2004	User Interface and Software Development
Microsoft Windows Server	2003	Internet Operating System
Compaq Server	ProLiant	System Hardware
Macromedia ColdFusion	MX 7	System Code and Web Application
Microsoft Access	2003	Relational Database
Verity Server	K2	Full-Text Indexing and Retrieval System

Table 2 (continued)

Tool Description	Version/Model	Function
Microsoft Word	2003	General Research Delivery
Microsoft Project	2003	Project Management
Adobe Acrobat	7	Viewing of PDF Documents
JASC Paint Shop Pro	7	Image Creation
Microsoft Visio	2003	Process Flow
Compaq Personal Computers	dc5000	End User Study
Microsoft Internet Explorer	6	End User Access to Search Engines
Scantron eListen	2005	Web Based Questionnaire Creation
Microsoft Excel	2003	Study Data Analysis

Macromedia Dreamweaver version 2004 was used for the development of the user interface. Macromedia Dreamweaver provides a Web application design environment that provides coding capabilities for Macromedia ColdFusion and is built around Cascading Style Sheets (CSS), which enables faster and more efficient development of clean-coded, professional sites.

Macromedia ColdFusion is a Web application middleware platform on which the Standards Directory was developed. The ColdFusion Markup Language (CFML) enables the creation of interactive, dynamic, and information-rich Web sites. Unlike static Web pages, dynamic Web pages contain very little actual text and pull needed information from other information sources. For example, ColdFusion communicates with the Standards Directory's online database as well as the Verity full-text index engine to obtain information and dynamically create its Web pages. The ColdFusion code utilized for the Standards Directory also extends the standard hypertext markup language (HTML) files with high-level formatting functions, conditional operators, and database commands. These commands serve as instructions to the ColdFusion middleware and form the building blocks on which the Standards Directory's interactive Web application features were developed.

The Microsoft Access database management system was utilized for the Standards Directory's relational database. Microsoft Access is a relational database management system (DBMS) for creating desktop and client/server database applications that run under the Windows operating system. Access stores an entire database application within a single file. An Access file can contain data objects, such as tables, indexes and queries, as well as application objects such as forms, reports, macros, and visual basic code. While utilizing Microsoft Access as the database for a production version of a Web application is not recommended (Macromedia, 2002; Microsoft, 2003), the methods used to store and normalize objects in Microsoft Access conform to industry standards, which, in turn, allows for portability to a production DBMS.

ColdFusion includes the Verity search engine, which provides full-text indexing and searching. The Verity K2 Server is a high-performance search engine designed to process searches quickly in a high-performance, distributed system. The Standards Directory uses the Verity search engine for the implementation of full text retrieval to search through paragraphs of text or files of varying types efficiently. The Verity engine performs searches against collections, not against the actual documents. A collection is a special database created by Verity, which contains metadata that describes the documents that the Verity engine indexes as a document is added to the collection. The indexing process includes examining documents of various types in a collection and creates an index or metadata description, which is specialized for rapid search and retrieval operations. The ColdFusion implementation of Verity supports collections of text files, such as HTML pages and CFML pages, and binary documents, such as word processing documents, spreadsheets, images, and multimedia files. Verity can also search against record sets returned from queries to existing databases. Verity collections can be built from individual documents or from an entire directory tree. Collections can be stored locally or on a remote network, which provides flexibility in accessing indexed data. In addition, a ColdFusion Web application can search multiple collections, each of which can focus on a specific group of documents or queries, according to subject, document type, location, or any other logical grouping. As such, standards developing organizations can make Verity indices of their standards collections available over networks, allowing engineering organizations to host a standards information retrieval system on their internal network that would allow a single search interface to access multiple Verity indices, for example, over the Internet as well as on a local intranet.

Domain Experts

Creating a digital library represents a challenging task, requiring considerable financial as well as human resources. Categorization is the process of associating a document with one or more subject categories. In the context of a digital library, the associated subject category stems from the digital library's taxonomy. While researchers have made some progress with the automatic categorization of technical information (Ardö & Koch, 1999), the manual categorization of standards requires a domain expert to determine which topic class or classes a given document belongs.

The process of cataloging documents in the Standards Directory into a category focused on capturing an expert's tacit knowledge. Ericsson and Charness (1997) found that such expertise stems primarily from the result of deliberate practice on representative tasks in the domain. As such, Olmstadt (2000) finds that expert systems (ES) must focus on a limited domain in order to be effective, but notes the difficulty in constructing the knowledge base of any ES. Olmstadt notes further that while experts show consistently superior performance over automated cataloging systems, they are almost uniformly poor at describing how they achieved that performance. With this, Olmstadt's research indicates that the transformation of their expertise into rules for cataloging can be very difficult.

Research Participants

This research drew on a number of Company professionals from several engineering disciplines. Over 500 Company employees in the disciplines of civil, electrical, mechanical, industrial, aeronautical, and structural engineering as well as other technical disciplines were contacted via email and solicited to participate in the survey; 68 Company employees responded of which 61 participated in the study.

The research was conducted in a computer lab at the Disney University. The lab contains 15 computers with Internet access and Microsoft Internet Explorer. Permission to have Company employees participate in the survey was obtained from the director of the Company's engineering division (see Appendix K). None of the information gathered on research participants was or will be used for evaluation of work-related performance. As this research involves human subjects, the study was submitted to the Nova Southeastern University Institutional Review Board for review and approval was obtained in January 2005 (see Appendix L).

Reliability and Validity

Questionnaire Pretest

Questionnaire pretesting is an indispensable mechanism for ensuring the reliability and validity of surveys (Krosnick, 1999; Synodinos, 2003). Synodinos asserts that a pretest of a survey questionnaire be done with potential respondents and with the intended questionnaire administration method and that pretesting the survey instrument and methodology will allow respondents to clarify questions verbally and identify comprehension problems. As such, the researcher conducted a declared pretest of the questionnaire with three randomly selected research participants in order to ensure the correct interpretation and understanding of questions by respondents and to determine the reliability of responses. Each participant of the pretest completed the questionnaire individually and participated in a pretest of the experiment itself. The researcher interviewed each participant at the conclusion of the pretest. The pretest revealed that the project could be completed in the time allotted for the six sessions that were to be held in the Disney University lab. The pretest participants suggested that the questionnaire be converted to a Web based survey citing greater ease when providing feedback as their reason. Research indicates that computer-savvy populations consider Web based surveys more convenient and tend to provide more open responses using Web based surveys (Carini, Hayek, Kuh, Kennedy, & Ouimet, 2003; Sax, Gilmartin, & Bryant, 2003; Sax, Gilmartin, Lee, & Hagedorn, 2003). With that, the questionnaire was converted to a Web-based survey using Scantron's eListen software (see Appendix M). Further, the pretest participants questioned the need to include questions relating to gender and age data as well as the year in which survey participants received their university degree given the survey's goal of assessing the overall relevance of search engine results for technical information needs. As the focus of the research was to improve the organization and retrieval of engineering and technology standards within the Company, the correlation between the methods of practicing various engineering disciplines and the methods used to organize and retrieve standards presented a greater area of interest for the research. With this, the researcher removed the gender, age, and year-conferred questions from the survey and added two questions related to the participant's length of experience in their discipline overall as well as for the organization.

Conducting the Survey

Experiments can be deemed reliable if the experiments repeatedly demonstrate the same results (Greenhalgh & Taylor, 1997). The order in which participants search the five search engines was balanced, which aids in reducing the learning effect of test results (Schaer, Schluep, Schierz, & Krueger 2000). The researcher added each of the five search engines to the favorites in Microsoft Internet Explorer on each workstation in the Disney University lab. The order in which participants searched the five search engines was randomized to reduce the learning effect of test results (see Appendix N). Each of the five search engines was listed alphabetically and numbered one through five. Three Latin squares of order five were generated to ensure that each search engine was searched in each of the five positions by an equal number of the participants (Su, 2003b), generating 15 sets of the numbers one through five in a different order (one set per workstation in the lab). Fifteen sets of bookmark files were then created according to the 15 sets of numbers in the Latin squares. This assured that each workstation in the lab had search engines bookmarked in each of the five positions (first, second, third, etc.). Participants in the seven sessions received instructions to search for engineering and technology standards using the search engines in the favorites list on their workstation in the order that they appeared (see Appendix N). A seventh session was held using video-over-Internet-protocol and Microsoft NetMeeting with participants in a conference room in California using laptops and the researcher in Florida. Each participant received a different set of bookmarks via email at the beginning of the session that was labeled *Search Site 1* to *Search Site 5* along with a link to the Web based survey. As such, an approximately equal number of participants used each search engine in each of the five positions. This helped control confounding variables such as the learning effect as well as information and technological literacy (Johnson & Christensen, 2003, p. 228). The makeup of participants was also essentially random, as the researcher has no control over which engineers and architects responded to the request to participate voluntarily in the study.

Content Analysis

Krosnick (1999) asserts that there are distinct disadvantages to closed-ended questions as respondents tend to limit their answers to the available options, even if it is not the intent of the researcher to do so. That is, study participants often simply select among the available options, even if the best answer is not included. Therefore, Krosnick asserts that a closed-ended question can only be used effectively if its answer choices are comprehensive, which, in turn, is difficult to assure. Conversely, Krosnick has found that the reliability and validity of open-ended questions has exceeded that of closed-ended questions. As such, open-ended questions were chosen as a more viable means for acquiring participants' overall relevance judgments of search engine results in the study.

Following the study, qualitative content analysis was used to determine the overall relevance of the search engines studied by analyzing participants' responses to questions related to the participants' feedback on overall relevance and helpfulness of the search engines compared (see Appendix O). Mayring's (2000) approach to qualitative text analysis was followed and a systematic, rule guided method for the coding process was developed (see Appendix O). In following Mayring's approach, mutually exclusive categories were developed whereby no participant feedback fell between two categories. The coding process and categories provided language that coded all participant feedback clearly without exception (Stemler, 2001). The categories for the participants' ranking of the overall success of a search engine in providing relevant results for their information need or problem (Johnson, Griffiths, & Hartley, 2003; Maglaughlin & Sonnenwald, 2002; Su, 2003a). The categories used for the scale of non-binary relevance assessments used to describe the overall relevance of the systems evaluated in the study were highly relevant, fairly relevant, marginally relevant, and irrelevant (Borlund, 2003; Järvelin & Kekäläinen, 2000; Kekäläinen & Järvelin, 2002; Sormunen, 2002; Spink, Greisdorf, & Bateman, 1998; Vakkari & Sormunen, 2004). To ensure the reliability and validity of the coding process, all study participants who indicated they were willing to provide additional information after the study were contacted and asked to assign one of the non-binary relevance assessment categories as a ranking of the overall relevance of each system evaluated in the study of which 11 responded. This sub-sample size exceeds reliability assessment guidelines of 10% to 20% of the study sample (Wimmer & Dominick, 2003). The Pearson Product Moment Correlation Coefficient was used to determine that the coding process used “replicable and valid inferences” (Krippendorf, 2004, p. 18), as discussed in Neuendorf (2002) and Krippendorf (2004). The high correlation between the coded relevance rankings and the relevance rankings provided by the sample of study participants provided a statistically significant assurance of “reproducibility” (Krippendorf, p. 215), and therefore demonstrated the reliability and validity of the coding process.

Constraints and Limitations

This project did not endeavor to evaluate the effectiveness of querying techniques or the properties of the commercial standards search engines, but compares the ability of various commercial standards search engines as well as the Standards Directory to deliver results relevant to the searchers involved. This study was limited to Company employees of various engineering and technical disciplines and levels of experience. As such, results may not be applicable to other engineering or architectural firms. In addition, the idea of recall, the ratio of the number of relevant records retrieved compared to the number of relevant records in a system (Meadow, Boyce, & Kraft, 2000, p. 323), was addressed in this experiment since one cannot know, on a large scale, what the search engine did not find (Chu & Rosenthal, 1996).

An additional factor in this study was the interaction between humans and computers and the research expertise of the participants. Given the role information technology plays in the engineering and technical disciplines, some participants were more competent with computers than others, were more information literate in general, or had more experience using IR systems. While this may have affected their relevance judgments, allowing for a wide range of technical expertise more accurately captured the problems and experiences real users of IR systems encounter.

Further, there were variations in participants' information literacy skills and adeptness at formulating appropriate research queries. Some participants had more practice or were naturally skillful in preparing suitable keywords and phrases on which to search. Therefore, participants using less appropriate queries received fewer relevant results. However, it is imperative to allow information seekers to formulate their own queries in order to examine search engines under authentic limits imposed by end-users and without influencing the information seeking process (Marchionini, 1995, p. 4).

Finally, this study was limited to comparing the overall relevance of search results provided by the Standards Directory with the overall relevance of search results from four leading commercial standards search engines in July 2005. As advances are made in IR research and practitioners adopt new methods for improving commercial search engine performance, this study's results may become irrelevant. Further, given the variability of search engine technology and the pace at which IR research is transferred, the results of this study may not be applicable to other search engines or even the same commercial standards search engines in the near future. However, given the limited performance of commercial standards search engines in retrieving relevant results for technical information users, as well as the effects domain expertise has on users' search behavior (Wildemuth, 2004; Zhang, Anghelescu, & Yuan, 2005), the results of this study will remain applicable for some time.

Benefits

The project affords several general benefits. As modern knowledge workers (Drucker, 1966), engineers, and architects use IR systems widely for reference and research. In today's engineering and science world, information plays a key role (Fjällbrant et al., 1998). Information is of vital importance in research and development work and is needed for functional engineering tasks, such as technical construction and manufacturing. Engineers and architects rely on a significant volume of recorded information, observations, experiments, measurements, standards, diagrams, and the opinions of others during the course of working in his or her main subject area. In particular, engineering and technology standards encompass one of the most essential bodies of knowledge from which engineers and architects draw in the course of their profession. As such, the improvements provided by the Standards Directory in the retrieval of standards can aid engineers and architects with their research. Company engineers and architects are called upon increasingly to retrieve information quickly, offer information interpretation and analysis of data from multiple sources, and provide recommendations based on many related forms of information. The challenges presented by this increasing demand to assimilate knowledge from standards may be diminished by improvements made available by the Standards Directory. In addition, an awareness of how standards search engines differ provides a basis for new ways of searching, organizing, and designing standards search engines. Finally, feedback from subject matter experts seeking specialized information within their area of expertise in an effort to determine the relevance of their search results will provide a more accurate picture of how such end-users view results, determine relevance, and approach the use of search engines in their profession.

In addition to these general benefits, this project affords several specific benefits to the Company as a whole. For example, determining how Company engineers and architects use search engines and navigate through digital libraries provides Company managers with the data needed to incorporate the use of standards in projects more effectively. The Company engineers and architects that participated in this study educated themselves about the use of search engines and the difficulties of finding information in digital libraries. It also gave them the opportunity to learn about issues surrounding the retrieval of standards. This, in turn, provided them with the knowledge necessary to adopt the most effective search strategy for each of Meadow, Boyce, and Kraft's (2000) four types of searching. Finally, establishing effective strategies for the retrieval of standards according to end-user relevance judgments will allow Company engineers and architects to fulfill their standards information needs more expeditiously, saving time and effort for the Company.

Summary

This chapter presented the procedures and principles used in developing and conducting the study. The research methods used for this project were presented. The specific procedures employed and problems encountered were delineated. The presentation of results was explained. Research precedents from the literature were presented. The resources utilized and the instruments that were employed were specified. The chapter also provided a discussion of reliability and validity, constraints and limitations, and the benefits this study will have. These procedures lead to the presentation of the results of the study.

Chapter 4

Results

This chapter describes the outcomes of the study detailed in the preceding chapter. It includes an analysis of the data collected, a discussion of findings, and a description of the results gathered from the study's participants with the online questionnaire. Statistical techniques for describing the data are explained and the results are presented.

Data Analysis

A total of 61 Company employees of various technical disciplines participated in the seven sessions conducted during this study. A breakdown of the study sessions participants attended is summarized in Table 3. Each participant received a packet containing a questionnaire and a copy of the Company's engineering and technology project-work-breakdown-structure (see Appendix A) as well as the National Science Digital Library's engineering and technology taxonomy (see Appendix J) (Pushpagiri & Rahman, 2002). At the beginning of the study, the researcher introduced participants to the nature and goals of the experiment through a short (20 minutes) presentation (see Appendix K).

Table 3. Study Sessions and Usable Data

Session Date and Time	Expected Participants	Actual Participants	Usable Responses	Unusable Responses
July 27, 2005 8:30 AM	10	7	7	0
July 27, 2005 3:30 PM	10	8	8	0
July 28, 2005 8:30 AM	11	11	10	1
July 28, 2005 3:30 PM	12	12	12	0
July 29, 2005 8:30 AM	6	4	4	0
July 29, 2005 3:30 PM	11	11	11	0
August 5, 2005 3:30 PM	8	8	8	0
Total	**68**	**61**	***N* = 60**	**1**

Of the 61 surveys submitted using the online survey, one was unusable because a participant did not save any of their survey responses (see section titled *Problems Encountered*). Sixty responses were usable and encompassed the total sample size for the research evaluation (*N*). This is an adequate sample given that 60 responses created a statistically appropriate sample of the Company's total engineering employee body, or 12% of 500 full-time engineering employees. The number of responses to some specific questions was lower than 60, as some participants did not answer every question. A more detailed account of the demographic data follows, which describes the information retrieval experience and computer experience of those participating in this study.

Participant Questionnaire: Professional Demographics

The demographic information collected from the questionnaire revealed several features about this participant's demographic characteristics. The participants in this study were comprised primarily of employees in engineering or technology based disciplines. This accounted for 53 (88.3%) of the participants. The primary occupation of 24 (40%), the largest group of participants, was in applied engineering, with 16 (26.7%)

in engineering management, 19 (31.7%) in another technical discipline or profession, and one (1.7%) participant in an engineering executive position. Twenty-two of the participants also indicated they functioned in some secondary capacity, including teaching engineering at the college level. Fifty-one (85%) of the participants indicated they held a bachelor's, master's, or doctorate degree in their field. Ten of the participants indicated they published in their field while 23 of participants were licensed professionals in their respective technical fields. Fifty-two of the participants (86.7%) had worked more than five years in their respective disciplines overall (M = 18.764, SD = 1.355) while 34 of the participants (56.6%) worked more then five years in their respective disciplines for the Company (M = 9.381, SD = 0.986). Overall, this demographic data reflected a high level of education and experience in engineering. Title VII of the Civil Rights Act of 1964 (Pub. L. 88-352) (Title VII), as amended, as it appears in volume 42 of the United States Code, beginning at section 2000e prohibits employment discrimination based on race, color, religion, sex, or national origin (United States Equal Employment Opportunity Commission, 2005). As the survey's participants, while participating voluntarily, did so within an organizational setting, any data gathered possessed the potential to expose the organization to a violation of Title VII. As such, the study specifically excluded the collection of gender and age data as well as the year in which survey participants received their university degree. Table 4 presents a summary of the participants' engineering disciplines and professional experience data collected in the study.

Table 4. Participants' Engineering Disciplines and Professional Experience

Engineering Discipline	***n***	**% *N***
Mechanical Engineering	25	41.7%
Electrical Engineering	9	15.0%

Table 4 (continued)

Engineering Discipline	***n***	**% *N***
Architecture	3	5.0%
Civil Engineering	3	5.0%
Industrial Engineering	3	5.0%
Business Administration	2	3.3%
Landscape Architecture	2	3.3%
Structural Engineering	2	3.3%
Aeronautical Science	1	1.7%
Communications	1	1.7%
Computer Engineering	1	1.7%
Computer Science	1	1.7%
Controls Design	1	1.7%
Finance	1	1.7%
Human Factors Psychology	1	1.7%
Journalism	1	1.7%
Liberal Arts	1	1.7%
Nuclear Engineering	1	1.7%
Physiology	1	1.7%
Total Respondents	**60**	

Primary Occupation	***n***	**% *N***
Applied Engineering	24	40%
Engineering Management	16	26.7%
Engineering Executive	1	1.7%
Other Technical Discipline	19	31.7%
Total Respondents	**59**	

Secondary Occupation	***n***	**% *N***
Applied Engineering	7	11.7%
Engineering Management	7	11.7%
Other Technical Discipline	6	10.0%
Engineering Academic	2	3.3%
Total Respondents	**22**	

Highest Degree Awarded	***n***	**% *N***
High School	1	1.7%
Associate’s Degree	4	6.7%
Bachelor’s Degree	28	46.7%
Master’s Degree	21	35.0%
Doctorate	2	3.3%
Total Respondents	**56**	

Table 4 (continued)

Published in Field	***n***	**% *N***
Yes	10	16.7%
No	48	80.0%
Total Respondents	**58**	

Licensed Professional (PE, PA)	***n***	**% *N***
Yes	23	38.3%
No	35	58.3%
Total Respondents	**58**	

Years in Discipline for Company	***n***	**% *N***
< 1	3	5.0%
1 to 5	21	35.0%
6 to 10	12	20.0%
11 to 15	8	13.3%
16 to 20	10	16.7%
21 to 25	2	3.3%
> 25	2	3.3%
Total Respondents	**58**	

Years in Discipline Overall	***n***	**% *N***
< 1	3	5.0%
1 to 5	4	6.7%
6 to 10	9	15.0%
11 to 15	8	13.3%
16 to 20	9	15.0%
21 to 25	10	16.7%
> 25	16	26.7%
Total Respondents	**59**	

Participant Questionnaire: Engineering Standards Experience

Twenty-five participants indicated they were members in one or more of 22 of the world’s most respected standards setting organizations (Breitenberg, 1987). Over three-fourths of participants rated their work as being standards-based as a four or above on a Likert 7-point scale from very limited (1) to highly (7) ($M = 4.898$, $SD = 0.203$). Content analysis was performed on the responses to the open-ended questions on how frequent a participant refers to either an engineering or technology standard in their work or to engineering texts. The content analysis revealed that 21 participants referenced engineering standards or texts at least daily, 20 participants referenced engineering standards or texts at least weekly or bi-weekly, and 14 participants indicated they referenced engineering standards or texts with some frequency, such as often, very often, frequently, regularly, in all work, or constantly. In all, 40 participants indicated they used engineering standards or texts daily, weekly, bi-weekly, or with some frequency. The same 40 participants rated their work as being standards-based on the Likert 7-point scale with a four and above, with 7 rating a four, 10 rating a five, 14 rating a six, and 9 rating a seven. Table 5 presents a summary of the engineering standards experience data collected in the study.

Table 5. Participants' Professional Affiliations and Work-Related Use of Engineering Standards

Professional or Standards Developing Association	*n*	% *N*
American Concrete Institute (ACI)	3	5.0%
Association for Computing Machinery (ACM)	1	1.7%
American Institute of Architects (AIA)	3	5.0%
American Institute of Steel Construction (AISC)	4	6.7%
American Institute of Timber Construction (AITC)	1	1.7%
American Society of Civil Engineers (ASCE)	4	6.7%
American Society of Landscape Architects (ASLA)	2	3.3%
American Society of Mechanical Engineers (ASME)	7	11.7%
American Society for Quality (ASQ)	2	3.3%
American Society of Safety Engineering (ASSE)	1	1.7%
American Society for Testing and Materials (ASTM)	3	5.0%
American Welding Society (AWS)	2	3.3%
Construction Specifications Institute (CSI)	1	1.7%
Irrigation Association (IA)	1	1.7%
Institute of Electrical and Electronics Engineers (IEEE)	2	3.3%
National Concrete Masonry Association (NCMA)	1	1.7%
Project Management Institute (PMI)	1	1.7%
Society of Automotive Engineers (SAE)	2	3.3%
Society of Motion Picture and Television Engineers (SMPTE)	1	1.7%
Society of Technical Analysts (STA)	1	1.7%
Society for Technical Communication (STC)	1	1.7%

Table 5 (continued)

Professional or Standards Developing Association	*n*	% *N*
Society of Women Engineers (SWE)	1	1.7%
Number of Responding Participants	**25**	

Extent to Which Work is Standards-Based	*n*	% *N*
1: Very Limited	1	1.7%
2	4	6.7%
3	7	11.7%
4	10	16.7%
5	12	20.0%
6	16	26.7%
7: Highly	9	15.0%
Total Respondents	**59**	

Participant Questionnaire: Library and Search Engine Experience

The questionnaire revealed various characteristics of the participants' library usage, IR experience, and perceptions of IR systems. On the whole, library use was substantial (80%) and averaged between at least once a day and at least once a week due, in part, to the significant number of original hand drawn engineering sketches in the Company's engineering and architectural drawing libraries. This was expected given that the age of most of the Company's physical assets predates the pervasive use of CAD. Most participants (55%) also used library online catalogs or card catalogs to find books or other materials on a daily basis. This was also expected given the standards-based nature of engineering and architectural practice within the Company.

All of the 58 participants who responded indicated they used the Internet and that they used World Wide Web search engines on a daily basis. However, only 11 participants indicated they used online research databases or indexes (such as Elsevier's ScienceDirect or Compendex, WilsonWeb's Applied Science & Technology Full Text, or General Science Full Text) doing so at varying frequencies. When searching for information on the World Wide Web, all of the 58 participants who responded indicated they used the search engines, in general, on a daily basis. The questionnaire provided a list of the most widely used search engines (Sullivan, 2005). The five most used of the search engines listed were Google, Yahoo!, Ask Jeeves, MSN Search, and AltaVista!. Fewer respondents indicated they used AOL Search, About.com, AllTheWeb.com, Excite, HotBot, Lycos, Netscape Search, or WebCrawler. Two participants also added that they used Dogpile and one participant indicated they also used Google Scholar. The vast majority (56 participants) believed search engines were helpful in finding information on the World Wide Web and most participants had positive views of search engines, citing ease of use and the ability to access an index to the vast amount of information available on the WWW as the predominant reasons for their usefulness. However, almost all participants also cited several disadvantages of WWW search engines, citing a lack of precision and accuracy, a lack of technical content, unfamiliarity with their functionality, and concerns about a growing influence by commercial considerations as sources of their discontent. Forty of the participants indicated they had not previously used any of the four commercial standards search engines described in the study. Table 6 presents a summary of the library and search engine experience data collected in the study.

Table 6. Participants' Library, Catalog, and Search Engine Usage

Use of Libraries (Company or Elsewhere)	***n***	**% *N***
Yes	49	81.7%
No	6	10.0%
Do not know/Not applicable	4	6.7%
Total Respondents	**59**	

Table 6 (continued)

Use of Library Online Catalogs or Card Catalogs	***n***	**% *N***
Yes	33	55.0%
No	23	38.3%
Do not know/Not applicable	3	5.0%
Total Respondents	**59**	

Search Engines Used	***n***	**% *N***
Google	57	95.0%
Yahoo!	43	71.7%
Ask Jeeves	24	40.0%
MSN Search	20	33.3%
AltaVista!	16	26.7%
AOL Search	6	10.0%
Lycos	5	8.3%
Netscape Search	5	8.3%
Excite	4	6.7%
HotBot	4	6.7%
About.com	2	3.3%
AllTheWeb.com	2	3.3%
Dogpile	2	3.3%
WebCrawler	1	1.7%
Google Scholar	1	1.7%
Responding Participants	**59**	

Use of Online Databases/Indexes	***n***	**% *N***
Yes	11	18.3%
No	44	73.3%
Do not know/Not applicable	4	6.7%
Total Respondents	**59**	

Commercial Standards Search Engines Used Prior to Study	***n***	**% *N***
ANSI NSSN Standards Search	15	25.0%
GlobalSpec's Engineering Search	6	10.0%
Thomson's Techstreet	2	3.3%
IHS Global Engineering Documents	5	8.3%

Search Expectations

Prior to conducting their search for engineering standards and related information, participants were asked to select one or more topics in their area of engineering expertise on which to search (see Appendix G). Gao, Murugesan, and Lo (2004) note that factors external from an IR system, including a user's knowledge, expertise, and searching behavior, affect retrieval results significantly. As such, retrieval evaluation requires that tests use a sufficient number of topics, search methods, and varying levels of searcher expertise to average the performance of a system for different levels of topic difficulty. Analysis of the search topics and terms selected by participants (see Appendix P) revealed that the topics chosen for the search experiment ranged across a broad spectrum of technical and engineering topics. The self-perceived level of expertise on the subjects selected on a Likert 7-point scale from no knowledge (1) to expert knowledge (7) was well distributed ($M = 4.714$, $SD = 0.174$). On a three-point scale, participants, on average, had a higher expectation for the comprehensiveness of the information gleaned from their search than retrieving *some relevant items* ($M = 2.228$, $SD = 0.094$). Of Meadow, Boyce, and Kraft's (2000, p. 273) four forms of search, discussed in the introductory presentation, three participants performed a known item search, 18 participants performed a specific information search, 31 participants performed a general information search, and seven participants performed a search to explore. Table 7 presents a summary of the data collected in the study on participants' search topic expertise, expectations, and type of search performed.

Table 7. Participants' Search Topic Expertise, Expectations, and Form of Search

Expertise on Selected Subject	*n*	% *N*
1: No Knowledge	0	0%
2	3	5%

Table 7 (continued)

Expertise on Selected Subject	*n*	% *N*
3	7	11.7%
4	14	23.3%
5	15	25%
6	13	21.7%
7: Expert Knowledge	4	6.7%
Total Respondents	**56**	

Search Comprehensiveness Expectation	*n*	% *N*
1: Narrow; a few representative items are OK	9	15.0%
2: Some relevant items	26	43.3%
3: Comprehensive; most or all relevant items	22	36.7%
Total Respondents	**57**	

Form of Search Performed	*n*	% *N*
Known Item Search	3	5%
Specific Information Search	18	30.0%
General Information Search	31	51.7%
Search to Explore	7	11.7%
Total Respondents	**59**	

Content Analysis and Statistical Techniques

As explained in Chapter 3, each participant completed a search on each of five predetermined search engines and provided qualitative as well as quantitative feedback on each of the search engine results. Appendix Q presents detailed qualitative and quantitative participant feedback used for the overall relevance assessments. First, qualitative content analysis was used to determine the overall relevance of the search engines studied by analyzing participants' responses to questions related to the participants' feedback on overall relevance and helpfulness of the search engines compared (see Appendix Q). These measures provided a ranking of the overall success of the search engines in providing relevant results for a participant's information need or problem (Johnson, Griffiths, & Hartley, 2003; Maglaughlin & Sonnenwald, 2002; Su, 2003a). The categories used for the scale of non-binary relevance assessments to describe the overall relevance of the systems evaluated in the study were highly relevant, fairly relevant, marginally relevant, and irrelevant (Borlund, 2003; Järvelin & Kekäläinen, 2000; Kekäläinen & Järvelin, 2002; Sormunen, 2002; Spink, Greisdorf, & Bateman, 1998; Vakkari & Sormunen, 2004). The method used for the coding process is presented in Appendix O and the results of the coding process is presented in detail in Appendix Q and summarized in Appendix R.

Social scientists have generally agreed that if the probability of getting a difference between the sample statistic and population parameter is less than 5%, the null hypothesis can be rejected and it can be concluded that the differences between the statistic and the parameter are probably not due to chance (Urdan, 2001). As such, a significance level (α) of .05 was used in this research. That is, if a calculated probability (p) was lower than the selected alpha level ($p < .05$), the null hypothesis was rejected. However, it is still possible for Type I errors to occur and for the null hypothesis to be rejected even though the null hypothesis is true. As such, when a smaller p-value was calculated (e.g. $p < .01$ or $p < .005$), that is, a more conservative alpha level could be assumed, the lower p-value was given. This approach has precedence in presenting results in similar research (Su, 2003b). Only statistically significant findings are presented. Since p-values are exact for tests such as the t-test, exact p-values are given in such cases.

To ensure the reliability and validity of the coding process, Potter and Levine-Donnerstein (1999) recommend calculating the correlation coefficient as a reliability measure. As such, all study participants who indicated they were willing to provide additional information after the study were contacted and asked to assign one of the non-binary relevance assessment categories as a judgment of the overall relevance of each system evaluated in the study. Eleven responded. This sub-sample size exceeded reliability assessment guidelines of 10% to 20% of the study sample (Wimmer & Dominick, 2003). The Pearson Product Moment Correlation Coefficient (represented as *r*) was used to determine coding process. It used the terms, "replicable and valid inferences" (Krippendorf, 2004, p. 18), as discussed in Neuendorf (2002) and Krippendorf (2004). Sheskin (2004, p. 956) suggests that if the Pearson Product Moment Correlation Coefficient $|r| \geq .70$, it is strong; if $.30 \leq |r| < .70$, the correlation is moderate; and if $|r| < .30$, the correlation is weak. With that, the high correlation between the coded relevance rankings and the overall relevance rankings provided by the sample of study participants ($r = .88513 \pm 0.15420$ for $p = .001$) provided a statistically significant assurance of "reproducibility" (Krippendorf, 2004, p. 215), and therefore demonstrated reliability and validity of the coding process. Table 8 presents the comparison of the coded overall relevance rankings against the overall relevance rankings provided by the participants.

Further, a test for significance for the Pearson product-moment correlation coefficient was performed to determine the likelihood that the outcome resulted from chance. The test for significance (t) was calculated for this Pearson of $r = .88513$ with the following formula, where n represents the number of responding participants (11) (Sheskin, 2004, p. 953):

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Substituting the appropriate values in the equation, the value $t = 5.71$ is computed, which, evaluated against a table of t distributions, revealed that at $p = .0005$ a significant $t \geq 3.460$, and as such, the computed value was significant at $p = .0005$. It can be concluded that this strong positive correlation was not likely achieved by chance.

Table 8. Comparison of Coded and Participant Responses on Overall Relevance

Participants' Unique Identifier	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	Pearson's *r*
3944	2 2	0 0	0 0	0 0	0 0	1
6978	2 3	0 0	3 3	0 0	0 0	0.96825
9594	2 2	0 0	0 0	0 0	0 0	1
3551	1 3	3 3	2 1	0 1	2 3	0.48038
8769	3 2	0 0	1 0	2 2	3 3	0.91466
6943	3 3	0 1	0 0	0 0	0 0	0.94324
4285	3 3	0 2	0 0	0 1	0 0	0.77174
1031	3 3	3 2	0 1	0 1	0 1	0.91856
7787	3 3	2 2	0 1	0 0	0 0	0.94907
6923	2 0	0 0	3 2	0 0	0 0	0.79057
5388	3 3	0 0	0 0	0 0	0 0	1
			Mean of *r* values			.88513±0.15420*

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. Values in the first row correspond to the coded overall relevance values for a given participant. Values in the second row correspond to the overall relevance values provided by the participant.

*$p = .001$.

Independent samples *t*-tests are used to compare the means of groups on an independent variable that consisted of two categories (Urdan, 2001). A one-way analysis of variance (ANOVA), also referred to as an *F*-test, is similar to the *t*-test. The major difference is that, where the *t*-test measures the difference between the means of groups with an independent variable with only two categories, a one-way ANOVA test can determine differences between the means of groups with an independent variable with more than two categories. One-way ANOVA tests and *t*-tests were used to compare the means of various groups in order to determine if group means were significantly ($p < .05$) different from each other. For ANOVA tests with significant differences, Scheffé post-hoc tests were used to identify the specific groups between which the significant differences existed. Further, Vaske, Gliner, and Morgan (2002) suggest that calculating an effect magnitude can be useful when dealing with a measuring scale that employs unfamiliar units. As such, Cohen's (1988) measure of effect size (*d*), which Cohen defines as "the degree to which the phenomenon is present in the population" (p. 9), was calculated for groups with significant differences. Cohen (p. 24) suggests that an effect size between groups is large for $d \geq 0.80$, medium for $0.50 \leq d < 0.80$, and small for $0.20 \leq d < 0.50$.

Findings

Overall Performance of the Search Engines Compared

The mean of the ordinal values from the coded overall relevance rankings were computed for each search engine with a confidence interval of $p = .05$ (see Table 9). For example, the mean for the Standards Directory was 1.97 ($SD = 0.92$). The confidence interval for this mean at $p = .05$ was 0.23, indicating that one can be 95% confident that the overall mean for the Standards Directory was in the interval 2.20 to 1.73. The nominal value that corresponds to the mean of the ordinal values for the Standards Directory equates to an overall relevance of *fairly relevant*. The median value of the ordinal values for the Standards Directory was a two.

Table 9. Overall Relevance Ranking of Search Engines Compared

Search Engine	*Mdn*	Mean*	*SD*	Overall Relevance
Standards Directory[a]	2	1.97 ± 0.23	0.92	Fairly Relevant
ANSI NSSN[b]	0	0.74 ± 0.31	1.19	Marginally Relevant
GlobalSpec[b]	0	1.09 ± 0.33	1.29	Marginally Relevant
Global Eng. Docs.[b]	0	0.38 ± 0.22	0.85	Irrelevant
Thomson's Techstreet[b]	0	0.86 ± 0.31	1.21	Marginally Relevant

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]$n = 60$. [b]$n = 58$.

*$p = .05$.

Several questions in the study also asked participants to rate whether the features and functions of the Standards Directory were helpful and in alignment with engineering practice, when compared with the commercial standards search engines evaluated in this study. Table 10 presents a summary of the means of participants' responses to the questions in which they compared the helpfulness and the alignment of the Standards Directory with the commercial standards search engines. The median values as well as the mean values of the responses to the questions were above the median value (4) of the scale that was used, indicating a higher level of helpfulness and alignment with engineering practice of the Standards Directory compared with the commercial standards search engines.

Table 10. Mean Comparing the Commercial Search Engines with the Standards Directory

Comparison Question	*Mdn*	Mean	*SD*
Helpfulness of the Overall Functionality	6	5.12	1.47
Alignment with Engineering Practice of the Overall Functionality	5	5.07	1.18
Helpfulness of the Search Manipulation Features	5	4.87	1.23
Alignment with Engineering Practice of the Search Manipulation Features	5	4.96	1.16
Helpfulness of the Browsing Features	5	4.90	1.19
Alignment with Engineering Practice of the Browsing Features	5	4.96	1.15

Note. Helpfulness was rated on a scale from 1: less helpful to 7: more helpful. Alignment was rated on a scale from 1: less aligned to 7: more aligned.

Demographic Characteristics and Search Engine Relevance

An analysis of the data presented suggested the possibility that some of the demographic characteristics obtained in the study influenced participants' overall relevance ranking of the search engines that were compared. As such, the mean of the overall relevance ranking for each of the search engines was compared for various demographic groups to determine the relationship between the overall relevance ranking and these demographic groups. These groups included participants' engineering discipline (see Table 11), participants' primary occupation (see Table 12), participants' highest degree (see Table 13), participants who had published in their fields of expertise (see Table 14), participants who were licensed professionals (see Table 15), and the length of time participants had worked in their discipline for the Company (see Table 16) as well as overall (see Table 17). Further, *t*-tests and one-way ANOVA tests (see Appendix S) were calculated to test for significant differences between these groups.

No significant differences were found in the overall relevance ranking of the search engines between the respective groups of participants in the various engineering disciplines, the various engineering occupations, the participants' licensed professional status, the length of time participants worked in their discipline for the Company, or the length of time participants worked in their discipline overall. Participants were grouped by highest degree awarded and their overall relevance ranking of the search engines was compared. A significant difference was found only for Thomson's Techstreet ($F_{(3,49)}$ = 5.916, p = .002). Employing the Scheffé post-hoc test found significant differences (p = .007) between participants with a bachelor's degree (M = 0.38) and participants with a master's degree (M = 1.48). The effect size between these groups (d = 1.02) was large. Comparing participants' overall relevance ranking of the search engines grouping participants by whether they had published in their field or not, a significant difference was found only for the Standards Directory (t = 2.082, df = 56, p = .042, two-tailed) between participants who had published in their field (M = 2.5) and those who had not (M = 1.9). The effect size between these groups (d = 0.83) was large. Differences in performance of the Standards Directory among demographic groups are discussed in further detail in the section titled *Performance of the Standards Directory within Participants' Demographics*.

Table 11. Mean of the Overall Relevance Ranking Grouped by Engineering Discipline

ED	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Electrical	1.67	1	1.11	0.89	1.33	9
Mechanical	1.91	0.83	1	0.30	1	23
Civil/Arch.	2	0[a]	1.67[a]	0[a]	1[a]	4
Other	2.05	0.55	1	0.35	0.6	20

Table 11 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. ED = engineering discipline, indicates participants' primary engineering discipline.

[a]*n* = 3.

Table 12. Mean of the Overall Relevance Ranking Grouped by Primary Occupation

PO	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Applied	1.83	0.92	1.33	0.5	1.13	24
Management	2.06	0.69	1	0.25	0.5	16
Executive	0	0	3	0	3	1
Other	2.156	0.59[a]	0.71[a]	0.35[a]	0.71[a]	19

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. PO = primary occupation, indicates participants' primary engineering occupation.

[a]*n* = 17.

Table 13. Mean of the Overall Relevance Ranking Grouped by Highest Degree Awarded

HD	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
High School	2	0	0	0	3	1
Associate's	2.25	0	0.75	0	0	4
Bachelor's	2.11	0.77[a]	0.96[a]	0.27[a]	0.38[a]*	28
Master's	1.71	0.81	1.1	0.43	1.48*	21
Doctorate	2.5	0	1.5	0	0	2

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. HD = highest degree, indicates participants' highest degree awarded.

[a]*n* = 26.

*$p < .05$.

Table 14. Mean of the Overall Relevance Ranking Grouped by Whether Participants had Published in their Field of Expertise

PF	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	2.5*	0.5	0.8	0.4	0.4	10

Table 14 (continued)

PF	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
No	1.88[*]	0.76[a]	1.13[a]	0.33[a]	0.93[a]	48

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. PF = published in field, indicates whether a participant published in their field of expertise.

[a]$n = 46$.

[*]$p < .05$, two-tailed.

Table 15. Mean of the Overall Relevance Ranking Grouped by Whether Participants were Licensed Professionals

LP	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	1.96	0.43[a]	1.10[a]	0.33[a]	1.05[a]	23
No	2.03	0.89	0.97	0.34	0.71	35

Note. [a]Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. LP = licensed professional, indicates whether or not a participant was a licensed professional.

[a]$n = 21$.

Table 16. Mean of the Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

YDC	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
< 6	1.83	0.67	1.04	0.29	0.63	24
6 to 10	2.5	0.75	1.08	0.58	1	12
11 to 15	2.13	1.14[a]	0.29[a]	0.29[a]	0.43[a]	8
> 15	1.86	0.31[b]	1.31[b]	0.23[b]	1.31[b]	14

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. YDC = years in discipline for the Company, indicates the number of years a participant worked in their discipline for the Company.

[a]$n = 7$. [b]$n = 13$.

Table 17. Mean of the Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

YDO	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
< 6	1.57	1	1.57	0.43	0.71	7
6 to 10	2.11	1.33	0.89	0.11	0.56	9
11 to 15	2.38	0	1	0.63	0.38	8
> 15	1.97	0.64[a]	1[a]	0.30[a]	1.03[a]	35

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. YDO = years in discipline overall, indicates the number of years a participant worked in their overall.

[a]*n* = 33.

Information Retrieval Experience and Search Engine Relevance

Analysis of the study data suggested the possibility that participants' information retrieval experience influenced their overall relevance ranking of search engines. As such, the mean of the overall relevance ranking for each of the search engines was compared against participants' information retrieval experience to determine the relationship between the overall relevance ranking and the experience within those groups. These groups included participants' use of libraries (see Table 18), online/card catalogs (see Table 19), the Internet (see Table 20), online databases (see Table 21), and the World Wide Web (see Table 22). Further, one-way ANOVA tests (see Appendix S) were calculated to test for significant differences between these groups.

No significant differences were found in the overall relevance ranking of the search engines between the respective groups of participants in their use of libraries, online/card catalogs, or online databases. Comparisons between groups of participants for the Internet and WWW use were not possible as all respondents indicated that they used the Internet and the World Wide Web.

However, content analysis of the search terms selected by participants (see Appendix P) suggested that participants' domain knowledge influenced search behavior. Unlike the public at large, who generally use between two and three search terms in a query (Jansen & Pooch, 2001; Spink, Wolfram, Jansen, & Saracevic, 2001), the participants in this study used an average of four search terms in their queries (excluding repeat queries). In addition to participants' domain knowledge, most participants used singular nouns and infinitive verbs to search for information on the topics they selected. This specific selection of search terms indicated that participants' experience with searching information systems, including the use of query language operators, being aware of synonyms, and knowledge of the limitations of free-text searching, influenced their search term selection, an observation supported by the literature (Wildemuth, 2004; Zhang, Anghelescu, & Yuan, 2005).

Table 18. Mean of the Overall Relevance Ranking Grouped by Library Use

Library Use	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	1.92	0.72[a]	1.02[a]	0.36[a]	0.91[a]	49
No	2.17	0.50	1.50	0.33	0.67	6
Do not know/ Not applicable	2.75	0.75	0.75	0	0	4

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]*n* = 47.

Table 19. Mean of the Overall Relevance Ranking Grouped by Online/Card Catalog Use

Online/Card Catalogs	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	2.06	0.58[a]	1.23[a]	0.45[a]	0.90[a]	33
No	1.83	0.96	0.87	0.13	0.78	23
Do not know/Not applicable	2.67	0	0.67	0.67	0.33	3

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]$n = 31$.

Table 20. Mean of the Overall Relevance Ranking Grouped by Internet Use

Internet Use	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	2.00	0.70[a]	1.05[a]	0.33[a]	0.82[a]	59

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]$n = 57$.

Table 21. Mean of the Overall Relevance Ranking Grouped by Online Database Use

Online Database Use	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	2.18	0.90[a]	1.50[a]	0.70[a]	0.80[a]	11
No	1.89	0.72[b]	0.98[b]	0.28[b]	0.91[b]	44
Do not know/ Not applicable	2.75	0	0.75	0	0	4

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]$n = 10$. [b]$n = 43$.

Table 22. Mean of the Overall Relevance Ranking Grouped by World Wide Web Use

WWW Use	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Yes	2.00	0.70[a]	1.05[a]	0.33[a]	0.82[a]	59

Table 22 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

[a]n = 57.

Form of Search and Search Engine Relevance

An analysis of the data presented suggested the possibility that the form of search (Meadow, Boyce, & Kraft, 2000, p. 273) participants used influenced their overall relevance ranking of the search engines that were compared. As such, the mean of the overall relevance ranking for each of the search engines was compared against the form of search used to determine whether any of the search engines performed better for a given form of search (see Table 23). Further, one-way ANOVA tests (see Appendix S) were calculated to test for significant differences between these groups. However, no significant differences were found in the overall relevance ranking of the search engines for the different types of search.

Table 23. Mean of the Overall Relevance Ranking Grouped by Form of Search Performed

FS	Standards Directory	ANSI NSSN	GlobalSpec	Global Eng. Docs	Thomson's Techstreet	*n*
Known Item	2.67	1	2	1	1	3
Specific Info.	2.18	0.29[a]	1.19[a]	0.31[a]	0.41[a]	18
General Info.	1.81	0.90	1	0.39	0.90	31
Explore	2.14	1.17[b]	0.67[b]	0.33[b]	1.5[b]	7

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. FS = form of search from Meadow, Boyce, and Kraft (2000, p. 273) performed.

[a]n = 17. [b]n = 6.

Performance of the Standards Directory within Participants' Demographics

An analysis of the data presented suggested the possibility that some of the demographic characteristics obtained in the study influenced participants' overall relevance ranking of the Standards Directory as the best performing search engine in the study based on overall relevance ranking. As such, the mean of the overall relevance ranking for the Standards Directory was compared for various demographic groups to determine the relationship between the overall relevance ranking and these demographic groups. These groups included participants who had published in their fields of expertise (see Table 24), were licensed professionals (see Table 25), the length of time participants had worked in their discipline for the Company (see Table 26) and overall (see Table 27), the extent to which participants considered their work standards-based (see Table 28), and participants' primary occupation (see Table 29 and Table 30). One-way ANOVA tests and *t*-tests (see Appendix S and Appendix T) were calculated to test for significant differences in the performance of the Standards Directory (i.e., the overall relevance ranking of the Standards Directory) between participant demographic groups.

Table 24. Mean of the Standards Directory's Overall Relevance Ranking Grouped by Whether Participants had Published in their Field of Expertise

Published in Field	*N*	Mean	*SD*
No	48	1.88*	0.914
Yes	10	2.50*	0.527

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

*$p < .05$.

Table 25. Mean of the Standards Directory's Overall Relevance Ranking Grouped by Whether Participants were Licensed Professionals

Licensed Professional	*N*	Mean	*SD*
Yes	23	1.96	1.022
No	35	2.03	0.822

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table 26. Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Years for Company	*N*	Mean	*SD*
0 to 5	24	1.83	0.816
6 to 10	12	2.50*	0.905
11 to 15	10	2.10	0.876
15 to 20	8	2.25	0.463
21 to 25	3	0.67*	1.155
Total	57	2.02	.896

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

$^{*}p < .05$.

Table 27. Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Years in Discipline	*N*	Mean	*SD*
0 to 5	7	1.57	.787
6 to 10	9	2.11	.782
11 to 15	8	2.38	1.061
16 to 20	9	1.67	1.225
21 to 25	10	2.30	.483
26 to 30	10	2.00	.816
31 to 35	4	2.25	.500
Total	57	2.04	.865

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table 28. Mean of the Extent to Which Work was Considered Standards-Based Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	4.667	2.160
Marginally Relevant	5	2.800*	1.304
Fairly Relevant	31	5.290*	1.321
Highly Relevant	17	4.882	1.409
Total	59	4.898	1.561

Note. Scale from 1: very limited to 7: highly.

*$p = .01$.

Table 29. Mean of the Helpfulness of the Standards Directory Grouped by Participants' Primary Occupation

Primary Occupation	*N*	Mean	*SD*
Engineer (Applied)	23	4.39*	1.62
Engineer (Management)	16	5.63*	1.45
Other Technical Disc./Profession	19	5.47	1.31
Total	59	5.03	1.60

Note. Scale from 1: hindrance to 7: helpful.

*$p < .05$.

Table 30. Mean of the Intuitiveness of the Standards Directory's Interface Grouped by Participants' Primary Occupation

Primary Occupation	*N*	Mean	*SD*
Engineer (Applied)	23	4.61*	1.34
Engineer (Management)	16	5.63*	1.09
Other Technical Disc./Profession	19	5.05	1.08
Total	59	5.00	1.26

Note. Scale from 1: awkward to 7: intuitive.

*$p < .05$.

The *t*-tests found that there was a statistically significant difference in the overall relevance ranking of the Standards Directory between the participants who had published in their field of expertise ($M = 2.50$) and those who had not ($M = 1.88$) ($t = 2.082$, $df = 56$, $p = .042$, two-tailed). The effect size between these groups ($d = 0.83$) was large. There was no statistically significant difference between the participants who were licensed professionals (*M* = 1.96) and those who were not (*M* = 2.03) in the overall relevance ranking of the Standards Directory ($t = 0.296$, $df = 56$, $p = .768$, two-tailed). A one-way ANOVA ($F_{(4,52)} = 3.519$, $p = .013$) and Scheffé post-hoc test ($p = .028$) found a statistically significant difference in the overall relevance ranking of the Standards Directory between the participants who had worked in their field/discipline for the Company for 6 to 10 years (*M* = 2.50) and those who had worked in their field/discipline for the Company for 21 to 25 years (*M* = 0.67). This difference between groups indicates that the Standards Directory was more relevant to participants who worked in their field/discipline for the Company for 6 to 10 years (between highly relevant and fairly relevant) than participants who had worked in their field/discipline for the Company for 21 to 25 years (between marginally relevant and irrelevant). A one-way ANOVA test found no statistically significant difference in the overall relevance ranking of the Standards Directory ($F_{(6,50)} = 1.027$, $p = .419$) between participants grouped into five year increments of experience in their field/discipline overall. Participants rated the extent to which they considered their work standards-based on a 7-point scale between very limited (1) and highly (7). A one-way ANOVA tests found significant differences in the extent to which participants considered their work standards-based and the overall relevance ranking of the Standards Directory ($F_{(3,55)} = 4.35$, $p = .008$). Employing the Scheffé post-hoc test found significant differences ($p = .01$) between participants who ranked the overall relevance of the Standards Directory as fairly relevant (*M* = 5.29) and participants who ranked the overall relevance of the Standards Directory as marginally relevant (*M* = 2.8). The effect size between these groups ($d = 1.9$) was large. This difference between groups indicated that the search results of the Standards Directory were of greater relevance to participants whose work was more standards-based than others were. Significant differences were found in the participants' ranking of the helpfulness of the Standards Directory in supporting their search for a given standard and their primary occupation, with the helpfulness rated on a 7-point scale between hindrance (1) and helpful (7) ($F_{(2,55)} = 4.26$, $p = .0190$). Employing the Scheffé post-hoc test found significant differences ($p = .04$) between participants who were applied engineers (M = 4.39) and participants who were engineering managers (M = 5.63). The effect size between these groups (d = 0.81) was large. This difference between groups indicates that the Standards Directory was more helpful to participants who were in management than participants who were in applied engineering. Significant differences were found in the participants' ranking of the intuitiveness of the Standards Directory's interface in supporting their search for a given standard and their primary occupation, with the helpfulness rated on a 7-point scale between awkward (1) and intuitive (7) ($F_{(2,55)} = 3.43$, $p = .0394$). Employing the Scheffé post-hoc test found significant differences ($p = .04$) between participants who were applied engineers (M = 4.61) and participants who were engineering managers (M = 5.63). The effect size between these groups (d = 0.84) was large. This difference between groups indicates that the Standards Directory was more intuitive to participants who were in management than participants who were applied engineers. Overall, more experienced participants (i.e., participants who worked for over 20 years in their discipline for the Company and who had published in their field) found the search results of the Standards Directory more relevant than less experienced participants did. This increased performance of the Standards Directory encountered by more experienced participants may stem from a greater level of domain expertise and familiarity with standards from practice (Jenkins, Corritore, & Wiedenbeck, 2003).

Performance Characteristics of the Standards Directory

One-way ANOVA tests (see Appendix T) and *t*-tests were calculated to test for significant differences between the participants' overall relevance ranking of the Standards Directory and their rating of various performance characteristics of the Standards Directory. The performance characteristics evaluated included limiting searches to discipline before or after a search was performed (see Table 31), the effectiveness of supporting Meadow, Boyce, and Kraft's (2000) four forms of search (see Table 32), participants' overall reaction to the Standards Directory (see Table 33 to Table 39), and the helpfulness, intuitiveness, and alignment with engineering practice of the Standards Directory (see Table 40 to Table 47).

Table 31. Mean of the Standards Directory's Overall Relevance Ranking Grouped by Whether Participants Limited Their Search to a Discipline Before or After They Performed Their Search

Limited Search	*N*	Mean	*SD*
Before	24	2.04	0.690
After	24	1.79	1.215

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table 32. Mean of the Effectiveness as it Related to the Form of Search Performed Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.857*	2.340
Marginally Relevant	5	3.800	1.643
Fairly Relevant	30	4.933*	1.484

Table 32 (continued)

Overall Relevance	***N***	**Mean**	***SD***
Highly Relevant	17	5.882*	1.219

Note. Scale from 1: ineffective to 7: effective.

*$p < .05$.

Table 33. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	2.000*	1.155
Marginally Relevant	4	4.750*	0.957
Fairly Relevant	30	4.833*	1.206
Highly Relevant	16	5.563*	0.964

Note. Scale from 1: rigid to 7: flexible.

*$p < .01$.

Table 34. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	4.571	1.618
Marginally Relevant	4	5.000	2.000
Fairly Relevant	30	4.833	1.416
Highly Relevant	17	5.588	1.502

Note. Scale from 1: difficult to 7: easy.

Table 35. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	2.714*	0.756
Marginally Relevant	4	5.000	2.000
Fairly Relevant	30	4.833*	1.416
Highly Relevant	17	5.588*	1.502

Note. Scale from 1: frustrating to 7: satisfying.

*$p < .05$.

Table 36. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	4.714	1.254
Marginally Relevant	5	5.000	1.414
Fairly Relevant	29	4.897	1.047
Highly Relevant	16	5.313	1.250

Note. Scale from 1: awkward to 7: intuitive.

Table 37. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.429^*	1.134
Marginally Relevant	5	4.400	1.817
Fairly Relevant	30	5.133^*	1.358
Highly Relevant	16	5.938^*	0.680

Note. Scale from 1: inadequate to 7: adequate.

$^*p < .01$.

Table 38. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	2.500^*	1.761
Marginally Relevant	5	4.800^*	1.643
Fairly Relevant	28	5.536^*	1.138
Highly Relevant	16	6.063^*	0.443

Note. Scale from 1: useless to 7: helpful.

$^*p < .05$.

Table 39. Mean of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.143^*	1.215
Marginally Relevant	5	4.200	1.095
Fairly Relevant	28	4.893^*	1.166
Highly Relevant	16	5.500^*	0.730

Note. Scale from 1: terrible to 7: wonderful.

$^*p < .01$.

Table 40. Mean of the Helpfulness of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	2.714^{*}	1.976
Marginally Relevant	4	4.500	1.915
Fairly Relevant	31	5.065^{*}	1.124
Highly Relevant	17	6.059^{*}	1.088

Note. Scale from 1: hindrance to 7: helpful.

$^{*}p < .01$.

Table 41. Mean of the Intuitiveness of the Standards Directory's Interface Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	4.714	1.604
Marginally Relevant	5	4.400	1.817
Fairly Relevant	31	5.032	1.016
Highly Relevant	16	5.250	1.390

Note. Scale from 1: awkward to 7: intuitive.

Table 42. Mean of the Helpfulness of the Standards Directory's Overall Functionality Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	7	2.286^{*}	1.380
Marginally Relevant	4	3.250^{*}	0.500
Fairly Relevant	31	5.452^{*}	0.723
Highly Relevant	17	6.118^{8}	0.697

Note. Scale from 1: less helpful to 7: more helpful.

$^{*}p < .01$.

Table 43. Mean of the Overall Alignment with Engineering Practice of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	***N***	**Mean**	***SD***
Irrelevant	6	3.333^{*}	1.366
Marginally Relevant	4	4.500	1.732
Fairly Relevant	31	5.387^{*}	0.803
Highly Relevant	17	5.235^{*}	1.091

Table 43 (continued)

Note. Scale from 1: less aligned to 7: more aligned.

$^{*}p < .01$.

Table 44. Mean of the Helpfulness of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.857*	1.069
Marginally Relevant	3	5.000*	1.000
Fairly Relevant	28	5.143*	0.970
Highly Relevant	17	5.235*	0.970

Note. Scale from 1: less helpful to 7: more helpful.

$^{*}p < .05$.

Table 45. Mean of the Alignment with Engineering Practice of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	3.500*	1.517
Marginally Relevant	3	5.333	0.577
Fairly Relevant	27	5.111*	1.121
Highly Relevant	17	5.176*	0.809

Note. Scale from 1: less aligned to 7: more aligned.

$^{*}p < .05$.

Table 46. Mean of the Helpfulness of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.286*	0.488
Marginally Relevant	3	4.333	0.577
Fairly Relevant	27	4.963*	1.055
Highly Relevant	15	5.667*	0.976

Note. Scale from 1: less helpful to 7: more helpful.

$^{*}p < .01$.

Table 47. Mean of the Alignment with Engineering Practice of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.143*	0.690
Marginally Relevant	3	4.333	0.577
Fairly Relevant	27	5.222*	0.892
Highly Relevant	15	5.467*	0.990

Note. Scale from 1: less aligned to 7: more aligned.

*$p < .05$.

The *t*-tests found no significant difference in the overall relevance ranking of the Standards Directory (t = 0.876, df = 36.444, p = .387, two-tailed, equal variances not assumed) between the participants who indicated they had limited their search to a given discipline before executing their search (M =2.042) and those who indicated they had limited their search to a given discipline after executing their search (M = 1.792). The ANOVA tests found significant differences in the effectiveness as it related to the form of search performed and participants' overall relevance ranking of the Standards Directory, with the effectiveness rated on a 7-point scale between ineffective (1) and effective (7) ($F_{(3,55)}$ = 7.21, p = .0004). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant (M = 2.857) and fairly relevant (M = 4.933, p = .02) as well as between participants who ranked the overall relevance of the Standards Directory as irrelevant and highly relevant (M = 5.882, p < .001). All effect sizes between these groups (d = 1.06 & d = 1.62 respectively) were large.

Significant differences were found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between rigid (1) and flexible (7) ($F_{(3,55)}$ =

16.77, $p < .0005$). Employing the Scheffé post-hoc test found significant differences in the overall reaction between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 2.000$, $p < .01$) and all other relevance ratings (marginally relevant $M = 4.750$, fairly relevant $M = 4.833$, highly relevant $M = 5.563$). All effect sizes between these groups ($d = 2.59$, $d = 2.4$, & $d = 3.35$ respectively) were large.

Significant differences were not found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between difficult (1) and easy (7) ($F_{(3,55)} = 2.47$, $p = .0718$). Significant differences were found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between frustrating (1) and satisfying (7) ($F_{(3,54)} = 6.76$, $p = .0006$). Employing the Scheffé post-hoc test found significant differences in the overall reaction between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 2.714$) and fairly relevant ($M = 4.833$, $p = .01$) as well as irrelevant and highly relevant ($M = 5.588$, $p < .01$). All effect sizes between these groups ($d = 1.87$ & $d = 2.42$ respectively) were large.

Significant differences were not found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between awkward (1) and intuitive (7) ($F_{(3,53)} = 0.60$, $p = .6156$). Significant differences were found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between inadequate (1) and adequate (7)

($F_{(3,54)}$ = 13.86, $p < .0001$). Employing the Scheffé post-hoc test found significant differences in the overall reaction between participants who ranked the overall relevance of the Standards Directory as irrelevant (*M* = 2.429, $p < .01$) and fairly relevant (*M* = 5.133) as well highly relevant (*M* = 5.938). The effect sizes between these groups (*d* = 2.16 & *d* = 3.75 respectively) were large.

Significant differences were found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between useless (1) and helpful (7) ($F_{(3,54)}$ = 15.66, $p < .0001$). Employing the Scheffé post-hoc test found significant differences in the overall reaction between participants who ranked the overall relevance of the Standards Directory as irrelevant (*M* = 2.50) and all other relevance ratings (marginally relevant *M* = 4.800, *p* = .02; fairly relevant *M* = 5.536, $p < .01$; highly relevant *M* = 6.063, $p < .01$). All effect sizes between these groups (*d* = 1.35, *d* = 2.05, & *d* = 2.77 respectively) were large.

Significant differences were found in the participants' overall reaction to the Standards Directory and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between terrible (1) and wonderful (7) ($F_{(3,54)}$ = 8.64, *p* = .0001). Employing the Scheffé post-hoc test found significant differences in the overall reaction between participants who ranked the overall relevance of the Standards Directory as irrelevant (*M* = 3.143, $p < .01$) and fairly relevant (*M* = 4.893) as well highly relevant (*M* = 5.50). All effect sizes between these groups (*d* = 1.47 & *d* = 1.98 respectively) were large.

Significant differences were found in the participants' rating of the helpfulness of the Standards Directory in supporting their search for a given standard and their overall relevance ranking of the Standards Directory, with the helpfulness rated on a 7-point scale between hindrance (1) and helpful (7) ($F_{(3,55)} = 11.39$, $p < .0001$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 2.714$) and fairly relevant ($M = 5.065$, $p < .01$) as well as irrelevant and highly relevant ($M = 6.059$, $p < .01$). All effect sizes between these groups ($d = 1.46$ & $d = 2.08$ respectively) were large.

Significant differences were not found in the participants' rating of the intuitiveness of the Standards Directory's interface and their overall relevance ranking of the Standards Directory, with the overall reaction rated on a 7-point scale between awkward (1) and intuitive (7) ($F_{(3,55)} = 0.70$, $p = .5535$). Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the helpfulness of the Standards Directory's overall functionality when compared to the commercial standards search engines used, with the helpfulness rated on a 7-point scale between less helpful (1) and more helpful (7) ($F_{(3,55)} = 46.60$, $p < .0001$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 2.286$) and fairly relevant ($M = 5.452$, $p < .01$), irrelevant and highly relevant ($M = 6.118$, $p < .01$), marginally relevant ($M = 3.250$) and fairly relevant ($p < .01$), and marginally relevant and highly relevant ($p < .01$). All effect sizes between these groups ($d = 2.87$, $d = 3.22$, $d = 3.54$, & $d = 4.73$ respectively) were large.

Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the overall alignment with engineering practice of the Standards Directory when compared to the commercial standards search engines used, with the alignment rated on a 7-point scale between less aligned (1) and more aligned (7) ($F_{(3,54)} = 7.29$, $p = .0003$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 3.333$) and fairly relevant ($M = 5.387$, $p < .01$) as well as irrelevant and highly relevant ($M = 5.235$, $p < .01$). All effect sizes between these groups ($d = 1.83$ & $d = 1.57$ respectively) were large.

Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the helpfulness of the search manipulation features of the Standards Directory when compared to the commercial standards search engines used, with the helpfulness rated on a 7-point scale between less helpful (1) and more helpful (7) ($F_{(3,51)} = 11.29$, $p < .0001$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 2.857$) and marginally relevant ($M = 5.000$, $p = .03$), irrelevant and fairly relevant ($M = 5.143$, $p < .01$), and irrelevant and highly relevant ($M = 5.235$, $p < .01$). All effect sizes between these groups ($d = 2.07$, $d = 2.24$, & $d = 2.33$ respectively) were large.

Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the alignment with engineering practice of the search manipulation features of the Standards Directory when compared to the commercial standards search engines used, with the alignment rated on a 7-point scale between less aligned (1) and more aligned (7) ($F_{(3,49)} = 4.32$, $p = .0089$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 3.500$) and fairly relevant ($M = 5.111$, $p = .02$) as well as irrelevant and highly relevant ($M = 5.176$, $p = .02$). All effect sizes between these groups ($d = 1.21$ & $d = 1.38$ respectively) were large.

Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the helpfulness of the browsing features of the Standards Directory when compared to the commercial standards search engines used, with the helpfulness rated on a 7-point scale between less helpful (1) and more helpful (7) ($F_{(3,48)} = 10.14$, $p < .0001$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 3.286$) and fairly relevant ($M = 4.963$, $p < .01$) as well as irrelevant and highly relevant ($M = 5.667$, $p < .01$). All effect sizes between these groups ($d = 2.04$ & $d = 3.09$ respectively) were large.

Significant differences were found in the participants' overall relevance ranking of the Standards Directory and the alignment with engineering practice of the browsing features of the Standards Directory when compared to the commercial standards search engines used, with the alignment rated on a 7-point scale between less aligned (1) and more aligned (7) ($F_{(3,48)} = 12.66$, $p < .0001$). Employing the Scheffé post-hoc test found significant differences between participants who ranked the overall relevance of the Standards Directory as irrelevant ($M = 3.143$) and fairly relevant ($M = 5.222$, $p = .02$) as well as irrelevant and highly relevant ($M = 5.467$, $p = .02$). All effect sizes between these groups ($d = 2.61$ & $d = 2.72$ respectively) were large.

These statistically significant comparisons of means indicate that as participants' rating of the overall relevance of search results increased, participants' perception of the performance characteristics of the Standards Directory also increased. These findings also give further confidence in the reliability and validity of the content analysis methodology that was employed.

Strengths and Weaknesses of the Standards Directory

During the study, participants were asked to list three features or functions of the Standards Directory they found most useful and least useful (see Appendix G). Content analysis was performed on the comments from participants who provided feedback on the most and least useful features of the Standards Directory. In the list of most useful features, the 60 participants provided 113 comments and described the most useful features with 646 words. The most frequently supplied noun and verb words, including plurals, stem words, and synonyms (Stemler, 2001), were *search* (f = 30), *standard* (*f* = 29), *Disney* (*f* = 11), *document* (*f* = 8), *keyword* (*f* = 7), *industry* (*f* = 7), *link* (*f* = 6), and *sort/order/filter* (*f* = 5). In the list of least useful features, the 60 participants provided 51 comments that described the less useful features with 515 words. The most frequently supplied noun and verb words were *search* (*f* = 15), *standard* (*f* = 14), *time* (*f* = 6), *directory* (*f* = 5), *useful* (*f* = 4), *industry* (*f* = 4), *keyword* (*f* = 4), *feature* (*f* = 4), *result* (*f* = 4), and *find* (*f* = 4). Using content analysis, participants' comments on the most and least useful features of the Standards Directory were categorized into three topical areas; usability (ease of use and navigation), search (search interface and presentation of search results), and content (the availability of Company and industry standards in one system)

(Su, 2003b). The frequency of comments in each category for most useful features were usability (*f* = 35), search (*f* = 42), and content (*f* = 13). The frequency of comments in each category for less useful features were usability (*f* = 9), search (*f* = 12), and content (*n* = 8). Examples of participants' comments on the Standards Directory's most useful usability features included, "More intuitive to me," "Very accessible and easy to navigate," "Symbol telling if standard is in revision or is the current one," "The legend that tells you what type of article it is," and "Ease of use." Examples of participants' comments on the Standards Directory's most useful content features included, "Being able to bring up many standards in electronic format" and "The attached documents can be opened without having to use a special password." Examples of participants' comments on the Standards Directory's most useful search features included, "Good abstract or identification of the standard in the initial listing," "Ability to order results by name/number," and "Keyword search seem to be set up properly and always seems to find what I am looking for." Despite a higher number of comments on the most useful features of the Standards Directory, the comments on the least useful features provided insight into areas for potential improvements to the system. Some of the comments on features participants suggested could be improved included some difficulty in knowing what could be clicked on due to the site's color scheme. For example, "It's not readily apparent what you can 'click' on. Some words blend into the background" and "The layout where the color scheme is blue which confuses clickable links with regular words." Two participants also suggested that the term *Advanced Search* be used to differentiate between the keyword search tool and the search tool that provides pre-search category filtering. Participants also pointed to some of the drawbacks of word stemming when keyword searching. For example, "Projection != project" and "Giving results that do not have your keyword in them." In the content category, participants noted that the system did not always provide the electronic full-text of a given standard for download. For example, "Standards that aren't immediately available online electronically" and "Too many standards are not available online." This limitation of the system was not technical but due to the legal constraints related to copyright.

Comparison of Participants on Non-Performance Characteristics

Non-performance characteristics were compared by means of one-way ANOVA tests and *t*-tests (see Appendix U) to examine significant differences among various demographic groups. These groups included the extent to which work was considered standards-based (1: very limited - 7: highly), grouped by participants' licensed professional status (see Table 48); the extent to which work was considered standards-based, grouped by whether participants had published in their field of expertise (see Table 49); participants' licensed professional status, grouped by whether participants had published in their field of expertise (see Table 50); whether participants had published in their field of expertise, grouped by the highest degree awarded (see Table 51); and extent to which work was considered standards-based, grouped by the highest degree awarded (see Table 52).

The *t*-tests found a statistically significant difference in the extent to which participants considered their work standards-based between the participants who were licensed professionals ($M = 5.61$) and those who were not ($M = 4.43$) ($t = -2.978$, df = 56, $p = .004$, two-tailed). The effect size between these groups ($d = 0.8$) was large. There was no significant difference between the participants who had published in their field of expertise (M = 4.83) and those who had not (M = 5.30) in the extent to which participants considered their work standards-based (t = -0.853, df = 56, p = .397, two-tailed). There was a statistically significant difference between the participants who were licensed professionals (M = 0.70) and those who were not (M = 0.34) as to whether a participant had published in their field of expertise or not (t = -2.153, df = 55, p = .036, two-tailed). The effect size between these groups (d = 0.52) was medium. An ANOVA test found a significant difference between participants of different education levels and participants who had published in their field of expertise ($F_{(3,50)}$ = 4.303, p = .009). Employing the Scheffé post-hoc test found significant differences between participants with a doctorate (M = 1.0) and participants with an associate’s degree (M = 0, p = .024) and a bachelor’s degree (M = 0.11, p = .016). The effect size between the doctorate and bachelor’s groups (d = 3.93) was large. An ANOVA test found a significant difference between participants’ education levels and the likelihood that they had published in their field of expertise ($F_{(3,51)}$ = 2.938, p = .042). However, a Scheffé post-hoc test did not find significant differences between the individual participant groups. Overall, these findings indicated that participants who were licensed professionals and had higher levels of university education considered their work to be more standards-based and were more likely to have published in their field of expertise.

Table 48. Mean of the Extent to Which Work was Considered Standards-Based Grouped by Whether Participants were Licensed Professionals

Licensed Professional	*N*	Mean	*SD*
No	35	4.43*	1.461
Yes	23	5.61*	1.500

Note. Scale from 1: very limited to 7: highly.

*$p < .005$.

Table 49. Mean of the Extent to Which Work was Considered Standards-Based Grouped by Whether Participants had Published in their Field of Expertise

Published in Field	*N*	Mean	*SD*
No	48	4.83	1.562
Yes	10	5.30	1.636

Note. Scale from 1: very limited to 7: highly.

Table 50. Mean of Whether Participants were Licensed Professionals Grouped by Whether Participants had Published in their Field of Expertise

Published in Field	*N*	Mean	*SD*
No	47	0.34*	0.479
Yes	10	0.70*	0.483

Note. Values used for nominal scale were no: 0 and yes: 1.

*$p < .05$.

Table 51. Mean of Whether Participants had Published in their Field of Expertise Grouped by the Highest Degree Awarded

Highest Degree Awarded[a]	*N*	Mean	*SD*
Associate's	4	0.00*	0.000
Bachelor's	27	0.11*	0.320
Master's	21	0.24	0.436
Doctorate	2	1.00*	0.000
Total	54	0.19	0.392

Note. Values used for nominal scale were no: 0 and yes: 1.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases

*$p < .05$.

Table 52. Mean of the Extent to Which Work was Considered Standards-Based Grouped by the Highest Degree Awarded

Highest Degree Awarded[a]	*N*	Mean	*SD*
Associate’s	4	3.50	1.291
Bachelor’s	28	5.25	1.295
Master’s	21	4.52	1.750
Doctorate	2	6.50	0.707
Total	55	4.89	1.560

Note. Scale from 1: very limited to 7: highly.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases

Summary of Results

From an original sample of 61 Company employees of various technical disciplines, 60 participants’ surveys were used in this study. Demographic data indicated that study participants had a significant amount of experience with information retrieval, the Internet, and other online tools, all of which the participants used on a regular basis. The demographic data also indicated that the participants in this study were highly educated and experienced in their fields of expertise with a significant number of years in their profession. Many participants were licensed professionals, had published in their field of expertise, and considered their work highly standards-based.

Qualitative content analysis was used to determine the overall relevance of the search engines studied by analyzing participants’ responses to questions related to the participants’ feedback on overall relevance of the results of searches and the usefulness of the various search engines. These measures provided a ranking of the overall success of the search engines in providing relevant results for a participant’s information need or problem. The overall relevance ranking of the Standards Directory was fairly relevant while the overall relevance rankings of ANSI NSSN, GlobalSpec, and Thomson's Techstreet were marginally relevant and the overall relevance ranking of Global Engineering Documents was irrelevant.

Specifically for the Standards Directory, participants with higher levels of experience and education judged not only higher overall relevance rankings using the Standards Directory but also considered their work to be more standards-based and were more likely to have published in their field of expertise. For example, the Standards Directory was more intuitive and more helpful to participants who were in management than participants who were applied engineers. Overall, more experienced participants (i.e., participants who worked for over 20 years in their discipline for the Company and had published in their field) found the search results of the Standards Directory more relevant than less experienced participants did. The perceived enhanced performance of the Standards Directory expressed by more experienced participants may stem from a greater level of domain expertise and familiarity with standards (Jenkins, Corritore, & Wiedenbeck, 2003). Further, as participants' rating of the overall relevance of search results increased, participants' perception of the performance characteristics of the Standards Directory also increased.

An analysis of participants' comments revealed that the vast majority believed search engines were helpful in finding information on the World Wide Web and most participants had positive views of search engines, citing ease of use and the ability to access an index of the vast amount of information available on the WWW as the predominant reasons for their usefulness. However, almost all participants also cited several disadvantages with WWW search engines. The expressed disadvantages included citing a lack of precision and accuracy when using WWW search engines, a lack of technical content, unfamiliarity with their functionality, and concerns about possible growing commercial influences on search results.

The results and data analysis lead directly to an examination and interpretation of the findings. The following chapter outlines these conclusions, delineates their implications, and provides recommendations for future study.

Chapter 5

Conclusion, Implications, Recommendations, and Summary

Conclusions

This study presented the Standards Directory, an engineering and technology standards digital library and IR system and examined its effectiveness in relation to four major commercial engineering and technology standards search engines. The overall relevance ranking of the search engines was established by relevance judgments made by Company engineers fulfilling real information needs. The evaluation of the search engines in providing relevant results for a participant's information need or problem (Johnson, Griffiths, & Hartley, 2003; Maglaughlin & Sonnenwald, 2002; Su, 2003a) presented in Chapter 3 shows a higher level of overall success of the Standards Directory than the commercial standards search engines evaluated in this study (see Table 9). The categories used to describe the overall relevance of the systems evaluated in the study were highly relevant, fairly relevant, marginally relevant, and irrelevant (Borlund, 2003; Järvelin & Kekäläinen, 2000; Kekäläinen & Järvelin, 2002; Sormunen, 2002; Spink, Greisdorf, & Bateman, 1998; Vakkari & Sormunen, 2004). Whereas the Standards Directory's overall relevance ranking was considered *fairly relevant*, the commercial engineering and technology standards search engines' overall relevance ranking was considered *marginally relevant* (ANSI NSSN, GlobalSpec, and Thomson's Techstreet) and *irrelevant* (Global Engineering Documents). That is, the commercial search engines studied for their effectiveness in retrieving specific standards were judged ineffective in returning results relevant to Company engineers and architects and, as such, do not adequately support their standards seeking needs. Further, data analysis presented above indicates that the *fairly relevant* overall relevance ranking of the Standards Directory stemmed from the Standards Directory's ability to support various forms of search more effectively as well as be in closer alignment with engineering practice through features such as the combined use of standards metadata with a full text stem word search of standards.

Two research questions formed the basis of this study:

1. Can document categorization, the use of metadata for browsing, and document full-text searching improve the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines?
2. What are the strengths and weaknesses with respect to end-user searching of the Standards Directory compared with the commercial engineering and technology standards search engines utilized in this study?

A discussion of these research questions along with the applicable results of this study follow.

Research Question 1: Improve Search Engine Effectiveness

In the section of the survey titled *Commercial Standards Search Engine Comparison*, participants answered six questions in which they rated whether the overall functionality as well as the search manipulation and browsing features of the Standards Directory were helpful and in alignment with engineering practice when compared with the commercial standards search engines evaluated in this study (see Appendix G). The median values as well as the mean values of the responses were all above the median value (4) on the scale, indicating a higher level of helpfulness and alignment with engineering practice of the Standards Directory compared to the commercial standards search engines. Content analysis of the participants' comments associated with these specific questions was used to determine how specifically document categorization, the use of metadata for browsing, and document full-text searching improved the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines.

As discussed in Chapter 2, categorization provides the Standards Directory with three main functions. Categorization allows documents in the system to be assigned to a category, it provides the ability to limit searches to specific categories before and after searching, and it allows the Company to discover new categories for standards development. On the use of categories to limit search results before and after searches were performed, some participants noted that it was not evident that the feature was available or that they did not use it. For example, "Didn't know you could until just now," "Didn't use the feature," "Didn't limit to a specific discipline when searching," and “Didn’t see a way to limit the search.” Advanced search features are used rarely and are often overlooked by search engine users (Eastman & Jansen, 2003; Spink, Wolfram, Jansen, & Saracevic, 2001). The participants who did not limit their searches to a given discipline before their search noted that they did not wish to reduce recall. Participants stated, “Do not want to limit it [search results] too much at first,” and “I’m always looking for a wide spectrum of results and narrow down if I have to. There’s nothing worse that ‘no results found’ when you know something is out there. I need SOMETHING on which to refine my search parameters.” This indicates that limiting a search to categories prior to a search is undesirable to searchers as it can reduce recall by eliminating some potentially relevant results from being retrieved. The Standards Directory excludes potentially relevant results when limiting searches to certain categories due to the use of the Boolean AND operator being applied to the selected categories (see Appendix D) (Verhoeff, Goffman, & Belzer, 1961). Further, some participants found the selection of categories before searching might not be preferable due to a lack of clarity as to which categories to select. For example, “Some standards may apply to multiple disciplines” and “You get a lot of cross over into other disciplines.” Two participants also noted that there is the potential to expand upon the current list of categories, stating, “I was looking for a standard in a discipline not set aside as a category” and “Needs more categories.” As discussed in Chapter 1, the system was designed with sufficient flexibility to accommodate additional categories. Some participants’ approached the selection of their search terms to include likely categories noting, “I generally do this through the keywords I choose.” Some participants used the metadata that is displayed with the search results to determine relevant categories noting, "[I] limited [search results] to a specific discipline by looking through the results and determining what seemed relevant" and "[I] don't search by disciplines. I hope that my keywords will drill down for me." However, participants who filtered search results after searching to specific categories noted that this feature was useful. Examples of participant comments included, "Helpful," "Works well in daily use," "Filtering by discipline is helpfull [*sic*] to reduce incorrect results," "I like this feature," "I like this feature the most compared to other sites," "Good when drilling down," and "This is very helpful because you can eliminate disciplines that you know you won't find what you think would be relevant." Overall, the findings indicated that searchers preferred a simple keyword search and preferred not to limit their searches to specific categories before searching. Further, document categorization improved the retrieval effectiveness of engineering and technology standards by allowing searchers either to filter their search results by categories or to evaluate the relevance of a search result using the category metadata presented with their search results.

The metadata used to describe documents in the Standards Directory not only supports keyword searching but also supports browsing as a form of search. A document's metadata (see Appendix C) was used to support browsing within the Standards Directory; lists of documents could be filtered and sorted using metadata attributes. When searching, the participants noted that the metadata helped in determining the relevance of search results. Examples of participant comments included, "Use the [document] prefix part. I may know its ASME but not what the number is" and "Succinct display of the pertinent & useful information in the summary for each 'found' standard."

In supporting browsing, participants noted that the metadata page also provided valuable information. Examples of participant comments included, “More details of relevance,” “Easily accessible and relevant links,” and “Useful table of contents of documents.” Overall, the use of metadata for browsing improved the retrieval effectiveness of engineering and technology standards by providing pertinent information with search results and allowed participants to browse efficiently and effectively, a finding supported by Yau and Hawker (2004).

When comparing the effectiveness of the Standards Directory with the commercial standards search engines evaluated in this study, participants provided several positive comments about the Standards Directory’s search capabilities. Examples of participant comments included, “Only search that returned relevant results,” “This search engine produced the best results,” “This is superior to what I was able to see out there,” “Certainly better than most of the commercially available search engines,” “Gives Disney standards as well as the Industry,” “Compared with the external search engines evaluated, the internal Standards Directory has a broader base of information, is more effective, and more efficient,” “It found what I was looking for with just one keyword,” “great interface, good searches, [and is] well-displayed otherwise,” and “Best search engine for doing general searches.” However, some participants noted that the system was limited due to its limited content. Examples of participant comments included, “Generally very good. Would like more access to industry standards” and “I have found that for WDI and Disney specific spec’s it works well, but for industry standards it struggles.” Further, the data analysis in Chapter 3 also showed that as participants’ rating of the overall relevance of the Standards Directory’s search results increased, participants' perception of the performance characteristics of the Standards Directory also increased. Participants also offered several positive comments about the Standards Directory, overall, including, "This is a great tool," "Very helpful," "Quick and accurate," "Specifically relates to my core business," "Better page design than other search tools, better response time, and better summary page," "Because it is our directory for the information directly required for our business it functions very well and it [is] accurate," and "It appears to be very comprehensive, relevant and global." Overall, the document full-text searching capability appears to have improved the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared to existing commercial engineering and technology standards search engines.

The preceding analysis and discussion provide a result for Research Question 1 and suggest that the four commercial engineering and technology standards search engines, compared to the Standards Directory, are less effective in retrieving relevant results for information-seeking Company engineers and architects. Conversely, the results suggest that the Standards Directory's use of document categorization, metadata for browsing, and document full-text searching have improved the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs. As such, the hypothesis (see Chapter 3) that the use of document categorization, metadata for browsing, and document full-text searching improves the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines, was accepted.

Research Question 2 prompts discussion of the strengths and weaknesses of the Standards Directory.

Research Question 2: Strengths and Weaknesses of the Standards Directory

The data analysis indicated that as participants' overall relevance rating of the search results increased, participants' perception of the performance characteristics of the Standards Directory also increased. That is, participants who judged the Standards Directory's search results as being fairly relevant or highly relevant, gave a higher rating to the helpfulness and alignment with engineering practice of the Standards Directory's overall functionality, search manipulation features, and browsing features than participants with an irrelevant overall relevance rating for the Standards Directory. The data analysis also indicated that the Standards Directory was more intuitive and more helpful to participants who were in management positions than participants who were applied engineers. Overall, more experienced participants (i.e., participants who worked for over 20 years in their discipline for the Company and had published in their field) found the search results of the Standards Directory more relevant than less experienced participants did. This increased performance of the Standards Directory expressed by more experienced participants may stem from a greater level of domain expertise and familiarity with standards from experience in their discipline (Jenkins, Corritore, & Wiedenbeck, 2003).

As discussed in Chapter 4, participants' comments on the most and least useful features of the Standards Directory were categorized into three topical areas; usability (ease of use and navigation), search (search interface and presentation of search results), and content (the availability of Company and industry standards in one system) (Su, 2003b). Participants provided positive feedback on the Standards Directory's usability, content, and search features, indicating a relatively high level of satisfaction with the system's most useful features. However, despite a higher number of comments on the most useful features of the Standards Directory, the comments on the least useful features provided insight into areas for potential improvements to the system. For example, participants commented that the Standards Directory's usability could be improved if changes were made to the site's color scheme. Two participants also suggested that the term *Advanced Search* be used to differentiate between the keyword search tool and the search tool that provides presearch category filtering. In the search features category, participants also pointed out some drawbacks of word stemming when keyword searching as discussed by Müller, Kenny, and Sternberg (2004). In the content category, participants noted that the system did not always provide the electronic full-text of a given standard for download, which is a limitation that stems from working with copyright material.

Limitations of the Study

This project involved Company engineers and architects and, as such, may not directly be applicable to a wider, generalized audience. The study was also limited to a sample population of Company engineers and architects. Therefore, while the sample size was statistically representative, a larger sample for this population would have been beneficial, in particular given the wealth of experience participants brought to the experiment and the rich feedback participants provided. Further, constant changes in information systems research, specifically in online IR, digital libraries, and knowledge management, will make the results of this study become obsolete quickly. However, the methodology for ranking overall relevance should remain applicable to information systems research for some time to come.

The data analysis conducted with participants' responses addressed two research questions. The use of document categorization, the use of metadata for browsing, and document full-text searching improved the retrieval effectiveness of engineering and technology standards in terms of relevance to technical information users' information needs when compared with existing commercial engineering and technology standards search engines.

Implications

The conclusions discussed above have implications for researchers as well as practitioners. The strengths and weaknesses with respect to end-user searching of the Standards Directory compared with the commercial engineering and technology standards search engines included in this study provide opportunities for future research as well as the implementation of the Standards Directory in engineering and technology organizations.

This study served to identify and address some issues inhibiting the effective retrieval of domain specific knowledge by Company engineers and architects. In doing so, the study identified problems that stem from the ineffectiveness of engineering and technology standards search engines. Ultimately, resolution of such problems will contribute to the development of more effective information retrieval and knowledge management tools.

Though search engines are popular tools for information retrieval on the Internet, this study demonstrated that current commercial engineering and technology standards search engines do not meet the information-seeking needs of Company engineers and architects and that the ability to perform general and exploratory information searches for standards with commercial engineering and technology standards search providers is deficient. Further, the investigation determined that IR system design features such as document categorization, the use of metadata for browsing, and document full-text search can improve the retrieval effectiveness of engineering and technology standards in order to better support the standards seeking needs of Company engineers and architects. Effectiveness was measured in terms of the relevance of search results overall as established by end-user relevance judgments made by Company engineers and architects seeking standards and related technical information for their day-to-day information needs. In addition, an analysis of the demographic characteristics of the population participating in this experiment revealed that the Standards Directory was more intuitive and more helpful to participants who were in management positions than participants who were applied engineers. Overall, more experienced participants (i.e., participants who worked for over 20 years in their discipline for the Company and had published in their field) found the search results of the Standards Directory more relevant than less experienced participants did. This result will provide Company engineers and architects a better understanding of standards retrieval as well as their own search habits and skills, which, in turn, will aid them in selecting more effective search strategies. Company engineering and architectural managers can also glean an understanding of the effectiveness or ineffectiveness of standards retrieval from this study, which may then be used to develop instructional programs on the use of standards in Company engineering and architectural projects and to support funding the acquisition of standards. In addition, these results may be applied as an example of search engine efficiency and an impetus for positive change and refinement of standards search engines themselves. For example, the understanding of engineers and architects' search behavior in the domain of engineering and technology standards developed in this study may be used to improve retrieval relevance, efficiency, utility, and user satisfaction (Su, 1998) as well as to provide a more efficient, effective Web-based interface for user navigation and search results.

Despite the specific organizational context in which the study was conducted, standards-based engineering, architectural, and other high technology organizations may also benefit from the implementation of a Standards Directory. A broader, more pervasive use of standards in an organization as well as the integration of standards into a product's design can increase employee productivity, improve product quality, enhance the accuracy of organizational decision-making, and foster organizational learning (Argote, 1999; Girczyc & Carlson, 1993; Rolfe, 1998; Rus, Lindvall, & Sinha, 2002). The Standards Directory can help accomplish this by providing a platform for the categorization of organizational knowledge that has been captured and codified, whether as standards, operating procedures, or best practices, and provides not only an effective means for their retrieval but also allows the organization to assess where additional knowledge may need to be captured.

Recommendations

The study found that more experienced participants reported higher satisfaction with the performance of the Standards Directory. This suggests that the development of personalized retrieval, such as through the use of user profiles (Chen & Kuo, 2000) and information filtering (Hanani, Shapira, & Shoval, 2001), may improve the retrieval effectiveness of the Standards Directory for individuals with varying information needs and to expose users to only information that is relevant to them.

As discussed in Chapter 2, categorization provides the Standards Directory with three main functions; it allows documents in the system to be assigned to a category, it provides the ability to limit searches to specific categories before and after searching, and it will allow the Company to discover new categories for standards development. The study found that the use of categories to filter search results was helpful to participants in performing their search and that participants expressed the need for the adoption of additional applicable categories. The use of an engineering and standards taxonomy can also provide the Company and organizations with the ability to analyze the need for the adoption of additional standards in the development of its products. As the scope of applicable standards categories and subsequent subcategories had not been assessed previously, additional research should be performed to determine whether there are additional categories that need to be added to the taxonomy. As discussed in Chapter 1, the system was designed with flexibility sufficient to accommodate additional categories.

This study involved Company engineers and architects and, as such, may not directly be applicable to a wider, generalized audience. Further, the literature suggests that incomplete information, such as inadequate use of the explicit knowledge expressed in standards, can affect product quality negatively (Nasir, 2003). Therefore, two additional areas of research present opportunities for future study. First, experiments related to the present study and applied to varying populations of engineering and technology disciplines would broaden the spectrum of search engine users surveyed and produce a more accurate description of the effectiveness of technical information gathering through standards search engines and digital libraries. In addition, research should be conducted to determine the relationship between product quality and an increased use of standards in product design stemming from improved standards search capabilities (Rolfe, 1998).

Summary

Leading management and organization theorists have established in the literature the concept of treating organizational knowledge as a valuable strategic asset (Brown & Duguid, 1991; Davenport, Jarvenpaa, & Beers, 1996; Drucker, 1991; Nonaka, 1994). Knowledge management focuses on connecting people with each other and people with information in an effort to achieve competitive advantage in business (Hoyt, 2002). Knowledge or expertise is contextual and ranges in form from tacit (experiential) knowledge to explicit (physical) knowledge. Critical to successful employment of explicit knowledge is the provision of an effective means for its retrieval. Over the past 20 years, the study of information retrieval has evolved beyond its primary goals of indexing text and searching for useful documents in a collection (Baeza-Yates & Ribiero-Neto, 1999). Information retrieval technologies are vital to finding information, in particular for professions concerned with complete coverage of a topic. Today, research in information retrieval includes modeling, document classification and categorization, systems architecture, user interfaces, data visualization, filtering, languages, and many other areas of inquiry. For example, Bruno and Richmond (2003) assert that taxonomies support information management and retrieval in the areas of identification, discovery, and delivery. In evaluating search engine effectiveness, several recent studies of search engines use human relevance judgments as the basis of evaluation whereby participants are asked to rank items retrieved by search engines based on each item's relevance to their information needs (Nowicki, 2003; Su, 1994, 1998, 2003a, 2003b; Su & Chen, 1999; Vaughan, 2004).

The Walt Disney Company has developed several hundred internal standards that are used in the design, development, and maintenance of its physical infrastructure worldwide. However, current methods used to organize engineering and technology standards within the Company's EDMS system are incongruous with the manner in which they are used in practice. This, in turn, was causing deficient retrieval for end users. Further, existing commercial engineering and technology standards search engines, such as Information Handling Services' Global Engineering Documents, GlobalSpec's Engineering Search Engine, Thomson's Techstreet, and ANSI's National Standards Systems Network, only utilize a standard's document number, title, and keywords as metadata for searching. As such, the ability to perform general and exploratory information searches for standards with these search providers is deficient due to a lack of full-text searching capabilities. The Standards Directory, an engineering and technology standards digital library and information retrieval system, developed for this study, utilizes the Company's engineering and technology project-work-breakdown-structure (see Appendix A) as its taxonomy for the categorization of standards into appropriate engineering and technology categories and disciplines. The Standards Directory also supports general and exploratory information searches by supporting full-text searching that automatically expands search terms with its stem words and that can be narrowed to specific topic categories. In addition, the Standards Directory provides a retrieval interface that supports the customized retrieval of standards limited to specific engineering and technology categories before (see Appendix H) and after (see Appendix I) a search is performed to provide improved information retrieval results (Cutrell & Dumais, 2003). Further, the Standards Directory supports across-document browsing by linking standards to other related and referenced standards as well as provides users with the ability to browse standards by category and sub-category. The employment of these information retrieval system design characteristics provides the field of information systems research a model for supporting the development of effective digital libraries for engineering and technology standards.

The research consisted of two main components: system development and system evaluation (i.e., the end user study). Each of these components was comprised of multiple phases. The development of the Standards Directory consisted of four main phases: standards metadata definition, an evaluation of user navigation and interface requirements, document categorization and system population, and text query requirements. The evaluation of the Standards Directory in the study consisted of two main phases. The first evaluation phase consisted of conducting a study using research participants. The second phase consisted of an analysis of study results and modifications to the Standards Directory based on study results.

The study investigated the effectiveness of the Standards Directory compared to leading commercial information brokers of engineering and technology standards. The study evaluated these existing commercial engineering and technology standards search engines as they are used by technical information seekers and compared them with the Standards Directory. Specifically, 61 Company engineers and architects with various levels of experience in searching for engineering and technology standards as part of their profession participated in the evaluation. Each research participant was asked to choose an engineering or technology topic on which to search for information (Su, 2003a, 2003b) (see Appendix G). Research participants were allowed to browse or use as many queries as needed on each search engine for the same topic until they believe they obtained the most relevant results possible with that tool. This approach allowed research participants to find the information sought using any of Meadow, Boyce, and Kraft's (2000) four types of searches. On each of the four selected commercial standards search engines as well as the Standards Directory, research participants searched for their topics and analyzed the search results. Research participants then evaluated the search results for relevance. Research participants also noted why some results (if any) were most relevant to their information search on search forms for each search engine (Su, 2003a, 2003b) (see Appendix G).

Qualitative content analysis was used to determine the overall relevance of the search engines studied by analyzing participants' responses to questions related to the participants' feedback on overall relevance and helpfulness of the search engines compared. These measures provided a ranking of the overall success of the search engines in providing relevant results for a participant's information need or problem. The overall relevance ranking of the Standards Directory was fairly relevant while the overall relevance ranking of ANSI NSSN, GlobalSpec, and Thomson's Techstreet were marginally relevant and the overall relevance ranking of Global Engineering Documents was irrelevant. As such, the study found that the Standards Directory has improved the overall relevance of search results of engineering and technology standards by, among other things, providing full-text searching capabilities.

Specifically for the Standards Directory, participants with higher levels of experience and education expressed not only higher overall relevance rankings with the Standards Directory but also considered their work to be more standards-based and were more likely to have published in their field of expertise. For example, the Standards Directory was more intuitive and more helpful to participants who were in management than participants who were applied engineers. Overall, more experienced participants (i.e., participants who worked for over 20 years in their discipline for the Company and who had published in their field) found the search results of the Standards Directory more relevant than less experienced participants did. This increased performance of the Standards Directory encountered by more experienced participants may have stemmed from a greater level of domain expertise and familiarity with standards from practice (Jenkins, Corritore, & Wiedenbeck, 2003). Further, as participants' rating of the overall relevance of search results increased, participants' perception of the performance characteristics of the Standards Directory also increased.

Many issues that surfaced during the study are possible areas for future research. For example, the study found that more experienced participants reported a higher level of satisfaction with the performance of the Standards Directory. This suggests that the development of personalized retrieval, such as through the use of user profiles (Chen & Kuo, 2000) and information filtering (Hanani, Shapira, & Shoval, 2001), may improve the retrieval effectiveness of the Standards Directory for individuals with varying information needs and expose users to only information that is relevant to them. Further, the study found that the use of categories to filter search results was helpful to participants in performing their search and that participants expressed the need for the adoption of additional applicable categories. As such, additional research should be performed to determine whether there are additional categories that need to be added to the taxonomy.

Two additional areas for future research resulted from the study. First, performing experiments related to the present study and applied to varying populations of engineering and technology disciplines will broaden the spectrum of search engine users surveyed and produce a more accurate description of the effectiveness of technical information gathering through standards search engines and digital libraries. In addition, research should be conducted to determine the relationship between product quality and an increased use of standards in product design stemming from improved standards search capabilities (Rolfe, 1998).

Ultimately, this study served to identify and address some issues inhibiting the effective retrieval of domain specific knowledge by Company engineers and architects. In doing so, the study identified problems that stem from the ineffectiveness of engineering and technology standards search engines. In a broader context, this study articulates concerns about end-user searching and search engine effectiveness in a knowledge intensive domain that should create an awareness of the variability of retrieval success and factors underlying this variability. Ultimately, resolution of such problems will contribute to the development of more effective information retrieval and knowledge management tools. As most knowledge workers (Drucker, 1966) utilize information retrieval systems, successful information retrieval is essential. As such, it is imperative that end-user interaction with IR tools be researched further.

Appendix A

The Company's Engineering and Technology Taxonomy

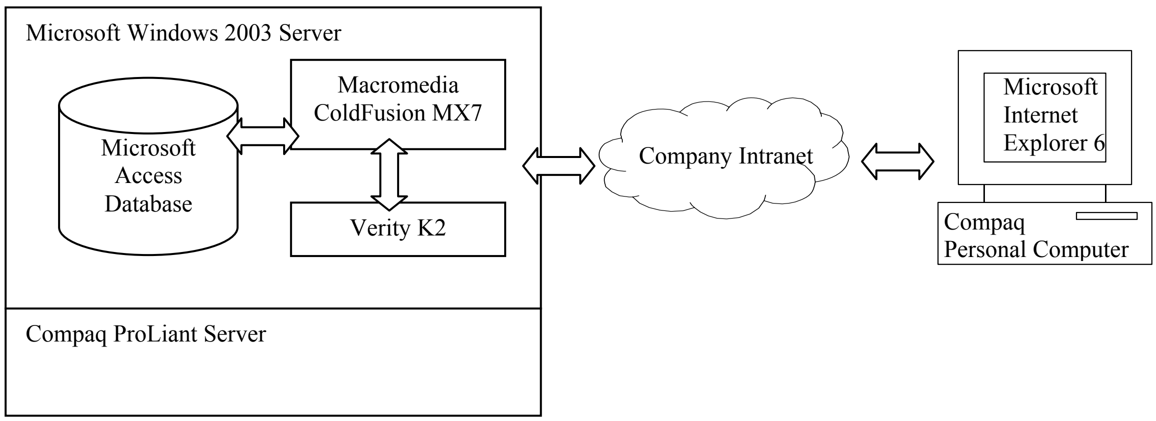
The Company's Engineering and Technology Project-Work-Breakdown-Structure.

Category/Discipline Division of Work/Sub-Discipline	**Category/Discipline** Division of Work/Sub-Discipline
Administrative	**Maintenance Requirements**
Administrative	As Applicable
Area/Site Development	**Non-Disney**
General	Non-Disney
Site Development	**Operator Requirements**
Site Improvement	Operational Requirements
Capitalized Interest	**Production/Manufacturing**
Capitalized Interest	As Applicable
Contingency	**Quality/Inspection**
Operational Contingency	As Applicable
Reserve Contingency	**Ride**
Creative Entertainment	Overall Ride System
Operating Procedures	Load/Unload Guest Conveyance
Design/Engineering	Turntables
A&FE Engineering	Lifts/Elevators
Ride & Show Engineering	Track/Guide/Flume
Planning Consultant	Ride Vehicle
Site Consultant	Ride On-board Audio/Video
Service Consultant	Propulsion/Brake
Construction Consultant	Ride Control System Hardware
Constituency Management	Ride Control System Software
Legal	Security/Surveillance/Safety
Creative Development	Ride Maintenance Equipment
Models	Ride Electrical
Colorboards	Ride Mechanical
Sculpting	Ride Hardhat Installation
Production Design	**Show**
Legislative Compliance	Film/Video Production
Facility	Overall Show System
General	Animated/Non-animated figures
Site Work	Animated Props

Category/Discipline Division of Work/Sub-Discipline	**Category/Discipline** Division of Work/Sub-Discipline
Concrete	Show Action Equipment
Masonry	Special Effects
Metals	Projection Hardware
Carpentry	Graphics Production
Moisture Protection	Audio/Video Hardware
Doors, Windows and Glass	Audio Software Production
Finishes	Theme Lighting
Specialties	Video Software Production
Equipment	Show Lighting
Furnishings	Show Control Hardware
Special Construction	Show Programming
Conveying Systems (Non-Ride)	Show Set Design & Production
Mechanical	Rockwork/Shotcrete
Electrical	Show Control Software
Contractor General Conditions	Static Props and Dressings
General Requirements	Scenic Painting Design
Project Team Staffing	Live Animals
Field Supervision	Show Maintenance Equipment
Travel and Relocation	Guest Activated/Interactive Equip
Project Services	Parkwide Systems
Ext. Construction Mgmt Services	Artificial Foliage
Field Costs	Theatrical Rigging & Stage Equip
Temporary Facilities	Show Electrical
Impact Permitting, Insurance, Taxes, Bonding & Duty	Show Mechanical Show Hardhat Installation
Transportation and Warehousing	**Software**
Helpful Information	General
Helpful Information	**Test/Verification**
Land Acquisition/Entitlements	As Applicable
Site Investigation Cost	**Theatrical Design & Production**
Land Cost	General
Due Diligence	
Entitlements	
Public Investment	
Constituency Management	

Appendix B

High-Level Functional System Design of the Standards Directory

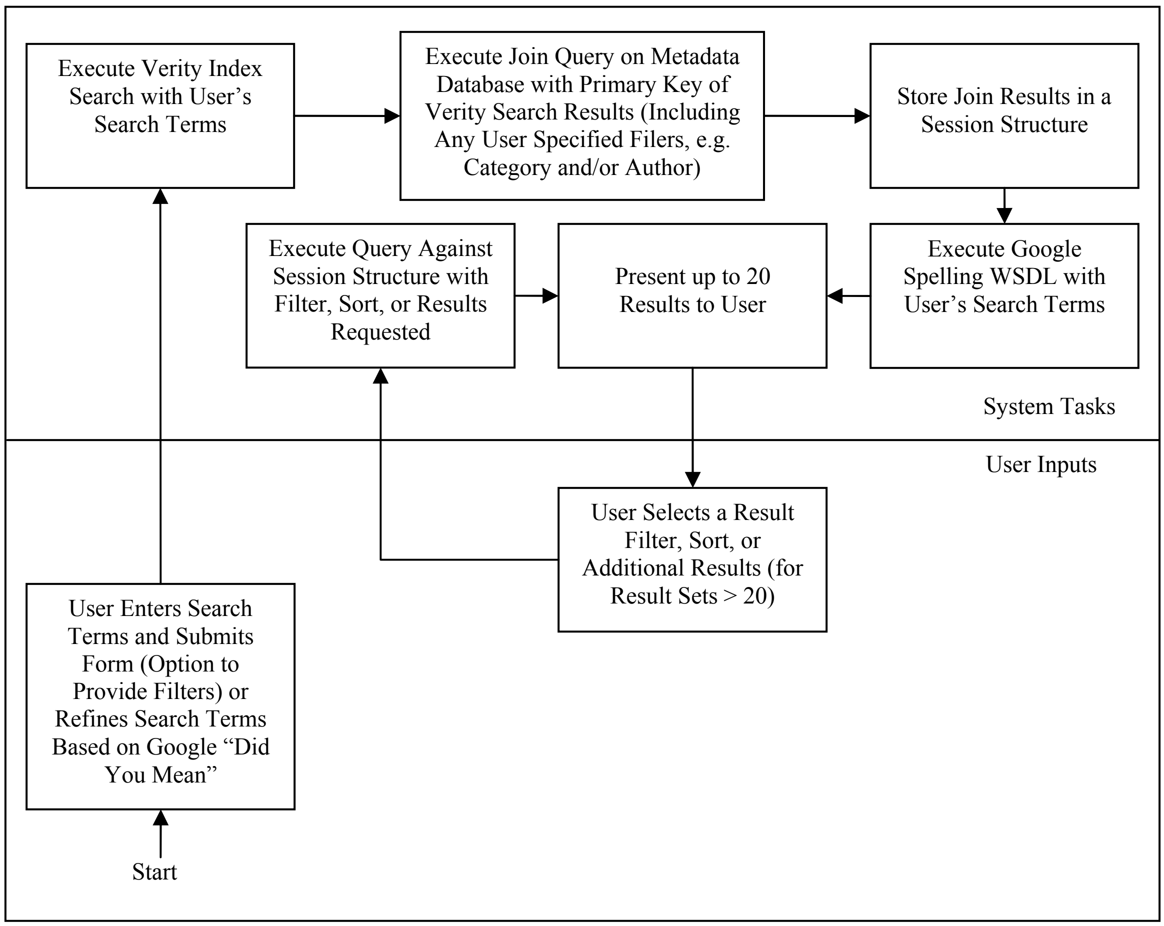


Appendix C

Presentation of a Document's Metadata on the Standards Directory

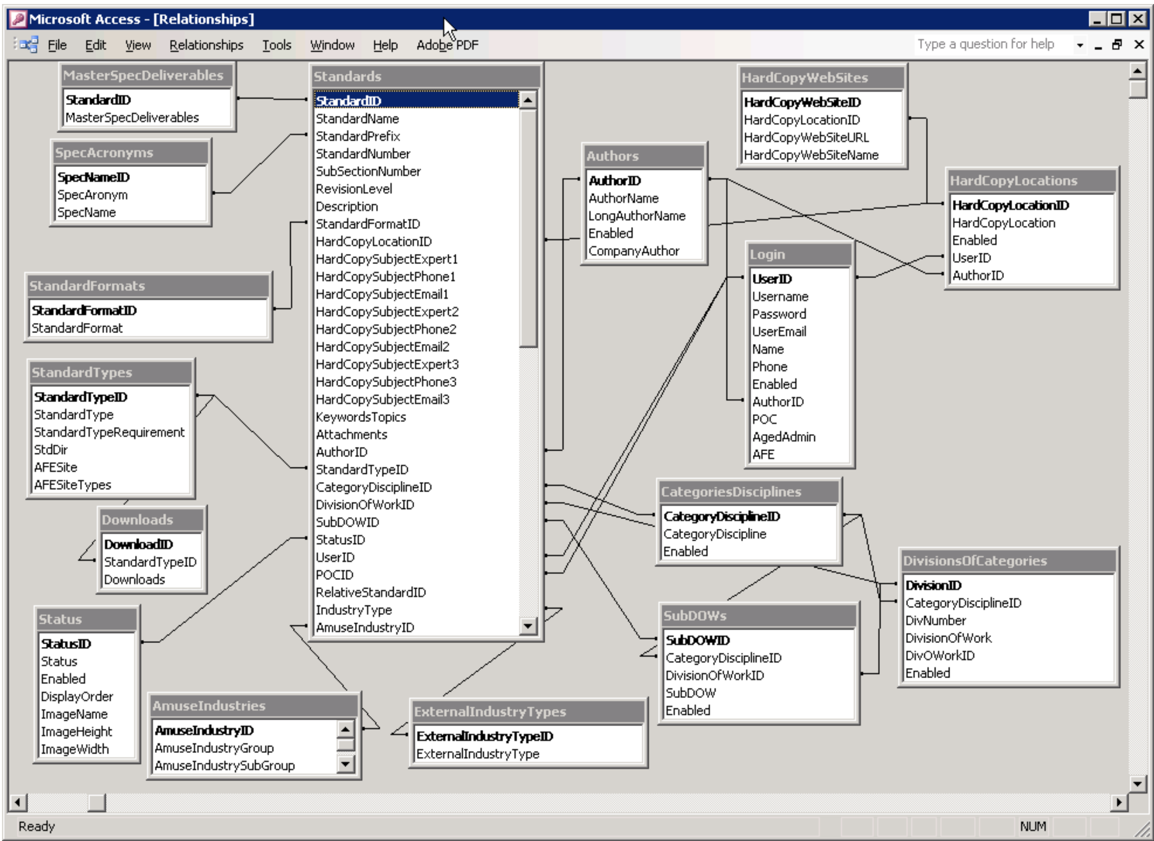
Appendix D

A High-Level Model of the Standards Directory's Search Engine Code



Appendix E

A Visual Representation of the Standards Directory's Database Schema



Appendix F

Preliminary Presentation and Instructions

An orientation to the experiment and the researcher's expectations allowed participants to understand better the project goals and their role in the research. The researcher presented the following points, which took no more than 20 minutes at the beginning of each of the seven sessions (including five minutes for participants to fill out the demographic information on the survey Web site). This permitted the participants to ask questions and the researcher to clarify any directions that were unclear.

I. Introduction to the study
   a. Introduction of the researcher
   b. Purpose and scope of the study
   c. Researcher's expectations of participants
   d. Statement of non-obligation to participate
   e. Statement of disassociation with work performance

II. Overview of the Role of Standards within the Company
   a. The role of standards within the Engineering Strategy Map
   b. The role of standards within the success formula

III. Overview of the World Wide Web and Search
   a. Definition of the Internet and World Wide Web
   b. Organization of the Internet and World Wide Web
   c. Overview of Meadow, Boyce, and Kraft's (2000) four forms of search: "the known item search, the specific information search, the general information search, and a search to explore" (p. 273)

IV. Engineering and Technology Taxonomy

a. Overview of taxonomies
b. Overview of the engineering and technology taxonomy
c. Overview of the standards categorization process
d. Overview of the National Science Digital Library's Engineering and Technology Taxonomy

V. Engineering and Technology Standards Search Engines

a. Introduction to the commercial standards search engines and Standards Directory
b. How to access the standards search engines being studied (bookmarks)
c. How to conduct standards searches with the standards search engines being studied (commercial and Standards Directory)
d. How to print out results if needed

VI. Experiment Instructions

a. Give instructions for accessing the survey Web site
b. Instruct participants to fill out demographic information on the survey Web site
c. Instruct participants to fill out search information on the survey Web site
d. Instruct participants to begin searching and complete search feedback on the survey Web site

Appendix G

Questionnaire

To help classify your answers and make statistical comparisons, please answer the following questions. Remember that your answers are voluntary and will be kept completely confidential. Any information that may identify the respondent will not be disclosed under any circumstances.

Last four digits of your SAP Personnel Number (used to correlate multiple responses):

____

Have you already completed a search evaluation and provided your occupational information?

○ **Yes** ○ **No**

[Yes: skip to Search Expectations; No: continue with Occupation/Experience]

Date: ___________ Which Session did you attend? ○ AM ○ PM

Engineering Discipline:
○ Civil/Architecture ○ Electrical ○ Mechanical ○ Other:__________

Occupation/Experience

Your primary occupation is what you spend the majority of your time doing. Secondary occupation includes activities that you perform that are not the primary focus of your job (example, 1. Professor, 2. Researcher and Applied Engineer).

Primary Occupation (Check one)	**Secondary Occupation** Check all that apply	**Title**
○	☐	Engineering Academic (Professor/Teacher)
○	☐	Engineering Researcher (Non-Professor)
○	☐	Engineer (Applied)
○	☐	Engineer (Management)
○	☐	Engineer (Executive)
○	☐	Other Technical Discipline/Profession

Professional Information

Professional information on your academic achievements allows the user to gauge your credibility. Professional affiliations are also good criteria for judging one's professional engagement.

Education (Highest Degree Awarded in related field)

○ PhD ○ MS/MBA/MEd ○ BS/BBA/B.Ed ○ Other:________________

Field of Degree: _______________________

Have you published in your field(s) of expertise? ○ Yes ○ No

Are you a licensed professional (PE, PA)? ○ Yes ○ No

How many years have you worked in your field/discipline for the Company: _________

How many years have you worked in your field/discipline overall: _________

If you are a member of any professional (engineering or architecture) or standards developing associations, please indicate which ones: ____________________________

To what extent would you consider your work to be standards based?

1……2……3……4……5……6……7 Comments:
Very Limited Highly

Please identify how often you use…

Engineering or technology standards in your work (such as ANSI, IEEE, AWS, etc.):_____________________

Engineering texts as a reference in your work:__________________________

Information Retrieval, World Wide Web, and Search Engine Experience
Do you use libraries (within the Company or elsewhere) for finding information?
○ Yes ○ No ○ Do not know/Not applicable
If so, how often? ____

Do you use library online catalogs or card catalogs to find books or other materials?
○ Yes ○ No ○ Do not know/Not applicable
If so, how often? ____

Do you use online databases or indexes (Elsevier's ScienceDirect or Compendex, WilsonWeb's Applied Science & Technology Full Text, or General Science Full Text)?
○ Yes ○ No ○ Do not know/Not applicable
If so, how often? ____

Do you use the Internet (World Wide Web, email)?
○ Yes ○ No ○ Do not know/Not applicable
If so, how often? ____

Do you use World Wide Web search engines? [Yes: continue with next question; Otherwise: skip to Search Expectations]
○ Yes ○ No ○ Do not know/Not applicable
If so, how often? ____

Which World Wide Web search engine(s) do you use?
☐ Google ☐ Yahoo! ☐ AltaVista! ☐ About.com ☐ WebCrawler
☐ HotBot ☐ Excite ☐ MSN Search ☐ Netscape Search
☐ Lycos ☐ Ask Jeeves ☐ AllTheWeb.com ☐ AOL Search
Please list any other(s): ____

What is your opinion of World Wide Web search engines?

Have you used any of the following online standards search engines (check all that apply):
☐ IHS Global Engineering Documents ☐ GlobalSpec's Engineering Search Engine
☐ Thomson's Techstreet ☐ ANSI Standards Search

Do you believe search engines are helpful in finding information on the World Wide Web?
○ Yes ○ No ○ Do not know/Not applicable
If so, why?

If not, why not?

What are some of the disadvantages of search engines?

Search Expectations
In this project you will be asked to search for engineering standards and related information on topics in your area of engineering expertise. Please state the topics below (such as "Design of Mechanical Assemblies," or "Installation of Electronic and Electrical Systems"):

What *kind* of information are you hoping to find? (such as "Methods for calculating fastener torque," or "Wire color coding for control box wiring"):

Please state the search terms you are planning to use (for example, "Fastener and torque" or "wiring and electrical and installation"):

On a scale of 1 to 7, what is your expertise on this subject?
1……2……3……4……5……6……7
No Knowledge   Expert Knowledge

On a scale of 1 to 3, how comprehensive would you like this search to be?
1. ○ Narrow; a few representative items are OK
2. ○ Some relevant items
3. ○ Comprehensive; most or all relevant items

Which of the four types of search (discussed in the introductory presentation) are your performing?

○ A known item search (I know exactly which document I am looking for)
○ A specific information search (I know what specific information I need, but not which document(s) it can be found in)
○ A general information search (I am searching for information on a subject in general that might be found in any number of document(s))
○ A search to explore (I am searching to find out what kinds of information are available in the system)

Please share any other comments you have about what you expect to search for using the Standards Directory.

Search Results Evaluation

Search engine(s) compared against Standards Directory:
☐ IHS Global Engineering Documents ☐ GlobalSpec's Engineering Search Engine
☐ Thomson's Techstreet ☐ ANSI Standards Search

When compared with the Standards Directory...

Which results from the search engines compared were most relevant to you (if any)?

Why were these results relevant?

Which results from the search engines compared were not relevant to you (if any)?

Why were these results not relevant?

Overall Reaction

This section gives an overall reaction to the features and functionality of the Standards Directory used in this exercise. Please be candid with your feedback and comments are encouraged.

I found the Standards Directory to be...

1……2……3……4……5……6……7 Comments:
Rigid Flexible
1……2……3……4……5……6……7 Comments:
Difficult Easy
1……2……3……4……5……6……7 Comments:
Frustrating Satisfying
1……2……3……4……5……6……7 Comments:
Awkward Intuitive
1……2……3……4……5……6……7 Comments:

Inadequate Adequate
1……2……3……4……5……6……7 Comments:
Useless Helpful
1……2……3……4……5……6……7 Comments:
Terrible Wonderful

Usability

This section evaluates how useable the Standards Directory is when searching for engineering and technology standards. Candor and comments are appreciated.

1. How helpful was the Standards Directory in supporting your search for a given standard?

   1……2……3……4……5……6……7 Comments:
   Hindrance Helpful

2. How intuitive was the Standards Directory's interface in supporting your search for a given standard (whether browsing or using the search engine)?

   1……2……3……4……5……6……7 Comments:
   Awkward Intuitive

3. When using the Standards Directory search engine, did you limit your search criteria to a given discipline before you executed your search or after?

   ○ Before ○ After Comments:

4. When using the Standards Directory search engine, did you use the available help? If you select No, please skip the next question.

   ○ Yes ○ No Comments:

5. How useful was the Standards Directory's help feature in supporting the problem you were seeking help for?

   1……2……3……4……5……6……7 Comments:
   Useless Helpful

Please share any other comments you have on the Standard Directory's usability.

Commercial Standards Search Engine Comparison

This section helps determine if the features and functions of the Standards Directory are both helpful and in alignment with engineering practice, when compared with the commercial standards search engines evaluated in this study. Again, please be candid with your feedback and your comments are encouraged.

When compared with the commercial standards search engines used…

1. How helpful is the overall functionality of the Standards Directory in finding standards?

   1……2……3……4……5……6……7 Comments:
   Less Helpful More Helpful

2. How aligned with engineering practice is the overall functionality of the Standards Directory?

   1……2……3……4……5……6……7 Comments:
   Less Aligned More Aligned

3. How helpful in finding standards are the search manipulation features of the Standards Directory, such as limiting search results to a specific engineering discipline?

   1……2……3……4……5……6……7 Comments:
   Less Helpful More Helpful

4. How aligned with engineering practice are the search manipulation features of the Standards Directory, such as limiting search results to a specific engineering discipline?

   1……2……3……4……5……6……7 Comments:
   Less Aligned More Aligned

5. How helpful in finding standards are the browsing features of the Standards Directory, such as by engineering discipline?

   1……2……3……4……5……6……7 Comments:
   Less Helpful More Helpful

6. How aligned with engineering practice are the browsing features of the Standards Directory, such as by engineering discipline?

   1……2……3……4……5……6……7 Comments:
   Less Aligned More Aligned

When compared with the commercial standards search engines used…

1. Which three features or functions of the Standards Directory do you find most useful?

1: ______________________ 2: ______________________ 3: ______________________

2. Which three features or functions of the Standards Directory do you find least useful?

1: ______________________ 2: ______________________ 3: ______________________

Please share any additional positive or negative differences between the features and functions offered by the commercial standards search engines and the Standards Directory:

Overall Effectiveness

This section touches on the Standards Directory's over all effectiveness as it relates to each of the Meadow, Boyce, and Kraft's (2000) four forms of search: "the known item search, the specific information search, the general information search, and a search to explore" (p. 273).

The type of search I performed was:

○ Known Item
○ Specific Information
○ General Information
○ Exploration

Please rate the effectiveness of the Standards Directory as it relates to the form of search you performed.

1……2……3……4……5……6……7 Comments:
Ineffective Effective

Additional Feedback

This section concludes the evaluation.

1. I am willing to be contacted to further discuss my responses: ○ No ○ Yes
   If you answered yes, please complete the following information:

   Name: ___________________________________

   Email: ___________________________________

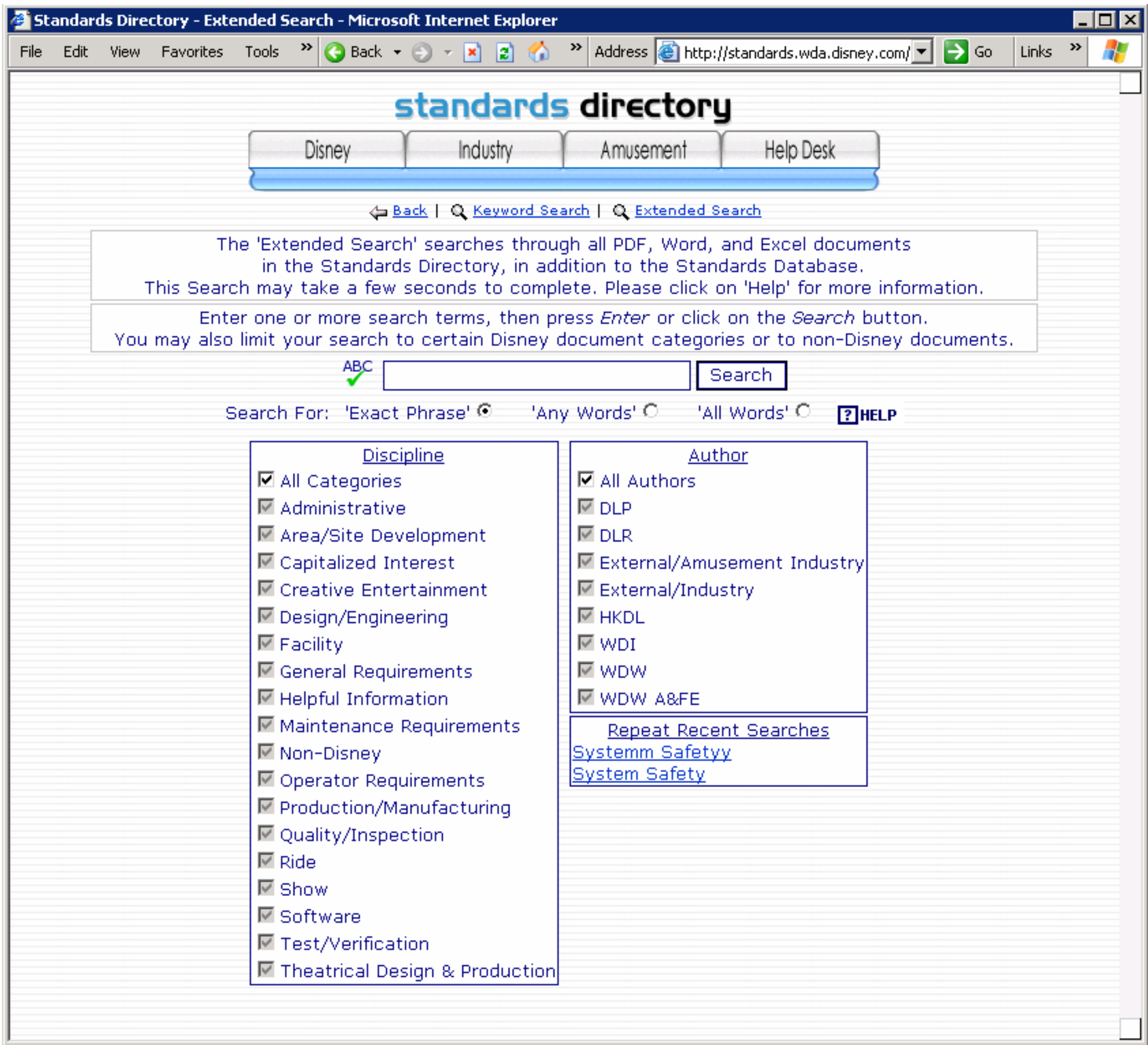
   Phone: ___________________________________

2. Would you like to receive a copy of the results? If so, please supply an email address ___________________.

3. Please feel free to give any other feedback you may have.

Appendix H

The Standards Directory's Extended Search Interface



Appendix I

Presentation of Search Results on the Standards Directory

Appendix J

National Science Digital Library's Engineering and Technology Taxonomy

The National Science Digital Library's Engineering and Technology Taxonomy (Pushpagiri & Rahman, 2002).

Engineering/Technology Area Major Topics	Engineering/Technology Area Major Topics
Aerospace Aeronautical Engineering	**Environmental Engineering**
Aerodynamics	Atmospheric Resources Management
Combustion and Propulsion	Environmental Planning and Management
Design and Manufacturing	Hydrology and Water Resources
Flight Dynamics and Control	Land Resources Management
Structural Mechanics and Dynamics	The Built Environment
Bio Engineering	Waste Management
Bioinformatics	**Industrial and Systems Engineering**
Biomedical	Human Factors
Bioprocessing	Manufacturing Processes and Systems
Biotechnology	Optimization and Operations Research
Environmental	Performance Improvement
Chemical Engineering	**Information and Communication Technologies**
Basics	Communication Technologies
Catalysis and Reaction	Internet Technologies
Particle Technology	Social, Economical and Global Aspects of ICT
Process Chemistry and Technology	Web Technologies
Transport Processes	**Materials Science and Engineering**
Civil Engineering	Advanced Instrumentation
Architectural and Building Engineering	Manufacturing and Processing
Construction Engineering and Management	Materials
Geotechnical Engineering	Mechanical/Physical Properties
Hydraulic Engineering and Infrastructure	Physics/Chemistry of Materials
Structural Engineering and Materials	Structures
Surveying	**Mechanical Engineering**
Transportation Engineering and Infrastructure	Acoustics
Computational Methods	Biomechanics
Calculus	Control Theory
Linear/Nonlinear Programming	Design and Manufacturing
Mathematical Theories	Fluid Mechanics

Engineering/Technology Area Major Topics	Engineering/Technology Area Major Topics
Numerical Methods	Materials
Statistical Methods	Robotics
Electrical Engineering	Solid Mechanics
Circuit Theory	Thermodynamics
Communications	Turbomachinery and Propulsion
Computer Engineering	**Mining Engineering**
Controls and Systems	Environmental Impacts Mitigation
Devices, Materials and Fabrication	Mine Design and Economics
Electromagnetics	Mine Health and Safety
Electronics	Mine Management and Operation
Energy and Power Systems	Mineral Processing
Instrumentation	Rock Fragmentation
Engineering Education	Rock Mechanics
Continuing Education	**Professional Development**
Curriculum Development and Implementation	Career and Personal Development
Global Issues	Engineering Mgmt
Information Technologies	Global Readiness
Instructional Design	Internet/Computer Skills
Student/Faculty Development	Research and Development

Appendix K

Authorization Letter

Walt Disney World Co.

August 26, 2005

To Whom It May Concern:

This letter confirms that Shawn Harrs was authorized to conduct the standards search engine comparison study for his dissertation.

Sincerely,

Rachel Hutter

Director of Attractions Engineering Services & Quality Assurance

P.O. Box 10000 / Lake Buena Vista, Florida 32830-1000

Appendix L

Institutional Review Board for Research with Human Subjects (IRB)

Submission Form

I. General Information

Project Title: Evaluation of five engineering and technology standards digital libraries' retrieval performance

Proposed Start Date: June 30, 2005

Proposed Duration of Research: 15 Days

Performance Site(s): Computer lab at the Disney University on the campus of the Walt Disney World Co.

A. Principal Investigator: Shawn Harrs

Faculty _____ Staff _____ Student __X__

Center/College/Department _Graduate School of Computer and Information Sciences___

Home Mailing Address (for students) __528 Jasmine Bloom Dr.

City_Apopka_____________ State___Florida_____ Zip___32712______________

Home Phone Number (for students) _(407) 859-2767____

Office Phone Number__(407) 824-4359__ E-mail address__harrs@nova.edu__

Co-Investigator(s) ____

B. Nova Southeastern University

Principal Investigator's Signature______________________Date______________________

New_____ Continuation/Renewal_____ Revision_____

II. Funding Information

If this protocol is part of an application to an outside agency, please provide:

A. Source of Funding ____

B. Project Title (if different from above)____

C. Principal Investigator (if different from above)______________________________

D. Type of Application:Grant_____ Subcontract_____ Contract_____ Fellowship______

E. Date of Submission _______________________

III. Cooperative Research

Cooperative research projects are those that involve more than one institution and can be designed to be both multi-site and multi-protocol in nature. Each participating institution is responsible for safeguarding the rights and welfare of human subjects and for complying with all regulations. If this proposal has been submitted to another Institutional Review Board please provide:

Name of Institution ____
Date of Review ___________ Contact Person _________________________________
IRB Recommendation ____

IV. Subject/patient Information

A. Types of Subjects/Patients (check all that apply):
Fetus in Utero/non-viable fetuses/abortuses
Newborns/Infants______
Children (aged 2-7) ______
Children (age 8-12) ______
Adolescents (aged 13-17) ______
Adults (18 and over) _24 to 40_
Pregnant Women______
Special populations (e.g., prisoners, mentally disabled) ______
Specify ____________

B. Other (Check all that apply)
Use of investigational drugs or devices______
Information to be collected may require special sensitivity______
(e.g. substance abuse, sexual behavior)

C. Number of Subjects/Patients _24 to 40_______
D. Approximate time commitment for each subject/patient _3 to 4 hours_______
E. Compensation to subjects/patients: Yes_____ No_X___
F. Form of Compensation (e.g. cash, taxi fare, meals, gifts) ________________________
______________________________Amount(value)_____________
G. Does this study involve the use of protected health information (PHI) from client charts or other records? Yes______No__X___
If Yes, will consent be obtained from the client for all PHI collected? Yes____ No____

If consent is not obtained, which of the following applies?

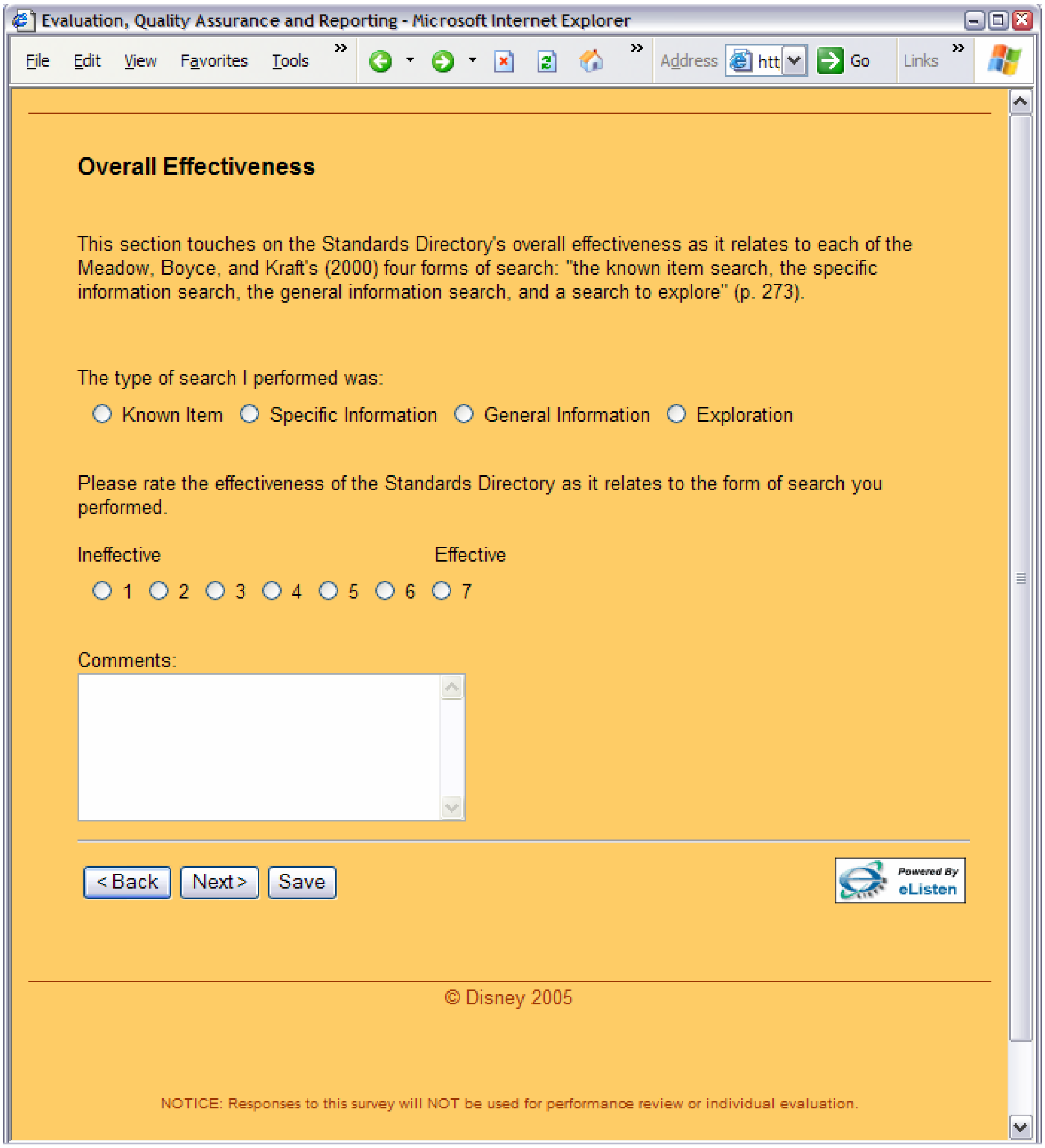
______The data will be collected in a fully de-identified data set.

______The data will be collected as part of a limited dataset agreement.

______The data will be collected under a waiver from a duly constituted privacy board. (Please attach a copy of the waiver to this form.)

Appendix M

Sample Page of Web Based Questionnaire



Appendix N

Search Order

The search engine order for this study was achieved through the following process:

1. Each search engine was listed alphabetically and assigned a number:

   1 = ANSI's National Standards Systems Network (NSSN)
   2 = GlobalSpec's Engineering Search Engine
   3 = Information Handling Services' Global Engineering Documents (GED)
   4 = Standards Directory
   5 = Thomson's Techstreet

2. A Latin square of order 5 was constructed by using the assigned numbers in increasing order for the first row then cyclically permuting the numbers in the first row for subsequent rows. The first rows of subsequent Latin squares were obtained by using the second to last row of the previous Latin square and switching the first two and last two digits in that row. This process was repeated to create three unique Latin squares of order 5:

   Set #1: 1, 2, 3, 4, 5
   Set #2: 2, 3, 4, 5, 1
   Set #3: 3, 4, 5, 1, 2
   Set #4: 4, 5, 1, 2, 3
   Set #5: 5, 1, 2, 3, 4

   Set #6: 5, 4, 1, 3, 2
   Set #7: 4, 1, 3, 2, 5
   Set #8: 1, 3, 2, 5, 4
   Set #9: 3, 2, 5, 4, 1
   Set #10: 2, 5, 4, 1, 3

   Set #11: 2, 3, 5, 1, 4
   Set #12: 3, 5, 1, 4, 2
   Set #13: 5, 1, 4, 2, 3
   Set #14: 1, 4, 2, 3, 5
   Set #15: 4, 2, 3, 5, 1

3. The search engine order was then assigned according to these random number sets:

Computer#1: NSSN, GlobalSpec, GED, Standards Directory, Techstreet
Computer#2: GlobalSpec, GED, Standards Directory, Techstreet, NSSN
Computer#3: GED, Standards Directory, Techstreet, NSSN, GlobalSpec
Computer#4: Standards Directory, Techstreet, NSSN, GlobalSpec, GED
Computer#5: Techstreet, NSSN, GlobalSpec, GED, Standards Directory
Computer#6: Techstreet, Standards Directory, NSSN, GED, GlobalSpec
Computer#7: Standards Directory, NSSN, GED, GlobalSpec, Techstreet
Computer#8: NSSN, GED, GlobalSpec, Techstreet, Standards Directory
Computer#9: GED, GlobalSpec, Techstreet, Standards Directory, NSSN
Computer#10: GlobalSpec, Techstreet, Standards Directory, NSSN, GED
Computer#11: GlobalSpec, GED, Techstreet, NSSN, Standards Directory
Computer#12: GED, Techstreet, NSSN, Standards Directory, GlobalSpec
Computer#13: Techstreet, NSSN, Standards Directory, GlobalSpec, GED
Computer#14: NSSN, Standards Directory, GlobalSpec, GED, Techstreet
Computer#15: Standards Directory, GlobalSpec, GED, Techstreet, NSSN

Appendix O

Qualitative Content Analysis Coding Process

Qualitative Content Analysis Coding Process Used to Assign Overall System Relevance Rankings Based On Study Participant Feedback (Mayring, 2000; Sormunen, 2002).

Numeric Value: Category	Definition Criteria	Examples (Participant ID)	Coding Rules
3: Highly Relevant	1. High relevance of search results presented is clearly discernable. 2. High relevance of search results are expected to help the user to take a good command of the topic. 3. No conditions are placed on relevance of search results. 4. Standards Directory only: Overall functionality question rated a six with a comment that meets one of the definition criteria or seven without a comment that violates any of the definition criteria.	1. “The Standards Directory was far and away the best of the bunch when doing a general information search, which most searches would likely be in our area.” (2426) 2. “Only the Standards Directory gave me a list of relevant standards both Disney and 3rd party.” (2426) 3. “Disney - The standards seemed most relevant and the search checked both the title and the body of text. I also liked that a percentile relevance was included.” (4088) 4. “6: Only search that returned relevant results.” (1680)	The search engine’s results would be deemed highly relevant if: – One of the participant’s answers clearly meets one definition criteria – No aspect of the participant’s answers violate any of the definition criteria – No aspect of the participant’s answers points to fairly relevant Otherwise 2: Fairly Relevant

Numeric Value: Category	Definition Criteria	Examples (Participant ID)	Coding Rules
2: Fairly Relevant	1. Search results contain more information than the title or topic description but the relevant information available is not exhaustive. 2. Qualitative statements about relevance are discernable. 3. The user is expected to gain some new information while already having a general intuition about the topic. 4. Standards Directory only: Overall functionality question rated a five or a six without a comment that violates any of the definition criteria.	1. "Techstreet was most useful since I could directly search IEEE standards" (3551) 2a. "IHS returned some good results…TechStreet - good results also" (4088) 2b. "GlobalSpec had good results…Techstreet gave me good results, but with more effort." (1182) 3. "GlobalSpec's were relevant if looking from an international standpoint…" (5594) 4. "5: It gives Disney standards as well as the Industry." (507)	The search engine's results would be deemed fairly relevant if: – One of the participant's answers clearly meets one definition criteria – No aspect of the participant's answers violate any of the definition criteria – No aspect of the participant's answers points to marginally relevant Otherwise 1: Marginally Relevant

Numeric Value: Category	Definition Criteria	Examples (Participant ID)	Coding Rules
1: Marginally Relevant	1. The search results only point to the topic. It does not contain more or other information than a descriptive title. 2. A low degree of relevance hardly contributes to the user's information need although it contains a piece of text mentioning the topic. 3. Relevance is likely; irrelevance can be ruled out. 4. Standards Directory only: Overall functionality question rated a three or a four without a comment that violates any of the definition criteria.	1. "ANSI and Global Spec search provided standards and information that looked like it might be applicable but there were only titles and no abstracts to make sure that is what you really want…" (8337) 2. "Techstreet provided a listing of standards with some abstract not necessarily close enough to what I was looking for a general overview." (8337) 3. "Techstreet did find something but I would have to purchase them to see if the information was in the standard." (9008) 4. "3: if it had it, it could find it…" (3551)	The search engine's results would be deemed marginally relevant if: – One of the participant's answers clearly meets one definition criteria – No aspect of the participant's answers violate any of the definition criteria – No all aspect of the participant's answers points to irrelevant Otherwise 1: Irrelevant

Numeric Value: Category	Definition Criteria	Examples (Participant ID)	Coding Rules
0: Irrelevant	1. The search results did not contain any information about the topic. 2. Irrelevance is discernible or no discernible indication relevant search results were present was given in the feedback. 3. Standards Directory only: Overall functionality question rated less than three.	1a. "ANSI did nothing good with 'wire color codes.'" (2426) 1b. "When searching on…'intelligibility' … putting the phrase in quotes 'audio systems testing' they were giving me links to standards on 'testing' and 'systems'. They didn't have anything to do with 'audio systems intelligibility'." (3318) 2a. "NSSN ANSI had no relevant results" (1182) 2b. "ANSI; result had no relation to search terms." (1281) 3. "1: They did not locate the US standard" (5594)	The search engine's results would be deemed irrelevant if: – Any aspect of the participant's answers meet one of the definition criteria – No fluctuations in comments on overall relevance is recognizable

Appendix P

Search Terms

Participants used search terms and phrases in this study. Some terms appear more than once. Only terms from participants whose feedback was used to calculate the data for this study appear on this list. This list presents the information provided by the participants verbatim, preserving the capitalization and syntax used by the participants.

Q1: In this project you will be asked to search for engineering standards and related information on topics in your area of engineering expertise. Please state the topics below (such as "Design of Mechanical Assemblies," or "Installation of Electronic and Electrical Systems").
Q2: What kind of information are you hoping to find? (such as "Methods for calculating fastener torque," or "Wire color coding for control box wiring").
Q3: Please state the search terms you are planning to use (for example, "Fastener and torque" or "wiring and electrical and installation").

Participants' Search Topics and Corresponding Search Terms and Phrases

PID	Q1	Q2	Q3
1680	Installation of Electrical Systems	National Electrical Code	National Electrical Code
1226	Ferrous material properties Non-Ferrous material properties	Material properties such as fatigue strength, ultimate strength, yield strength and impact properties.	Steel physical properties
1159	Show Control System Design Standards	Standard design guidelines for overall Show Control system design	Show Control Control Systems

PID	Q1	Q2	Q3
8337	Design of Mechanical Assemblies, Material Information, Pneumatic System	Methods for sizing and designing pneumatic systems. Standards on accepted safe operating pressure ranges. Operating ability of different types of equipment.	Pneumatic, tank, cylinder, pressure, and sizing system
9477	Design of stunt equipment and safety equipment.	Requirements for construction of stunt air bladders.	Air bladders Stunt Air Bag Air Bag Fall Bag Inflatable Stunt Air Bag
2121	Technical Publication formats, vendor information to be included in published documentation, safety related industry information, technical dictionaries. specific company standards	Specific formats, standards for safety information, vendor specific documents related to the project, specific word usage	technical documentation formats, specific vendor name, technical dictionary
2852	Linear Induction Motor	Information on applications and standards for construction of linear induction motors.	Linear Induction Motor; Linear Motor
9541	vendor products industry standards building codes	comparison of product characteristics standards applicable to a specific project codes applicable to a specific project	plaster lath ASTM #'s Florida Bldg Code 713
5594	Design of Mechanical Assemblies Performance standards	Amusement Device Standards Fastener Standards Material Standards icon standards	amusement device Fastener nut bolt steel stainless, plastics common icons documentation

PID	Q1	Q2	Q3
3944	Component standards / specifications	USS (ANSI A Wide) washer specifications	washer, USS, ANSI A Wide, hardened, flat
3285	Minimum light level for emergency lighting	minimum footcandles	emergency lighting
4088	What are the pressure testing requirements for pressurized tanks.	I want to know if there is a standard test method.	pressure test tank accumulator
5127	Federal regulations State regulations Product design/installation manuals Product catalogs	Regulation compliance criteria Design practices Product dimensions Product performance & limitations	CFR Florida watercraft regulations ASTM Standards Slewing bearings extrusions ASTM 2291
2091	Application and Life Expectancy of Lubrication Free Bearings	Actual Service Life on Bearings as opposed to Vendor Specified	Sleeve Bearings, Teflon Lined Bearings, Lubrication free Bearings, Life long bearings. I changed my search and narrowed it down to just Thrust Washers.
2403	Installation of Electronic and Electrical Systems	Wire color coding for control box wiring.	wiring and electrical and installation
9296	human computer interface standards	ergonomic considerations, anthropometric considerations, impact of the ADA on design, impact of Section 508 on designs	'human computer interaction' 'interface design' ergonomics

PID	Q1	Q2	Q3
4536	Bonding of plastics. Design of gears. Pneumatic motors/actuators.	Recommended adhesives for bonding certain plastics. Types of gears/calculation of tooth size and material Types of pneumatic motors and actuators and force capabilities/efficiency.	Plastic, adhesives, polyethylene Gears, determining gear ratios Pneumatic, motors, actuators
2426	Fabrication of control system boxes at Disney	All applicable standards and guidelines pertaining to what we need, for the purposes of making design/build vendors adhere to our requirements	UL, fire, and safety standards for control boxes; control system wire color codes
6978	ASTM 2291	guidelines and standards for design.	astm 2291
9594	Mechanical, Electrical, Plumbing and Fire Protection codes and standards for Facilities. HVAC & Electrical System equipment specifications. WDW Master Specification details. Project drawing and specification access.	Topic overviews for educational/familiarity purposes. Quick access to technical/standards questions. Multiple codes & standards search to evaluate compliance requirements. Product quality recommendations (lessons learned in industry and at WDW).	Egress Lighting
1182	Quality standards for grey iron castings	Non-destructive inspection methods and accept/reject criteria	cast grey iron inspection criteria
806	Design of Mechanical Assemblies Fatigue Stress analysis Torque loading	Methods for calculating fatigue Reminder of formulas Methods for choosing materials	Fatigue Analysis

PID	Q1	Q2	Q3
3300			
9071	ROOFING SYSTEM	INSULATION	R-VALUE
3551	1) SMPTE Timecode, 2) projection screen materials 3) digital cinema, 4) ip54 5) usb	1) definition & timing diagrams 2) types of materials, standard screen types, where used 3) standards applicable, general description 4) the standard 5) standard	1) 'SMPTE' 'timecode' 2) 'projection screen' 3) d-cinema, digital cinema, projection 4) ip-54 5) usb
3318	Audio Intelligibility	Methods of measuring audio intelligibility	'audio Intelligibility' 'Public address system testing' 'intelligibility'
7925	Accessibility Lifts	Variety of Lifts and features	Wheel chair lifts
3843	Design of structural cold formed steel stud shearwalls	Allowable shear values for shearwalls constructed from cold formed steel studs	cold formed steel shearwalls
3750	Technical Documentation	Structure of documents, formatting documents	writing technical documents
1281	Audio levels	maximum permissible audio level for prolonged exposure	maximum audio levels
4556	Accessibility	Surface and slope requirements related to wheelchairs	Wheelchair requirements, ramps, slope
874	Design of stainless steel structures	Yield stresses Allowable design stresses Examples of structural member design	stainless steel design
4002	Standards for application of video smoke detection systems	Commissioning requirements	video smoke detection

PID	Q1	Q2	Q3
9008	material properties for a specific grade of steel, AISI-316L in the Half-Hard condition.	modulus of elasticity coefficient of thermal expansion	stainless steel 316 half-hard modulus
1963	Fatigue of Structural Steel	Allowable Stress Limits of Cycles	Steel Fatigue Stress
7152	Quality Planning	Ways to prepare Quality Plans and available software applications.	Quality Planning, quality software applications, quality plans, and quality documentation, etc.
8769	Design and establishment minimum lighting levels in low light areas	Setting light levels and contrast levels for indoor and outdoor lighting in low light levels.	lighting levels contrast perception
6185	Staking and Guying of transplanted trees	Most effective methods of establishing trees	Staking and guying of transplanted trees
3128	Human factors in aircraft design	Safe forces for passengers	aircraft design, g-force, safety
507	Fabrication of Electrical Assemblies	Wire color codes and reference designators	Wire colors & Reference designation
3947	Design of mechanical assemblies	fastener types, component and material specs	fastener types
8902	Design of mechanical assemblies	Metal Stresses	Stress Allowables
6943	Anthropometric considerations for the design of seats for attractions	Anthropometric standards for children	Anthropometrics children chair

PID	Q1	Q2	Q3
4864	Dissimilar metals in water	how to cure the problem of dissimilar metals, what metal is the sacrificial piece, which metals can go together in water, how to keep metal from corroding, what processes take place within the water and how fast will the metal corrode, galvanic chart values	dissimilar metals, galvanic chart values
4285	Umbrella and Table Stanchions	Requirements and Specifications	Dimension
5572	Use of 'torque putty' to provide a visual check of fastener torque integrity.	How it should be applied, minimum amount necessary, precautions, etc.	torque putty, torque paste
2234	Design of pneumatic assemblies	Methods for sizing pneumatic cylinders	pneumatic cylinder sizing
4690	Material Properties Shock absorbing material	Material properties of 4130 steel High resilience foam	4130 Steel material properties Shock absorbing foam
W003	Marine Electrical Standards Marine Propulsion Ship Scantlings	Wiring Sizes Propeller sizing Ship Structure sizes	Ampacity Propellers Scantlings
1031	Operation of mechanical assemblies.	Allowable noise levels for use in public environment.	allowable 'noise level' public decibel
204	Standards for published technical information	various company or industry styles and standards	standards for published technical information
267	Design criteria for passenger railways	allowable passenger accelerations	Passenger railway accelerations

PID	Q1	Q2	Q3
1503	Design of mechanical assemblies	-How to calculate torque for arbitrary configurations. . - Suggestions on drawing hydraulic schematics	Spindle & Torque Hydraulic & Schematic
1159			
7787	Concrete Finishes	Methods, types, colors, textures, specifications, sealants, products, and innovative new tools to control concrete finishes.	Concrete finishes Concrete finish methods concrete textures Concrete toppings Concrete finish specifications Concrete products concrete Finish types Concrete finish colors Concrete stamps Concrete stamp manufacturers Concrete stamping Concrete hardeners Concrete sealants Concrete sealers Innovative concrete finish new finish for concrete Textures of concrete finishes
1019	amusement ride accessibility automatic door opener vertical platform lift auxiliary aids for effective communication	rules, standards, products	see topics and information above
2192			
1383			
5388	Accessibility Standards.	ADAAG - American Disabilities Act Accessible Guidelines.	Ride Accessibility.

PID	Q1	Q2	Q3
6923	interfacing IC chips to a computer	what types of interfaces are available, if there are any native hardware/software support	IC computer interface

Note. PID = participant's unique identifier.

Appendix Q

Study Participant Relevance Feedback and Overall System Relevance Ranking

Q1: Which results from the search engines compared were MOST relevant to you (if any)?
Q2: Why were these results relevant?
Q3: Which results from the search engines compared were NOT relevant to you (if any)?
Q4: Why were these results not relevant?
Q5: When compared with the commercial standards search engines used, how helpful is the overall functionality of the Standards Directory in finding standards (with comments)? 1: Less Helpful - 7: More Helpful

Study Participant Relevance Feedback and Coded Overall System Relevance Rankings

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1680	3: Highly Relevant	3: Highly Relevant	3: Highly Relevant	3: Highly Relevant	3: Highly Relevant
Q1	All				
Q2	All found the document				
Q3					
Q4					
Q5	4:				
1226	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	2: Fairly Relevant
Q1	Tech Street, but it listed obsolete specifications first, it took me a minute to figure out that I could click on the spec and it would go to the current spec.				
Q2	It at lest gave me a list of what was contained in the spec even though I could not look at the spec.				
Q3	All except Tech Street.				
Q4	Most would not give me a review of what was contained in the spec. but wanted me to buy the spec.				
Q5	5:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1159	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Disney Standards Directory was the only search that returned any relevant results.				
Q2	Specific to Disney.				
Q3	Did not find any relevant results for Show Control on any of the other search engines. I did find some results on the ANSI search relating to Audio and Video, and some generic controls system documents on TechStreet.				
Q4	No specific Show Control results.				
Q5	6: Only search that returned relevant results.				
8337	2: Fairly Relevant	1: Marginally Relevant	1: Marginally Relevant	0: Irrelevant	1: Marginally Relevant
Q1	Techstreet provided a listing of standards with some abstract not necessarily close enough to what I was looking for a general overview. ANSI and Global Spec search provided standards and information that looked like it might be applicable but there were only titles and no abstracts to make sure that is what you really want before ordering.				
Q2	The results were relevant because even with just titles I could go to the standards directory and try to look up that standard for a better description.				
Q3	Like all search engines searching for key words some irrelevant results appeared along with the applicable ones. This occurred in each of the searches including the standards directory.				
Q4					
Q5	6: It is more helpful when there is a chance that there may be a record of that standard. For a more general search to see what is out there the commercial engines may be better.				
9477	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	The Disney Standards Directory was more relevant once I found a key word string that produced the results that I was looking for. I used the same key word string on the other four sites and did not find any of the same information.				
Q2	They were relevant because they dealt with inflatable structures and their maintenance/construction. While a stunt bag is not a bounce house, it was beneficial information.				
Q3	None of the other searches produced any information that was relevant. IHS was the worst as it does not give abstracts. It would only be helpful if you knew exactly what standard you were looking for.				
Q4	They had no bearing on the topic or key words I was searching for.				
Q5	5:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
2121	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	none, all of the results were general in nature.				
Q2					
Q3	Most of the returns were specific to product listings then to a listing you would be able to click on with relevant information.				
Q4					
Q5	7:				
2852	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	None				
Q2					
Q3	Some results did not include the key words used.				
Q4	Did not match key words or got results but couldn't see the standard without purchasing.				
Q5	6: Had significant trouble in accessing or searching on other sites.				
9541	2: Fairly Relevant	No Answer	No Answer	No Answer	No Answer
Q1					
Q2					
Q3					
Q4					
Q5	5:				
5594	0: Irrelevant	0: Irrelevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec's were relevant if looking from an international standpoint but unable to determine where they come from without opening each one. Did not find US standard. Others offered very little.				
Q2	Finding international standards that might be of use.				
Q3	Could not get Techstreet to work NSSN not much use				
Q4	Did not pertain to topic				
Q5	1: They did not locate the US standard				
3944	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	none				
Q2					
Q3	most				
Q4	they did not find information on my topic. Most were at best partial successes.				
Q5	5:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
3285	2: Fairly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	ANSI was most relevant				
Q2	most complete listing				
Q3	GlobalSpecs				
Q4					
Q5	6:				
4088	3: Highly Relevant	0: Irrelevant	0: Irrelevant	2: Fairly Relevant	2: Fairly Relevant
Q1	I felt the Disney site returned the best results. IHS returned some good results but I was disappointed by the firewall issue. TechStreet - good results also				
Q2	Disney - The standards seemed most relevant and the search checked both the title and the body of text. I also liked that a percentile relevance was included.				
Q3	nssn I thought it was very poor Globalspec returned 40,000 hits with none of th first ones of relevance.				
Q4					
Q5	6:				
5127	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	Tech Street was 'best' for standards but not good for products. For products, tech street was not good but global was the best.				
Q2	They hit exactly what I wanted.				
Q3	Disney stds was not relevant for CFR because not in their database. Star & IHS also was way off the mark.				
Q4	See above + Star & HIS displayed books for sale and not the standards themselves.				
Q5	3:				
2091	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Global Spec returned individual items found in documents, but you have to pay to download. The documents returned where international and all were not in English and looked irrelevant.				
Q2					
Q3	No return from TechStreet. Global seemed irrelevant and the WDW Standards Directory was the only return that gave me an SAE standard that was useful.				
Q4					
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
2403	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Thomson Techstreet provided same result and ANSI did not.				
Q2	It provided the same standard.				
Q3					
Q4					
Q5	6:				
9296	1: Marginally Relevant	2: Fairly Relevant	2: Fairly Relevant	0: Irrelevant	2: Fairly Relevant
Q1	Human Engineering - Mil-Std-1472 Note 1 (SD#1) ADA Technical Assistance CD-ROM (SD#8) Ergonomics of Human-System Interaction - Guidance on Accessibility for Human-Computer Interfaces Document Number : TS 16071 (GS#3) HUMAN ENGINEERING DESIGN GUIDELINES Document Number : MIL-HDBK-759B CHG NOTICE 2 (GS#4) ISO TS 16071 (IHS#1) ISO/TS 16071:2003 (NSSN#1) BS DD ISO/PAS 18152:2003 (Techstreet#7)				
Q2	these standards concern ergonomics and the impact of the ADA				
Q3	SD#2 - Ships and Marine Technology SD#3 - 2003 SAE handbook on CD-Rom SD#4 National Electrical Code NEC 2002 SD#5 National Electrical Code SD#6 National Electrical Code				
Q4	May contain words searched for but did not focus on concepts searched for.				
Q5	3: too many irrelevant results in SD				
4536	0: Irrelevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	Global Spec				
Q2	They gave me general pieces of information that allowed me to quickly narrow my focus and start me on the right path.				
Q3	IHS				
Q4	It seemed to just pull up anything that contained the keywords I used.				
Q5	4:				
2426	2: Fairly Relevant	2: Fairly Relevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant
Q1	ANSI was actually quite fast, and provided reasonable results. The Standards Directory was far and away the best of the bunch when doing a general information search, which most searches would likely be in our area.				
Q2	Both of these gave pertinent information, with multiple hits to choose from.				
Q3	IHS was no good at all using broad terms. In fact, they even say so. For instance, 'Ul standards control systems' came up with nothing. Thomson's Techstreet never came up with proper responses at all, it typically timed out or couldn't find the page. GlobalSpec had reasonable results. ANSI did nothing good with 'wire color codes.'				
Q4					
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
6978	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	Only Global spec could find the standard. The others could not find it at all.				
Q2	Important standard				
Q3	the 3 others gave me nothing				
Q4					
Q5	6:				
9594	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Only the Standards Directory found relevant documents. None of the other search engines found any of the relevant documents (only an obscure military specification. In the past, I was able to find relevant code information in a matter of minutes using the hard copy table of contents. I am not a fan of hardcopy materials - I prefer electronic searches. However, the Standards Directory did not provide the access required to get to the specifics on line.				
Q2	Although I know that the documents found by the Standards Directory do include the information that I'm looking for. I was not able to access the specific information (e.g., most often, the site instructed me to obtain a hard copy).				
Q3	Standards Directory Mostly retuned results that instructed me to get the hard copy. Provided only titles of documents. The 'More Content' link did not provide more content. The 'More Info' link told me about the document, not the subject (keyword references). Techstreet Crashed on the first search. No results returned on the second try. ANSI Only found one military spec (access restricted). IHS Only found the same military spec (required purchase) GlobalSpec Only found the same military spec (link never responded).				
Q4	Standards Directory Ten Results means ten documents (I'm interested in specific document references).				
Q5	4: I find standards, not the information that I need.				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1182	3: Highly Relevant	0: Irrelevant	2: Fairly Relevant	2: Fairly Relevant	1: Marginally Relevant
Q1	WDW Standards had relevant results IHS had relevant results GlobalSpec had good results Techstreet gave me good results, but with more effort				
Q2	WDW Standards results were relevant because they led me to ASTM standards with a table of contents with several titles that sounded applicable. I still don't know if these standards are applicable but at least I know the possible relevant standard numbers. Globalspec had good results, good drilldown, and a good description. I still don't know if the standards really contain what I need, but at least I have numbers. Tech street originally rejected my search criteria until I told it only to search ASTM documents. I expected it to find everythin, and then have me drilldown to ASTM... IHS was relevant with a few iterations on my search criteria. I ended up finding general standards for gray iron and a specific standard on reference radiographs. All of this was manual as the details links were of no use.				
Q3	NSSN ANSI had no relevant results				
Q4	NSSN ANSI results were not relevant because none of the results were related to my search e.g. results were specifically iron valves...				
Q5	6:				
806	2: Fairly Relevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	2: Fairly Relevant
Q1	1. welding standards (D1.1) 2. ISO documentation on Metallic materials 3. Standard Practices for Cycle Counting in Fatigue Analysis 4. Standard Practice for Design of Amusement Rides and Devices				
Q2	Sources for analysis of materials and weld fatigue for amusement rides.				
Q3	The search engines, especially IHS global search and GlobalSpec, pulled up a bunch of links for offshore structures that would probably not be as useful to me, versus Thompsons, ANSI, and the Standards directory which pulled up more hits on the amusement industry and codes.				
Q4	I was looking for hits that focused on the basics of analysis (formulas and tools to use) and how to apply these to the amusement industry - so, hits on offshore structures etc. were just not the focus I wanted.				
Q5	5:				
3300	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec				
Q2	allowed me to view information,				
Q3	all but GlobalSpec				
Q4	other sites only offered opportunity to buy information / publications according to my search requests				
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
9071	2: Fairly Relevant	No Answer	No Answer	No Answer	No Answer
Q1					
Q2					
Q3					
Q4					
Q5	6:				
3551	1: Marginally Relevant	3: Highly Relevant	2: Fairly Relevant	0: Irrelevant	2: Fairly Relevant
Q1	Sorry - the following is mostly a quick summary of the good & bad... 1) SMPTE Timecode - Disney found a direct standard, ihs and techstreet - nothing, global spec and nssn had lots of interesting standards (good for a broader search), but nssn has the best summaries (when you click on results). digital cinema: Disney- lots of unrelated links (anything using 'project'), ihs- gave interesting link to data encoded on film (a search I had though to run but didn't) but digital cinema itself was lacking,; global spec-'search all' finally gave lots of potentially interesting links, but it was pretty much akin to a google search; techstreet -little, but one link interesting, nssn- little but could not tell from summaries. ip54: failure everywhere, and global spec 'search all' was not very useful usb and ieee1394 (other than Disney) - all search returned some info though mostly targeted to specific industries/groups (like connectors or applications). Techstreet was most useful since I could directly search IEEE standards (so great success for 1394). Global Spec 'search all' and 'patent' searches were useful in IEEE-1394. USB was very little useful info (except the Global Spec - web 'search all'). nssn did impress with the best standards summaries. projection screens: found interesting info from a variety of sources including Disney. Global Spec patents were very interesting here.				
Q2	The relevant researches either provided an exact standard I was looking for, or provided related info that would lead to further searching.				
Q3	In some areas, like USB and 1394, the results tended to be focused on certain industries (mechanical) or certain applications, instead of a general overview or the specific areas (electrical implementation) I was shooting for. In some cases (digital cinema/projection) the results were wildly all over (pretty much everything but anything useful). I think 'projection' seemed to really throw all the engines. But a later 'projection screen' search did mush better everywhere.				
Q4	see above				
Q5	3: if it had it, it could find it, if not, it could often get really lost				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
3318	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	When searching on a single word 'intelligibility' all of the search engines supplied a wide selection of standards (except the Disney standards) to choose from. Using multiple words like 'audio intelligibility' the differences were far different. Only the WDW Stadards Directory gave me a list of relevant standards both Disney and 3rd party.				
Q2	They addressed the standards that dealt with intelligibility only.				
Q3	Many even putting the phrase in quotes 'audio systems testing' they were giving me links to standards on 'testing' and 'systems'				
Q4	They didn't have anythng to do with 'audio systems intelligibility'				
Q5	6: especially when using phrases				
7925	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	Techstreet appeared to have the greatest variety of source material.				
Q2	Several different resources were available.				
Q3	global				
Q4	Too obscure with non-USA resources; I need US requirements primarily.				
Q5	5:				
3843	0: Irrelevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	NO standards were available, but outside articles from Global spec were helpful				
Q2	They gave information desired				
Q3	All results from Disney site were not relevant				
Q4	they dealt with anything having to do with one word in the search, looked like they didn't filter based on more tahn one word				
Q5	2:				
3750	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec and Standards Directory				
Q2	came up with results that reflected the requested subject				
Q3	Global and Thomson searches came up with the most non-relevant items. Both of these search engines came up with zero items when the original keywords were typed and I had to broaden the search to receive any results, which caused the unusually high amount of results.				
Q4	they were not related to the requested topic, only one word of the search				
Q5	5: better than most				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1281	1: Marginally Relevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant	2: Fairly Relevant
Q1	Ihs produced one result which was relevant Globalspec produced no results techstreet produced two results which were relevant ANSI produced no relevant results Disney produced multiple relevant results however none were in the top 10				
Q2	IHS; The standard directly related to my search terms Techstreet;they both dealt with the subject Disney; they directly dealt with the search terms				
Q3	Techstreet; results 3&4 ANSI; only produced one Disney; the vast majority of the 83 results				
Q4	Techstreet; they were in German ANSI; result had no relation to search terms they had nothing to do with my search terms				
Q5	3: the number of incorrect results limits its usefulness				
4556	1: Marginally Relevant	3: Highly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec and ANSI NSSN compared most favorably with the Standards Directory				
Q2	Produced the closest match to what I was looking for with additional relevant information.				
Q3	Thomson's TechStreet produced no matches.				
Q4	This search engine produced no matches - only one that did not. Not as user friendly as the others.				
Q5	4:				
874	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	Tech Street gave the most relevant items for the design information I was searching for. It also gave good descriptions.				
Q2	Top matches actually had relevance to structural design information wanted				
Q3	Disney site did not have any relevant info ANSI Site was extremely limited				
Q4	Disney Standards did not have any standard for design of stainless steel members				
Q5	1:				
4002	2: Fairly Relevant	0: Irrelevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant
Q1	Only GlobalSpec provided any hits. Much of it looked like it would be relevant. The Standards Directory provided hits, but I do not know why (The hits did not include info on video smoke detection).				
Q2	It was specifically related to video smoke detection (a specifc subject without much info on the web).				
Q3	No hits = no information = no relevance.				
Q4	No hits = no information = no relevance.				
Q5	6: More intuitive				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
9008	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec				
Q2	The information found was not in a specific standard, instead it was in a material data-sheet from a manufacturer. The only search engine that allowed general searches was GlobalSpec.				
Q3	IHS found nothing. Techstreet did find something but I would have to purchase them to see if the information was in the standard. NSSN was awful, hard to use, found nothing. WDW found several standards that may or may not contain the information but couldn't verify since uses printed copies.				
Q4					
Q5	7: for standards that are only available in printed form it is not possible to verify that the information looking for is actually contained in the standard. Suggest getting electronic copies of all standards.				
1963	2: Fairly Relevant	0: Irrelevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec was the most relevant.				
Q2	Approximately 50% of the same documents were referenced within the first 20 references.				
Q3	IHS Global, Thompson's and ANSI				
Q4	These sites made reference to commercial sources before referencing non-commercial sites. The most relevant sources are non-commercial.				
Q5	6:				
7152	2: Fairly Relevant	0: Irrelevant	2: Fairly Relevant	2: Fairly Relevant	2: Fairly Relevant
Q1	Disney Standards website gave me the most useful list followed by IHS Global, GlobalSpec, and Techstreet.				
Q2	Yes.				
Q3	NSSN did not give me the expected results.				
Q4	Some were, but most were useless.				
Q5	5:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
8769	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	2: Fairly Relevant	3: Highly Relevant
Q1	Disney, Techstreet, and IHS				
Q2	Disney did a surprisingly good job of pulling up several items, but did not include DIN on the first blush. Techstreet gave the most relevant items with almost NO irrelevant items. All pertained to lighting IHS had a fairly good list, but focused more on roadways and airport lighting				
Q3	ANSI seemed to go off on a tangent listing tires and other items where I found no relevance to the word search. Changing the word search did not improve the situation. Global Spec provided the most limited number of answers, most of which were poor in relevance.				
Q4	Tires, lighting appliances came up when lighting or lighting levels were used. Several other subject appeared on the ANSI that did not make sense to me.				
Q5	6: Did not provide as many hits as techstreet. Let's get more standards on the system in electronic copy.				
6185	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	2: Fairly Relevant
Q1	Thomson's was most relevant... although it would require that I purchase a book for $91 to get the information. None of the other search engines help much at all.				
Q2	The book that it suggested I buy appear as though it would provide the information that I was looking for. However it did NOT provide the information on the web.				
Q3	IHS found no results... GlobalSpec just reference a requirement without telling me how... ANSI had 15 matches but none of them were appropriate				
Q4	They did not provide the information that I was looking for.				
Q5	6:				
3128	3: Highly Relevant	0: Irrelevant	1: Marginally Relevant	1: Marginally Relevant	0: Irrelevant
Q1	Of the different search engines used, they all performed subpar to the Standards Directory used at WDW. Globalspec and IHS were the only search engines that returned anything that perhaps I could have worked with.				
Q2	I haphazard to guess that from the title, it may have been something to work with. There was no additional info available.				
Q3	nssn, techstreet.				
Q4	No results returned with my search criteria.				
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
507	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	NONE! as the results were only for something to buy without being able to see what was in the standard, which would enable me to have an opinion as to whether or not I wanted it.				
Q2					
Q3	Do not know.				
Q4	I could not see what the standards had for information.				
Q5	5: It gives Disney standards as well as the Industry				
3947	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	Thomson's Techstreet				
Q2	Most variety, ability to search particular families of standards such as 'Ansi'				
Q3	IHS Global, Globalspec				
Q4	Too few				
Q5	6:				
8902	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Standards Directory				
Q2	Related to my work				
Q3	none				
Q4					
Q5	7:				
6943	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Disney's - the others produced some results that might have been helpful but did not address my specific needs.				
Q2	Addresses the specific area that I was looking for.				
Q3	All the other search engines did not give results that I could directly use becasue I would have to order the item(s). Also I couldn't tell if the hits would produce any relevant information.				
Q4	Most did not address the topic area - seat design for children with relevant anthropometric data.				
Q5	7:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
4864	2: Fairly Relevant	1: Marginally Relevant	1: Marginally Relevant	0: Irrelevant	0: Irrelevant
Q1	Thomson's Techstreet and ANSI Standards Search, as well as GlobalSpec had a few summaries that seem to be relevant but you cannot tell if they were relevant because we could not view what was actually contained in the article. The other sites did not even give a small synopsis of what the article contained and you could not tell at all whether it was relevant. Our Standards directory had relevant information as well because it was referenced exactly where you could find it which was very helpful in getting something if you needed it quickly.				
Q2	The results were relevant because they explained briefly what the article contained because I was searching for something and the most relevant information to be whether it answered the questions I was looking to have answered. Also, they had related keywords that I could also search under when the results were given which gave a better idea of what I could search for that would be already related to what I was already searching.				
Q3	Some search engines came up with no results at all. Especially IHS Global. Also I did an entire article search and some results showed up that did not have my keyword in the title. This was entirely unhelpful because if you cannot even locate where in the article because you cannot view the article, what use is it to tell the user that the keyword is hidden somewhere in it.				
Q4	The results were not relevant because in some cases the keyword was too broad and garnered a lot of results which had a common word in it such as 'metal' or 'corrosion' and if I searched for a keyword that was too specific or long, there would be no results at all. There needs to be an advanced search where you can add or omit keywords or combine words instead of one box that you have to guess what to type into it. Also, you could not determine whether some results were relevant or not because of lack of information provided by the result or result description.				
Q5	5:				
4285	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1					
Q2					
Q3	None of the above search engines contained the specific standards that I was searching for. Most results were irrelevant. Disney Standards Directory accessed the document I wanted.				
Q4	They were too general.				
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
5572	1: Marginally Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	None of these search engines returned any hits for either 'torque putty' or 'torque paste.' The Disney search engine, however, returned 8 hits of greater than 77% -- some of the hits were Disney standards, the others were industry standards. I could not verify if the other standards actually addressed 'torque putty' or were just returning the keyword 'torque.'				
Q2	I was looking for the application of torque putty/paste -- something I knew nothing about until today (that there were applicable standards).				
Q3	Of the 8 Disney hits, several were very questionable (e.g., national fire standards), even though they were rated as 77%.				
Q4	I just didn't feel that all the hits contained applicable references to torque putty/paste.				
Q5	:				
2234	2: Fairly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	ANSI and Techstreet				
Q2	Better summary descriptions of the documents.				
Q3	Globalspec and IHSGlobal				
Q4	Scope or summary description of the documents were too specific/narrow.				
Q5	6:				
4690	2: Fairly Relevant	3: Highly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	NSSN globalspec				
Q2	NSSN was great for standard content searches or number searches globalspec was great for materials/properties and pricing				
Q3	ihs had a cumbersome interface, it took me a while just to find the search bar				
Q4	ihs seemed a bit trickier to use, however that is not a complaint of the supplied content				
Q5	5:				
W003	2: Fairly Relevant	2: Fairly Relevant	1: Marginally Relevant	1: Marginally Relevant	1: Marginally Relevant
Q1	Marine Propellers found only on NSSN All search engines found relevant information on Scantlings				
Q2	NSSN returned a know SAE standard we actually use. All search engines returned scantling standards, but none found Nation Bureau of Shipping				
Q3	Ampacity - None of the engines returned relevant information, None indexes ABYC directly				
Q4	No Marine wiring standards were found on any search engines				
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1031	3: Highly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	nssn.org Google Disney Standards Directory - Very good. Standard was 2nd result in my first search.				
Q2	nssn.org - Good search results using the 'find terms anywhere in record' field. Also gave good description of document scope. Google - Found what I was looking for on my first search with the following criteria (hazardous 'noise level' standard). Result was actually in a non-standards based site..that referenced this information.				
Q3	IHS Global Thomson's GlobalSpec				
Q4	IHS Global - Hard to tell if I found relevant information since this site doesn't give a document description...only a title. Thomson's - Difficult to narrow search down to 'mechanical' criteria included lots of 'electrical noise' results. GlobalSpec - Could not open this site.				
Q5	6: Good, though I usually know exactly what I'm looking for. If looking for anything other than a Disney standard I will typically use Google.				
204	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	GlobalSpec				
Q2	A representative selection of different standards on publishing were listed.				
Q3	ANSI -- no results provided; tried 6 different phrases with no results				
Q4	no results provide				
Q5	4:				
267	3: Highly Relevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant	3: Highly Relevant
Q1	nssn.org and thomson				
Q2	nssn gave me the most relevant docs, for this particular search. then the standards directory , then the Thomson site.				
Q3	nothing from IHS Global Spec nothing				
Q4					
Q5	6:				
1503	0: Irrelevant	3: Highly Relevant	3: Highly Relevant	3: Highly Relevant	3: Highly Relevant
Q1	I found an ISO hydraulic symbols standard (5859)through -IHS, GlobalSpec, Techstreet, and NSSN. Standard directory did not have this				
Q2	Contains basic symbols I was looking for				
Q3	No search was able to solve my unusual torque situation.				
Q4	Found keywords items within the document as opposed to the overall relevance.				
Q5	4: On par with average overall. My particular search failed on our standards directory only.				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1159	0: Irrelevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	3: Highly Relevant
Q1	Techstreet & GlobalSpec				
Q2	specific documents dealing with the subject were identified				
Q3	IHS showed no results Standards Directory gave extraneous results NSSN gave no results				
Q4	IHS showed no results Standards Directory gave extraneous results NSSN gave no results				
Q5	1:				
7787	3: Highly Relevant	2: Fairly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	Search Engine 5 - ANSI				
Q2	Good depth of information; however not exactly what I was looking for, would have search many of the documents and they cost.				
Q3	#2 IHS -GLOBAL #3 Globalspec #4 Techstreet				
Q4	Very Limited on type of information available and cost. Never found a close match for what I was looking for.				
Q5	6: Very helpful if you are looking for our standards and specifications. If you are researching new innovative ideas, methods, techniques or products, all of sites would not be sufficient as of today to find my desired information.				
1019	3: Highly Relevant	3: Highly Relevant	0: Irrelevant	2: Fairly Relevant	0: Irrelevant
Q1	Best (#1)to Worst (#4): 1. ANSI 2. IHS 3. Global Spec 4. Thomson's those relating to standards and products, and including summary information				
Q2	ANSI: in-depth; global; comprehensive Disney application				
Q3	Thomson's & Global spec listing of documents and products for sale, with little summary information				
Q4	lack of results; little detail on information content; focused on sales of documents more than content contained in documents not enough information to proceed / take action				
Q5	6:				
2192	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	Global Spec Engineering Search engine				
Q2	Good abstracts, provided both general and specific hits that were relevant				
Q3	NSSN global stds, IHS global std and tech street				
Q4	Poor abstracts that did not provide enough information for me to know what is in the standard. NSSN only provided results with very general entries. Specific searches provided no results				
Q5	6:				

PID	Standards Directory	ANSI's NSSN	GlobalSpec	IHS Global Eng. Docs	Thomson's Techstreet
1383	2: Fairly Relevant	1: Marginally Relevant	1: Marginally Relevant	1: Marginally Relevant	1: Marginally Relevant
Q1	About 20%				
Q2	Because I used general keywords.				
Q3					0.8
Q4	Did not apply at all				
Q5	5:				
5388	3: Highly Relevant	0: Irrelevant	0: Irrelevant	0: Irrelevant	0: Irrelevant
Q1	None.				
Q2					
Q3					
Q4	None were specific for attraction types of business.				
Q5	7: It specifically relates to my core business.				
6923	2: Fairly Relevant	0: Irrelevant	3: Highly Relevant	0: Irrelevant	0: Irrelevant
Q1	globalspec				
Q2	They actually showed devices that would allow me to interface IC chips to a computer, which is precisely what I was looking for.				
Q3	All others. They either returned 0 results or did not return relevant results				
Q4	They either had nothing to do with IC chips or interfaces.				
Q5	4:				

Note. Qualitative content analysis and coding methodology from Mayring (2000) and Sormunen (2002).

PID = participant's unique identifier.

Appendix R

Summary of Coded Participant Responses on Overall Relevance

Summary of Coded Participant Responses on Overall Search Engine Relevance

Standards Directory

	Category	*n*	%*N*
Valid	0	7	11.67
	1	5	8.33
	2	31	51.67
	3	17	28.33
	N	60	100.00

ANSI NSSN

	Category	*n*	%*N*
Valid	0	40	66.67
	1	3	5.00
	2	5	8.33
	3	10	16.67
	Subtotal	58	96.67
	Missing	2	3.33
	N	60	100.00

GlobalSpec

	Category	*n*	%*N*
Valid	0	31	51.67
	1	5	8.33
	2	8	13.33
	3	14	23.33
	Subtotal	58	96.67
	Missing	2	3.33
	N	60	100.00

Global Eng. Docs			
	Category	*n*	%*N*
Valid	0	47	78.33
	1	3	5.00
	2	5	8.33
	3	3	5.00
	Subtotal	58	96.67
	Missing	2	3.33
	N	60	100.00

Thomson's Techstreet			
	Category	*n*	%*N*
Valid	0	36	60.00
	1	4	6.67
	2	8	13.33
	3	10	16.67
	Subtotal	58	96.67
	Missing	2	3.33
	N	60	100.00

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Appendix S

ANOVA, *t*-Tests, and Multiple Comparisons of the Mean for the Search Engines Compared in the Study

Table S1. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Engineering Discipline

Search Engine	Eng. Disc.	*N*	Mean[a]	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Electrical	9	1.67	0.866	0.289	1.00	2.33
	Mechanical	23	1.91	0.996	0.208	1.48	2.34
	Civil/Arch.	4	2.00	0.000	0.000	2.00	2.00
	Other	20	2.05	0.999	0.223	1.58	2.52
	Total	56	1.93	0.931	0.124	1.68	2.18
AN	Electrical	9	1.00	1.500	0.500	-0.15	2.15
	Mechanical	23	0.83	1.267	0.264	0.28	1.37
	Civil/Arch.	3	0.00	0.000	0.000	0.00	0.00
	Other	20	0.55	1.050	0.235	0.06	1.04
	Total	55	0.71	1.197	0.161	0.39	1.03
GS	Electrical	9	1.11	1.364	0.455	0.06	2.16
	Mechanical	23	1.00	1.279	0.267	0.45	1.55
	Civil/Arch.	3	1.67	1.528	0.882	-2.13	5.46
	Other	20	1.00	1.298	0.290	0.39	1.61
	Total	55	1.05	1.283	0.173	0.71	1.40
GED	Electrical	9	0.89	1.364	0.455	-0.16	1.94
	Mechanical	23	0.30	0.822	0.171	-0.05	0.66
	Civil/Arch.	3	0.00	0.000	0.000	0.00	0.00
	Other	20	0.35	0.671	0.150	0.04	0.66
	Total	55	0.40	0.873	0.118	0.16	0.64
TT	Electrical	9	1.33	1.323	0.441	0.32	2.35
	Mechanical	23	1.00	1.279	0.267	0.45	1.55
	Civil/Arch.	3	1.00	1.732	1.000	-3.30	5.30
	Other	20	0.60	1.046	0.234	0.11	1.09
	Total	55	0.91	1.221	0.165	0.58	1.24

Table S1 (continued)

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table S2. ANOVA for the Search Engines' Overall Relevance Ranking by Grouped by Engineering Discipline

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	0.938	3	0.313	0.348	.791
	Within Groups	46.776	52	0.900		
	Total	47.714	55			
AN	Between Groups	3.091	3	1.030	0.708	.552
	Within Groups	74.254	51	1.456		
	Total	77.345	54			
GS	Between Groups	1.281	3	0.427	0.249	.862
	Within Groups	87.556	51	1.717		
	Total	88.836	54			
GED	Between Groups	2.892	3	0.964	1.283	.290
	Within Groups	38.308	51	0.751		
	Total	41.200	54			
TT	Between Groups	3.745	3	1.248	0.829	.484
	Within Groups	76.800	51	1.506		
	Total	80.545	54			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S3. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Engineering Discipline

Dependent Variable	Engineering Discipline (I)	Engineering Discipline (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	Electrical	Mechanical	-0.246	0.373	.932	-1.32	0.83
		Civil /Arch.	-0.333	0.570	.952	-1.98	1.31
		Other	-0.383	0.381	.798	-1.48	0.72
	Mechanical	Electrical	0.246	0.373	.932	-0.83	1.32
		Civil /Arch.	-0.087	0.514	.999	-1.57	1.40
		Other	-0.137	0.290	.974	-.97	0.70
	Civil/Arch.	Electrical	0.333	0.570	.952	-1.31	1.98

Dependent Variable	Engineering Discipline (I)	Engineering Discipline (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
		Mechanical	0.087	0.514	.999	-1.40	1.57
		Other	-0.050	0.519	1	-1.55	1.45
	Other	Electrical	0.383	0.381	.798	-0.72	1.48
		Mechanical	0.137	0.290	.974	-0.70	0.97
		Civil /Arch.	0.050	0.519	1	-1.45	1.55
AN	Electrical	Mechanical	0.174	0.474	.987	-1.20	1.55
		Civil /Arch.	1.000	0.804	.674	-1.33	3.33
		Other	0.450	0.484	.834	-.95	1.85
	Mechanical	Electrical	-0.174	0.474	.987	-1.55	1.20
		Civil /Arch.	0.826	0.741	.743	-1.32	2.97
		Other	0.276	0.369	.905	-0.79	1.34
	Civil /Arch.	Electrical	-1.000	0.804	.674	-3.33	1.33
		Mechanical	-0.826	0.741	.743	-2.97	1.32
		Other	-0.550	0.747	.909	-2.71	1.61
	Other	Electrical	-0.450	0.484	.834	-1.85	0.95
		Mechanical	-0.276	0.369	.905	-1.34	0.79
		Civil /Arch.	0.550	0.747	.909	-1.61	2.71
GS	Electrical	Mechanical	0.111	0.515	.997	-1.38	1.60
		Civil /Arch.	-0.556	0.874	.939	-3.08	1.97
		Other	0.111	0.526	.997	-1.41	1.63
	Mechanical	Electrical	-0.111	0.515	.997	-1.60	1.38
		Civil /Arch.	-0.667	0.804	.876	-2.99	1.66
		Other	0.000	0.401	1	-1.16	1.16
	Civil /Arch.	Electrical	0.556	0.874	.939	-1.97	3.08
		Mechanical	0.667	0.804	.876	-1.66	2.99
		Other	0.667	0.811	.878	-1.68	3.01
	Other	Electrical	-0.111	0.526	.997	-1.63	1.41
		Mechanical	0.000	0.401	1	-1.16	1.16
		Civil/Arch.	-0.667	0.811	.878	-3.01	1.68
GED	Electrical	Mechanical	0.585	0.341	.409	-0.40	1.57
		Civil/Arch.	0.889	0.578	.506	-0.78	2.56
		Other	0.539	0.348	.500	-0.47	1.54
	Mechanical	Electrical	-0.585	0.341	.409	-1.57	0.40
		Civil/Arch.	0.304	0.532	.954	-1.23	1.84
		Other	-0.046	0.265	.999	-0.81	0.72
	Civil/Arch.	Electrical	-0.889	0.578	.506	-2.56	0.78
		Mechanical	-0.304	0.532	.954	-1.84	1.23
		Other	-0.350	0.537	.934	-1.90	1.20
	Other	Electrical	-0.539	0.348	.500	-1.54	0.47
		Mechanical	0.046	0.265	.999	-0.72	0.81
		Civil/Arch.	0.350	0.537	.934	-1.20	1.90

Dependent Variable	Engineering Discipline (I)	Engineering Discipline (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
TT	Electrical	Mechanical	0.333	0.482	.923	-1.06	1.73
		Civil/Arch.	0.333	0.818	.983	-2.03	2.70
		Other	0.733	0.493	.534	-0.69	2.16
	Mechanical	Electrical	-0.333	0.482	.923	-1.73	1.06
		Civil/Arch.	0.000	0.753	1	-2.18	2.18
		Other	0.400	0.375	.769	-0.68	1.48
	Civil/Arch.	Electrical	-0.333	0.818	.983	-2.70	2.03
		Mechanical	0.000	0.753	1	-2.18	2.18
		Other	0.400	0.760	.964	-1.80	2.60
	Other	Electrical	-0.733	0.493	.534	-2.16	0.69
		Mechanical	-0.400	0.375	.769	-1.48	0.68
		Civil/Arch.	-0.400	0.760	.964	-2.60	1.80

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S4. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Primary Occupation

Search Engine	Primary Occupation[a]	*N*	Mean[b]	*SD*	Std. Error	95% Confidence Interval for Mean	
						Lower	Upper
SD	Applied	24	1.83	0.963	0.197	1.43	2.24
	Management	16	2.06	0.929	0.232	1.57	2.56
	Other	19	2.16	0.765	0.175	1.79	2.53
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	Applied	24	0.92	1.316	0.269	0.36	1.47
	Management	16	0.69	1.138	0.285	0.08	1.29
	Other	17	0.59	1.121	0.272	0.01	1.16
	Total	57	0.75	1.199	0.159	0.44	1.07
GS	Applied	24	1.33	1.373	0.280	0.75	1.91
	Management	16	1.00	1.155	0.289	0.38	1.62
	Other	17	0.71	1.213	0.294	0.08	1.33
	Total	57	1.05	1.274	0.169	0.71	1.39
GED	Applied	24	0.50	1.022	0.209	0.07	0.93
	Management	16	0.25	0.577	0.144	-0.06	0.56
	Other	17	0.35	0.862	0.209	-0.09	0.80
	Total	57	0.39	0.861	0.114	0.16	0.61
TT	Applied	24	1.13	1.262	0.258	0.59	1.66
	Management	16	0.50	1.033	0.258	-0.05	1.05
	Other	17	0.71	1.160	0.281	0.11	1.30

Search Engine	Primary Occupation[a]	*N*	Mean[b]	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
	Total	57	0.82	1.182	0.157	0.51	1.14

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]Engineering Executive as an occupation was left out of the analysis due to fewer than two cases.

[b]Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table S5. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Primary Occupation[a]

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	1.203	2	0.601	0.752	.476
	Within Groups	44.797	56	0.800		
	Total	46.000	58			
AN	Between Groups	1.173	2	0.586	0.399	.673
	Within Groups	79.388	54	1.470		
	Total	80.561	56			
GS	Between Groups	3.979	2	1.990	1.237	.298
	Within Groups	86.863	54	1.609		
	Total	90.842	56			
GED	Between Groups	0.626	2	0.313	0.414	.663
	Within Groups	40.882	54	0.757		
	Total	41.509	56			
TT	Between Groups	4.091	2	2.046	1.490	.235
	Within Groups	74.154	54	1.373		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]Engineering Executive as an occupation was left out of the analysis due to fewer than two cases.

Table S6. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Primary Occupation

Search Engine	Primary Occupation[a] (I)	Primary Occupation (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
SD	Applied	Management	-0.229	0.289	.731	-0.96	0.50
		Other	-0.325	0.275	.502	-1.02	0.37
	Management	Applied	0.229	0.289	.731	-0.50	0.96
		Other	-0.095	0.303	.952	-0.86	0.67
	Other	Applied	0.325	0.275	.502	-0.37	1.02
		Management	0.095	0.303	.952	-0.67	0.86
AN	Applied	Management	0.229	0.391	.843	-0.76	1.21
		Other	0.328	0.384	.696	-0.64	1.30
	Management	Applied	-0.229	0.391	.843	-1.21	0.76
		Other	0.099	0.422	.973	-0.96	1.16
	Other	Applied	-0.328	0.384	.696	-1.30	0.64
		Management	-0.099	0.422	.973	-1.16	0.96
GS	Applied	Management	0.333	0.409	.719	-0.70	1.36
		Other	0.627	0.402	.304	-0.38	1.64
	Management	Applied	-0.333	0.409	.719	-1.36	0.70
		Other	0.294	0.442	.802	-0.82	1.41
	Other	Applied	-0.627	0.402	.304	-1.64	0.38
		Management	-0.294	0.442	.802	-1.41	0.82
GED	Applied	Management	0.250	0.281	.675	-0.46	0.96
		Other	0.147	0.276	.868	-0.55	0.84
	Management	Applied	-0.250	0.281	.675	-0.96	0.46
		Other	-0.103	0.303	.944	-0.87	0.66
	Other	Applied	-0.147	0.276	.868	-0.84	0.55
		Management	0.103	0.303	.944	-0.66	0.87
TT	Applied	Management	0.625	0.378	.264	-0.33	1.58
		Other	0.419	0.371	.533	-0.52	1.35
	Management	Applied	-0.625	0.378	.264	-1.58	0.33
		Other	-0.206	0.408	.881	-1.23	0.82
	Other	Applied	-0.419	0.371	.533	-1.35	0.52
		Management	0.206	0.408	.881	-0.82	1.23

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]Engineering Executive as an occupation was left out of the analysis due to fewer than two cases.

Table S7. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Highest Degree Awarded

Search Engine	Highest Degree Awarded[a]	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Associate's	4	2.25	0.957	0.479	0.73	3.77
	Bachelor's	28	2.11	0.786	0.149	1.80	2.41
	Master's	21	1.71	1.056	0.230	1.23	2.19
	Doctorate	2	2.50	0.707	0.500	-3.85	8.85
	Total	55	1.98	0.913	0.123	1.74	2.23
AN	Associate's	4	0.00	0.000	0.000	0.00	0.00
	Bachelor's	26	0.77	1.177	0.231	0.29	1.24
	Master's	21	0.81	1.250	0.273	0.24	1.38
	Doctorate	2	0.00	0.000	0.000	0.00	0.00
	Total	53	0.70	1.153	0.158	0.38	1.02
GS	Associate's	4	0.75	1.500	0.750	-1.64	3.14
	Bachelor's	26	0.96	1.248	0.245	0.46	1.47
	Master's	21	1.10	1.221	0.266	0.54	1.65
	Doctorate	2	1.50	2.121	1.500	-17.56	20.56
	Total	53	1.02	1.248	0.171	0.67	1.36
GED	Associate's	4	0.00	0.000	0.000	0.00	0.00
	Bachelor's	26	0.27	0.778	0.152	-0.04	0.58
	Master's	21	0.43	0.746	0.163	0.09	0.77
	Doctorate	2	0.00	0.000	0.000	0.00	0.00
	Total	53	0.30	0.723	0.099	0.10	0.50
TT	Associate's	4	0.00	0.000	0.000	0.00	0.00
	Bachelor's	26	0.38	0.752	0.148	0.08	0.69
	Master's	21	1.48	1.327	0.290	0.87	2.08
	Doctorate	2	0.00	0.000	0.000	0.00	0.00
	Total	53	0.77	1.137	0.156	0.46	1.09

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]High School as the highest degree awarded was left out of the analysis due to fewer than two cases.

Table S8. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Highest Degree Awarded[a]

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	2.768	3	0.923	1.115	.352
	Within Groups	42.214	51	0.828		
	Total	44.982	54			

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
AN	Between Groups	3.316	3	1.105	0.823	.488
	Within Groups	65.853	49	1.344		
	Total	69.170	52			
GS	Between Groups	0.960	3	0.320	0.196	.899
	Within Groups	80.021	49	1.633		
	Total	80.981	52			
GED	Between Groups	.912	3	0.304	0.567	.639
	Within Groups	26.258	49	0.536		
	Total	27.170	52			
TT	Between Groups	17.891	3	5.964	5.916	.002
	Within Groups	49.392	49	1.008		
	Total	67.283	52			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]High School as the highest degree awarded was left out of the analysis due to fewer than two cases.

Table S9. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Highest Degree Awarded

Search Engine	Highest Degree Awarded[a] (I)	Highest Degree Awarded(J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
SD	Associate's	Bachelor's	0.143	0.486	.993	-1.26	1.55
		Master's	0.536	0.496	.762	-0.90	1.97
		Doctorate	-0.250	0.788	.992	-2.53	2.03
	Bachelor's	Associate's	-0.143	0.486	.993	-1.55	1.26
		Master's	0.393	0.263	.530	-0.37	1.15
		Doctorate	-0.393	0.666	.950	-2.32	1.53
	Master's	Associate's	-0.536	0.496	.762	-1.97	0.90
		Bachelor's	-0.393	0.263	.530	-1.15	0.37
		Doctorate	-0.786	0.673	.716	-2.73	1.16
	Doctorate	Associate's	0.250	0.788	.992	-2.03	2.53
		Bachelor's	0.393	0.666	.950	-1.53	2.32
		Master's	0.786	0.673	.716	-1.16	2.73
AN	Associate's	Bachelor's	-0.769	0.623	.678	-2.57	1.03
		Master's	-0.810	0.632	.653	-2.64	1.02
		Doctorate	0.000	1.004	1	-2.91	2.91
	Bachelor's	Associate's	0.769	0.623	.678	-1.03	2.57
		Master's	-0.040	0.340	1	-1.03	0.94

Search Engine	Highest Degree Awarded[a] (I)	Highest Degree Awarded(J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
		Doctorate	0.769	0.851	.845	-1.69	3.23
	Master's	Associate's	0.810	0.632	.653	-1.02	2.64
		Bachelor's	0.040	0.340	1	-0.94	1.03
		Doctorate	0.810	0.858	.828	-1.67	3.29
	Doctorate	Associate's	0.000	1.004	1	-2.91	2.91
		Bachelor's	-0.769	0.851	.845	-3.23	1.69
		Master's	-0.810	0.858	.828	-3.29	1.67
GS	Associate's	Bachelor's	-0.212	0.686	.992	-2.20	1.78
		Master's	-0.345	0.697	.970	-2.36	1.67
		Doctorate	-0.750	1.107	.927	-3.95	2.45
	Bachelor's	Associate's	0.212	0.686	.992	-1.78	2.20
		Master's	-0.134	0.375	.988	-1.22	0.95
		Doctorate	-0.538	0.938	.954	-3.25	2.18
	Master's	Associate's	0.345	0.697	.970	-1.67	2.36
		Bachelor's	0.134	0.375	.988	-0.95	1.22
		Doctorate	-0.405	0.946	.980	-3.14	2.33
	Doctorate	Associate's	0.750	1.107	.927	-2.45	3.95
		Bachelor's	0.538	0.938	.954	-2.18	3.25
		Master's	0.405	0.946	.980	-2.33	3.14
GED	Associate's	Bachelor's	-0.269	0.393	.925	-1.41	0.87
		Master's	-0.429	0.399	.765	-1.58	0.73
		Doctorate	0.000	0.634	1	-1.84	1.84
	Bachelor's	Associate's	0.269	0.393	.925	-0.87	1.41
		Master's	-0.159	0.215	.907	-0.78	0.46
		Doctorate	0.269	0.537	.969	-1.29	1.82
	Master's	Associate's	0.429	0.399	.765	-0.73	1.58
		Bachelor's	0.159	0.215	.907	-0.46	0.78
		Doctorate	0.429	0.542	.890	-1.14	2.00
	Doctorate	Associate's	0.000	0.634	1	-1.84	1.84
		Bachelor's	-0.269	0.537	.969	-1.82	1.29
		Master's	-0.429	0.542	.890	-2.00	1.14
TT	Associate's	Bachelor's	-0.385	0.539	.916	-1.95	1.18
		Master's	-1.476	0.548	.077	-3.06	0.11
		Doctorate	0.000	0.869	1	-2.52	2.52
	Bachelor's	Associate's	0.385	0.539	.916	-1.18	1.95
		Master's	-1.092	0.295	.007	-1.94	-0.24
		Doctorate	0.385	0.737	.965	-1.75	2.52
	Master's	Associate's	1.476	0.548	.077	-0.11	3.06
		Bachelor's	1.092	0.295	.007	.24	1.94
		Doctorate	1.476	0.743	.280	-0.67	3.63
	Doctorate	Associate's	0.000	0.869	1	-2.52	2.52

Search Engine	Highest Degree Awarded[a] (I)	Highest Degree Awarded(J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
		Bachelor's	-0.385	0.737	.965	-2.52	1.75
		Master's	-1.476	0.743	.280	-3.63	0.67

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]High School as the highest degree awarded was left out of the analysis due to fewer than two cases.

Table S10. Independent *t*-Tests Comparing the Means for the Search Engines' Overall Relevance Ranking Grouped by Whether Participants had Published in their Field of Expertise

Search Engine	Published in Field	*N*	Mean	*SD*	Std. Error Mean
Standards Directory	No	48	1.88	0.914	0.132
	Yes	10	2.50	0.527	0.167
ANSI NSSN	No	46	0.76	1.233	0.182
	Yes	10	0.50	0.850	0.269
GlobalSpec	No	46	1.13	1.293	0.191
	Yes	10	0.80	1.229	0.389
Global Eng. Docs	No	46	0.33	0.818	0.121
	Yes	10	0.40	0.699	0.221
Thomson's Techstreet	No	46	0.93	1.254	0.185
	Yes	10	0.40	0.699	0.221

SE	EVA	Levene's Test for Equality of Variances.		*t*-Test for Equality of Means						
				t	*df*	p^a	MD	SED	95% Confidence Interval of the Difference	
		F	Sig.						Lower	Upper
SD	Yes	.559	.458	-2.082	56	.042	-0.625	0.300	-1.226	-0.024
	No			-2.941	22.141	.008	-0.625	0.213	-1.066	-0.184
AN	Yes	3.097	.084	0.635	54	.528	0.261	0.411	-0.563	1.085
	No			0.804	18.347	.432	0.261	0.324	-0.420	0.942
GS	Yes	1.808	.184	0.738	54	.463	0.330	0.447	-0.567	1.228
	No			0.763	13.690	.458	0.330	0.433	-0.600	1.261
GED	Yes	.001	.972	-0.265	54	.792	-0.074	0.279	-0.633	0.485
	No			-0.293	14.888	.773	-0.074	0.252	-0.611	0.463
TT	Yes	11.86	.001	1.299	54	.200	0.535	0.412	-0.291	1.360
	No	.559	.458	1.855	23.681	.076	0.535	0.288	-0.061	1.130

Table S10 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SE = search engine; EVA = equal variances assumed; MD = mean difference; SED = standard error difference; SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]2-tailed.

Table S11. Independent *t*-Tests Comparing the Means for the Search Engines' Overall Relevance Ranking Grouped by Whether Participants were Licensed Professionals

Search Engine	Licensed Professional	*N*	Mean	*SD*	Std. Error Mean
Standards Directory	Yes	23	1.96	1.022	0.213
	No	35	2.03	0.822	0.139
ANSI NSSN	Yes	21	0.43	0.978	0.213
	No	35	0.89	1.255	0.212
GlobalSpec	Yes	21	1.10	1.261	0.275
	No	35	0.97	1.272	0.215
Global Eng. Docs	Yes	21	0.33	0.730	0.159
	No	35	0.34	0.838	0.142
Thomson's Techstreet	Yes	21	1.05	1.244	0.271
	No	35	0.71	1.152	0.195

Search Engine	EVA	Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
				t	*df*	*p*[a]	MD	SED	95% Confidence Interval of the Difference	
		F	Sig.						Lower	Upper
SD	Yes	.499	.483	-0.296	56	.768	-0.072	0.243	-0.559	0.415
	No			-0.283	40.017	.778	-0.072	0.254	-0.586	0.442
AN	Yes	6.505	.014	-1.427	54	.159	-0.457	0.320	-1.099	0.185
	No			-1.519	50.200	.135	-0.457	0.301	-1.062	0.147
GS	Yes	.097	.756	0.354	54	.725	0.124	0.350	-0.578	0.825
	No			0.355	42.531	.725	0.124	0.349	-0.581	0.828
GED	Yes	.034	.855	-0.043	54	.966	-0.010	0.221	-0.452	0.433
	No			-0.045	46.881	.965	-0.010	0.213	-0.439	0.419
TT	Yes	.680	.413	1.017	54	.314	0.333	0.328	-0.324	0.990
	No			0.998	39.701	.324	0.333	0.334	-0.342	1.009

Table S11 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. EVA = equal variances assumed; MD = mean difference; SED = standard error difference; SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]2-tailed.

Table S12. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Search Engine	Years for Company	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	< 6	24	1.83	0.816	0.167	1.49	2.18
	6 to 10	12	2.50	0.905	0.261	1.93	3.07
	11 to 15	8	2.13	0.991	0.350	1.30	2.95
	> 15	14	1.86	0.864	0.231	1.36	2.36
	Total	58	2.02	0.888	0.117	1.78	2.25
AN	< 6	24	0.67	1.090	0.223	0.21	1.13
	6 to 10	12	0.75	1.357	0.392	-0.11	1.61
	11 to 15	7	1.14	1.464	0.553	-0.21	2.50
	> 15	13	0.31	0.751	0.208	-0.15	0.76
	Total	56	0.66	1.133	0.151	0.36	0.96
GS	< 6	24	1.04	1.233	0.252	0.52	1.56
	6 to 10	12	1.08	1.379	0.398	0.21	1.96
	11 to 15	7	0.29	0.756	0.286	-0.41	0.98
	> 15	13	1.31	1.377	0.382	0.48	2.14
	Total	56	1.02	1.258	0.168	0.68	1.35
GES	< 6	24	0.29	0.751	0.153	-0.03	0.61
	6 to 10	12	0.58	1.084	0.313	-0.11	1.27
	11 to 15	7	0.29	0.756	0.286	-0.41	0.98
	> 15	13	0.23	0.599	0.166	-0.13	0.59
	Total	56	0.34	0.793	0.106	0.13	0.55
TT	< 6	24	0.63	0.970	0.198	0.22	1.03
	6 to 10	12	1.00	1.348	0.389	0.14	1.86
	11 to 15	7	0.43	1.134	0.429	-0.62	1.48
	> 15	13	1.31	1.377	0.382	0.48	2.14
	Total	56	0.84	1.187	0.159	0.52	1.16

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S13. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	4.060	3	1.353	1.786	.161
	Within Groups	40.923	54	0.758		
	Total	44.983	57			
AN	Between Groups	3.344	3	1.115	0.862	.467
	Within Groups	67.210	52	1.292		
	Total	70.554	55			
GS	Between Groups	4.909	3	1.636	1.037	.384
	Within Groups	82.073	52	1.578		
	Total	86.982	55			
GED	Between Groups	0.942	3	0.314	0.486	.694
	Within Groups	33.611	52	0.646		
	Total	34.554	55			
TT	Between Groups	5.445	3	1.815	1.309	.281
	Within Groups	72.109	52	1.387		
	Total	77.554	55			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S14. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Search Engine	Years for Company (I)	Years for Company (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	< 6	6 to 10	-0.667	0.308	.209	-1.55	0.22
		11 to 15	-0.292	0.355	.879	-1.32	0.73
		> 15	-0.024	0.293	1	-0.87	0.82
	6 to 10	< 6	0.667	0.308	.209	-0.22	1.55
		11 to 15	0.375	0.397	.827	-0.77	1.52
		> 15	0.643	0.342	.328	-0.35	1.63
	11 to 15	< 6	0.292	0.355	.879	-0.73	1.32
		6 to 10	-0.375	0.397	.827	-1.52	0.77
		> 15	0.268	0.386	.922	-0.85	1.38
	> 15	< 6	0.024	0.293	1	-0.82	0.87
		6 to 10	-0.643	0.342	.328	-1.63	0.35
		11 to 15	-0.268	0.386	.922	-1.38	0.85
AN	< 6	6 to 10	-0.083	0.402	.998	-1.24	1.08
		11 to 15	-0.476	0.488	.813	-1.89	0.93
		> 15	0.359	0.392	.839	-0.77	1.49
	6 to 10	< 6	0.083	0.402	.998	-1.08	1.24

Search Engine	Years for Company (I)	Years for Company (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
		11 to 15	-0.393	0.541	.912	-1.96	1.17
		> 15	0.442	0.455	.815	-0.87	1.76
	11 to 15	< 6	0.476	0.488	.813	-0.93	1.89
		6 to 10	0.393	0.541	.912	-1.17	1.96
		> 15	0.835	0.533	.490	-0.70	2.38
	> 15	< 6	-0.359	0.392	.839	-1.49	0.77
		6 to 10	-0.442	0.455	.815	-1.76	0.87
		11 to 15	-0.835	0.533	.490	-2.38	0.70
GS	< 6	6 to 10	-0.042	0.444	1	-1.32	1.24
		11 to 15	0.756	0.540	.584	-0.80	2.32
		> 15	-0.266	0.433	.944	-1.52	0.98
	6 to 10	< 6	0.042	0.444	1	-1.24	1.32
		11 to 15	0.798	0.597	.622	-0.93	2.52
		> 15	-0.224	0.503	.978	-1.68	1.23
	11 to 15	< 6	-0.756	0.540	.584	-2.32	0.80
		6 to 10	-0.798	0.597	.622	-2.52	0.93
		> 15	-1.022	0.589	.399	-2.72	0.68
	> 15	< 6	0.266	0.433	.944	-0.98	1.52
		6 to 10	0.224	0.503	.978	-1.23	1.68
		11 to 15	1.022	0.589	.399	-0.68	2.72
GED	< 6	6 to 10	-0.292	0.284	.789	-1.11	0.53
		11 to 15	0.006	0.345	1	-0.99	1.00
		> 15	0.061	0.277	.997	-0.74	0.86
	6 to 10	< 6	0.292	0.284	.789	-0.53	1.11
		11 to 15	0.298	0.382	.895	-0.81	1.40
		> 15	0.353	0.322	.754	-0.58	1.28
	11 to 15	< 6	-0.006	0.345	1	-1.00	0.99
		6 to 10	-0.298	0.382	.895	-1.40	0.81
		> 15	0.055	0.377	.999	-1.03	1.14
	> 15	< 6	-0.061	0.277	.997	-0.86	0.74
		6 to 10	-0.353	0.322	.754	-1.28	0.58
		11 to 15	-0.055	0.377	.999	-1.14	1.03
TT	< 6	6 to 10	-0.375	0.416	.846	-1.58	0.83
		11 to 15	0.196	0.506	.985	-1.27	1.66
		> 15	-0.683	0.406	.426	-1.85	0.49
	6 to 10	< 6	0.375	0.416	.846	-0.83	1.58
		11 to 15	0.571	0.560	.791	-1.05	2.19
		> 15	-0.308	0.471	.934	-1.67	1.05
	11 to 15	< 6	-0.196	0.506	.985	-1.66	1.27
		6 to 10	-0.571	0.560	.791	-2.19	1.05
		> 15	-0.879	0.552	.475	-2.47	0.72

Search Engine	Years for Company (I)	Years for Company (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
	> 15	< 6	0.683	0.406	.426	-0.49	1.85
		6 to 10	0.308	0.471	.934	-1.05	1.67
		11 to 15	0.879	0.552	.475	-0.72	2.47

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S15. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Search Engine	Years Overall	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean	
						Lower	Upper
SD	< 6	7	1.57	0.787	0.297	0.84	2.30
	6 to 10	9	2.11	0.782	0.261	1.51	2.71
	11 to 15	8	2.38	1.061	0.375	1.49	3.26
	> 15	35	1.97	0.891	0.151	1.67	2.28
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	< 6	7	1.00	1.155	0.436	-0.07	2.07
	6 to 10	9	1.33	1.414	0.471	0.25	2.42
	11 to 15	8	0.00	0.000	0.000	0.00	0.00
	> 15	33	0.64	1.168	0.203	0.22	1.05
	Total	57	0.70	1.164	0.154	0.39	1.01
GS	< 6	7	1.57	1.397	0.528	0.28	2.86
	6 to 10	9	0.89	1.167	0.389	-0.01	1.79
	11 to 15	8	1.00	1.195	0.423	0.00	2.00
	> 15	33	1.00	1.323	0.230	0.53	1.47
	Total	57	1.05	1.274	0.169	0.71	1.39
GED	< 6	7	0.43	1.134	0.429	-0.62	1.48
	6 to 10	9	0.11	0.333	0.111	-0.15	0.37
	11 to 15	8	0.63	0.916	0.324	-0.14	1.39
	> 15	33	0.30	0.770	0.134	0.03	0.58
	Total	57	0.33	0.787	0.104	0.12	0.54
TT	< 6	7	0.71	0.951	0.360	-0.17	1.59
	6 to 10	9	0.56	0.882	0.294	-0.12	1.23
	11 to 15	8	0.38	0.744	0.263	-0.25	1.00
	> 15	33	1.03	1.357	0.236	0.55	1.51
	Total	57	0.82	1.182	0.157	0.51	1.14

Table S15 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S16. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	2.550	3	0.850	1.076	.367
	Within Groups	43.450	55	0.790		
	Total	46.000	58			
AN	Between Groups	8.293	3	2.764	2.166	.103
	Within Groups	67.636	53	1.276		
	Total	75.930	56			
GS	Between Groups	2.239	3	0.746	0.446	.721
	Within Groups	88.603	53	1.672		
	Total	90.842	56			
GED	Between Groups	1.219	3	0.406	0.644	.590
	Within Groups	33.448	53	0.631		
	Total	34.667	56			
TT	Between Groups	3.750	3	1.250	0.889	.453
	Within Groups	74.495	53	1.406		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S17. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Search Engine	Years Overall (I)	Years Overall (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	< 6	6 to 10	-0.540	0.448	.695	-1.83	0.75
		11 to 15	-0.804	0.460	.392	-2.13	0.52
		> 15	-0.400	0.368	.758	-1.46	0.66
	6 to 10	< 6	0.540	0.448	.695	-0.75	1.83
		11 to 15	-0.264	0.432	.945	-1.51	0.98
		> 15	0.140	0.332	.981	-0.82	1.10
	11 to 15	< 6	0.804	0.460	.392	-0.52	2.13
		6 to 10	0.264	0.432	.945	-0.98	1.51
		> 15	0.404	0.348	.720	-0.60	1.41

Search Engine	Years Overall (I)	Years Overall (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
	> 15	< 6	0.400	0.368	.758	-0.66	1.46
		6 to 10	-0.140	0.332	.981	-1.10	0.82
		11 to 15	-0.404	0.348	.720	-1.41	0.60
AN	< 6	6 to 10	-0.333	0.569	.951	-1.98	1.31
		11 to 15	1.000	0.585	.411	-0.69	2.69
		> 15	0.364	0.470	.896	-0.99	1.72
	6 to 10	< 6	0.333	0.569	.951	-1.31	1.98
		11 to 15	1.333	0.549	.130	-0.25	2.92
		> 15	0.697	0.425	.449	-0.53	1.92
	11 to 15	< 6	-1.000	0.585	.411	-2.69	0.69
		6 to 10	-1.333	0.549	.130	-2.92	0.25
		> 15	-0.636	0.445	.568	-1.92	0.65
	> 15	< 6	-0.364	0.470	.896	-1.72	0.99
		6 to 10	-0.697	0.425	.449	-1.92	0.53
		11 to 15	0.636	0.445	.568	-0.65	1.92
GS	< 6	6 to 10	0.683	0.652	.778	-1.20	2.56
		11 to 15	0.571	0.669	.866	-1.36	2.50
		> 15	0.571	0.538	.771	-0.98	2.12
	6 to 10	< 6	-0.683	0.652	.778	-2.56	1.20
		11 to 15	-0.111	0.628	.999	-1.93	1.70
		> 15	-0.111	0.486	.997	-1.52	1.29
	11 to 15	< 6	-0.571	0.669	.866	-2.50	1.36
		6 to 10	0.111	0.628	.999	-1.70	1.93
		> 15	0.000	0.510	1.000	-1.47	1.47
	> 15	< 6	-0.571	0.538	.771	-2.12	0.98
		6 to 10	0.111	0.486	.997	-1.29	1.52
		11 to 15	0.000	0.510	1.000	-1.47	1.47
GED	< 6	6 to 10	0.317	0.400	.889	-0.84	1.47
		11 to 15	-0.196	0.411	.973	-1.38	0.99
		> 15	0.126	0.331	.986	-0.83	1.08
	6 to 10	< 6	-0.317	0.400	.889	-1.47	0.84
		11 to 15	-0.514	0.386	.624	-1.63	0.60
		> 15	-0.192	0.299	.937	-1.05	0.67
	11 to 15	< 6	0.196	0.411	.973	-0.99	1.38
		6 to 10	0.514	0.386	.624	-0.60	1.63
		> 15	0.322	0.313	.787	-0.58	1.23
	> 15	< 6	-0.126	0.331	.986	-1.08	0.83
		6 to 10	0.192	0.299	.937	-0.67	1.05
		11 to 15	-0.322	0.313	.787	-1.23	0.58
TT	< 6	6 to 10	0.159	0.597	.995	-1.57	1.88
		11 to 15	0.339	0.614	.959	-1.43	2.11

Search Engine	Years Overall (I)	Years Overall (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
		> 15	-0.316	0.493	.938	-1.74	1.11
	6 to 10	< 6	-0.159	0.597	.995	-1.88	1.57
		11 to 15	0.181	0.576	.992	-1.48	1.84
		> 15	-0.475	0.446	.769	-1.76	0.81
	11 to 15	< 6	-0.339	0.614	.959	-2.11	1.43
		6 to 10	-0.181	0.576	.992	-1.84	1.48
		> 15	-0.655	0.467	.583	-2.00	0.69
	> 15	< 6	0.316	0.493	.938	-1.11	1.74
		6 to 10	0.475	0.446	.769	-0.81	1.76
		11 to 15	0.655	0.467	.583	-0.69	2.00

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S18. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Library Use

Search Engine	Library Use	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Yes	49	1.92	0.932	0.133	1.65	2.19
	No	6	2.17	0.408	0.167	1.74	2.60
	DNK/NA	4	2.75	0.500	0.250	1.95	3.55
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	Yes	47	0.72	1.192	0.174	0.37	1.07
	No	6	0.50	1.225	0.500	-0.79	1.79
	DNK/NA	4	0.75	0.957	0.479	-0.77	2.27
	Total	57	0.70	1.164	0.154	0.39	1.01
GS	Yes	47	1.02	1.310	0.191	0.64	1.41
	No	6	1.50	1.225	0.500	0.21	2.79
	DNK/NA	4	0.75	0.957	0.479	-0.77	2.27
	Total	57	1.05	1.274	0.169	0.71	1.39
GED	Yes	47	0.36	0.819	0.119	0.12	0.60
	No	6	0.33	0.816	0.333	-0.52	1.19
	DNK/NA	4	0.00	0.000	0.000	0.00	0.00
	Total	57	0.33	0.787	0.104	0.12	0.54
TT	Yes	47	0.91	1.213	0.177	0.56	1.27
	No	6	0.67	1.211	0.494	-0.60	1.94
	DNK/NA	4	0.00	0.000	0.000	0.00	0.00
	Total	57	0.82	1.182	0.157	0.51	1.14

Table S18 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S19. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Library Use

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	2.743	2	1.372	1.776	.179
	Within Groups	43.257	56	0.772		
	Total	46.000	58			
AN	Between Groups	0.276	2	0.138	0.098	.906
	Within Groups	75.654	54	1.401		
	Total	75.930	56			
GS	Between Groups	1.613	2	0.807	0.488	.616
	Within Groups	89.229	54	1.652		
	Total	90.842	56			
GED	Between Groups	0.482	2	0.241	0.381	.685
	Within Groups	34.184	54	0.633		
	Total	34.667	56			
TT	Between Groups	3.253	2	1.626	1.171	.318
	Within Groups	74.993	54	1.389		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S20. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Library Use

Search Engine	Library Use (I)	Library Use (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	Yes	No	-0.248	0.380	.809	-1.08	0.58
		DNK/NA	-0.832	0.457	.200	-1.83	0.17
	No	Yes	0.248	0.380	.809	-0.58	1.08
		DNK/NA	-0.583	0.567	.592	-1.83	0.66
	DNK/NA	Yes	0.832	0.457	.200	-0.17	1.83
		No	0.583	0.567	.592	-0.66	1.83
AN	Yes	No	0.223	0.513	.910	-0.90	1.35
		DNK/NA	-0.027	0.616	.999	-1.38	1.33
	No	Yes	-0.223	0.513	.910	-1.35	0.90

Search Engine	Library Use (I)	Library Use (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
		DNK/NA	-0.250	0.764	.948	-1.93	1.43
	DNK/NA	Yes	0.027	0.616	.999	-1.33	1.38
		No	0.250	0.764	.948	-1.43	1.93
GS	Yes	No	-0.479	0.557	.693	-1.70	0.74
		DNK/NA	0.271	0.670	.921	-1.20	1.74
	No	Yes	0.479	0.557	.693	-0.74	1.70
		DNK/NA	0.750	0.830	.667	-1.07	2.57
	DNK/NA	Yes	-0.271	0.670	.921	-1.74	1.20
		No	-0.750	0.830	.667	-2.57	1.07
GED	Yes	No	0.028	0.345	.997	-0.73	0.78
		DNK/NA	0.362	0.414	.685	-0.55	1.27
	No	Yes	-0.028	0.345	.997	-0.78	0.73
		DNK/NA	0.333	0.514	.811	-0.79	1.46
	DNK/NA	Yes	-0.362	0.414	.685	-1.27	0.55
		No	-0.333	0.514	.811	-1.46	0.79
TT	Yes	No	0.248	0.511	.889	-0.87	1.37
		DNK/NA	0.915	0.614	.337	-0.43	2.26
	No	Yes	-0.248	0.511	.889	-1.37	0.87
		DNK/NA	0.667	0.761	.683	-1.00	2.33
	DNK/NA	Yes	-0.915	0.614	.337	-2.26	0.43
		No	-0.667	0.761	.683	-2.33	1.00

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S21. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Online/Card Catalog Use

Search Engine	Online/ Card Catalog Use	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Yes	33	2.06	0.704	0.123	1.81	2.31
	No	23	1.83	1.114	0.232	1.34	2.31
	DNK/NA	3	2.67	0.577	0.333	1.23	4.10
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	Yes	31	0.58	1.025	0.184	0.20	0.96
	No	23	0.96	1.364	0.285	0.37	1.55
	DNK/NA	3	0.00	0.000	0.000	0.00	0.00
	Total	57	0.70	1.164	0.154	0.39	1.01
GS	Yes	31	1.23	1.283	0.231	0.76	1.70
	No	23	0.87	1.290	0.269	0.31	1.43

Search Engine	Online/ Card Catalog Use	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
	DNK/NA	3	0.67	1.155	0.667	-2.20	3.54
	Total	57	1.05	1.274	0.169	0.71	1.39
GED	Yes	31	0.45	0.925	0.166	0.11	0.79
	No	23	0.13	0.458	0.095	-.007	0.33
	DNK/NA	3	0.67	1.155	0.667	-2.20	3.54
	Total	57	0.33	0.787	0.104	0.12	0.54
TT	Yes	31	0.90	1.165	0.209	0.48	1.33
	No	23	0.78	1.278	0.266	0.23	1.34
	DNK/NA	3	0.33	0.577	0.333	-1.10	1.77
	Total	57	0.82	1.182	0.157	0.51	1.14

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S22. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Online/Card Catalog Use

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	2.150	2	1.075	1.373	.262
	Within Groups	43.850	56	0.783		
	Total	46.000	58			
AN	Between Groups	3.425	2	1.712	1.275	.288
	Within Groups	72.505	54	1.343		
	Total	75.930	56			
GS	Between Groups	2.147	2	1.074	0.654	.524
	Within Groups	88.695	54	1.642		
	Total	90.842	56			
GED	Between Groups	1.714	2	0.857	1.404	.254
	Within Groups	32.953	54	0.610		
	Total	34.667	56			
TT	Between Groups	0.956	2	0.478	0.334	.717
	Within Groups	77.289	54	1.431		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S23. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Online/Card Catalog Use

Search Engine	Online/Card Catalog Use (I)	Online/ Card Catalog Use (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
SD	Yes	No	0.235	0.240	.624	-0.29	0.76
		DNK/NA	-0.606	0.534	.529	-1.78	0.56
	No	Yes	-0.235	0.240	.624	-0.76	0.29
		DNK/NA	-0.841	0.543	.310	-2.03	0.35
	DNK/NA	Yes	0.606	0.534	.529	-0.56	1.78
		No	0.841	0.543	.310	-0.35	2.03
AN	Yes	No	-0.376	0.319	.504	-1.08	0.32
		DNK/NA	0.581	0.701	.711	-0.96	2.12
	No	Yes	0.376	0.319	.504	-0.32	1.08
		DNK/NA	0.957	0.711	.411	-0.60	2.52
	DNK/NA	Yes	-0.581	0.701	.711	-2.12	0.96
		No	-0.957	0.711	.411	-2.52	0.60
GS	Yes	No	0.356	0.353	.603	-0.42	1.13
		DNK/NA	0.559	0.775	.772	-1.14	2.26
	No	Yes	-0.356	0.353	.603	-1.13	0.42
		DNK/NA	0.203	0.787	.967	-1.52	1.93
	DNK/NA	Yes	-0.559	0.775	.772	-2.26	1.14
		No	-0.203	0.787	.967	-1.93	1.52
GED	Yes	No	0.321	0.215	.335	-0.15	0.79
		DNK/NA	-0.215	0.472	.902	-1.25	0.82
	No	Yes	-0.321	0.215	.335	-0.79	0.15
		DNK/NA	-0.536	0.480	.539	-1.59	0.52
	DNK/NA	Yes	0.215	0.472	.902	-0.82	1.25
		No	0.536	0.480	.539	-0.52	1.59
TT	Yes	No	0.121	0.329	.935	-0.60	0.84
		DNK/NA	0.570	0.723	.734	-1.02	2.16
	No	Yes	-0.121	0.329	.935	-0.84	0.60
		DNK/NA	0.449	0.734	.830	-1.16	2.06
	DNK/NA	Yes	-0.570	0.723	.734	-2.16	1.02
		No	-0.449	0.734	.830	-2.06	1.16

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S24. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Online Database Use

Search Engine	Online Database Use	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Yes	11	2.18	0.751	0.226	1.68	2.69
	No	44	1.89	0.920	0.139	1.61	2.17
	DNK/NA[a]	4	2.75	0.500	0.250	1.95	3.55
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	Yes	10	0.90	1.197	0.379	0.04	1.76
	No	43	0.72	1.202	0.183	0.35	1.09
	DNK/NA	4	0.00	0.000	0.000	0.00	0.00
	Total	57	0.70	1.164	0.154	0.39	1.01
GS	Yes	10	1.50	1.434	0.453	0.47	2.53
	No	43	0.98	1.225	0.187	0.60	1.35
	DNK/NA	4	0.75	1.500	0.750	-1.64	3.14
	Total	57	1.05	1.274	0.169	0.71	1.39
GED	Yes	10	0.70	1.252	0.396	-0.20	1.60
	No	43	0.28	0.666	0.102	0.07	0.48
	DNK/NA	4	0.00	0.000	0.000	0.00	0.00
	Total	57	0.33	0.787	0.104	0.12	0.54
TT	Yes	10	0.80	1.135	0.359	-0.01	1.61
	No	43	0.91	1.231	0.188	0.53	1.29
	DNK/NA	4	0.00	0.000	0.000	0.00	0.00
	Total	57	0.82	1.182	0.157	0.51	1.14

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S25. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Online Database Use

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	3.182	2	1.591	2.081	.134
	Within Groups	42.818	56	0.765		
	Total	46.000	58			
AN	Between Groups	2.379	2	1.189	0.873	.423
	Within Groups	73.551	54	1.362		
	Total	75.930	56			
GS	Between Groups	2.615	2	1.308	0.800	.454
	Within Groups	88.227	54	1.634		
	Total	90.842	56			
GED	Between Groups	1.916	2	0.958	1.579	.216

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
	Within Groups	32.751	54	0.607		
	Total	34.667	56			
TT	Between Groups	3.018	2	1.509	1.083	.346
	Within Groups	75.228	54	1.393		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S26. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Online Database Use

Search Engine	Database Use (I)	Database Use (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	Yes	No	0.295	0.295	.608	-0.35	0.94
		DNK/NA	-0.568	0.511	.542	-1.69	0.55
	No	Yes	-0.295	0.295	.608	-0.94	0.35
		DNK/NA	-0.864	0.457	.177	-1.86	0.14
	DNK/NA	Yes	0.568	0.511	.542	-0.55	1.69
		No	0.864	0.457	.177	-0.14	1.86
AN	Yes	No	0.179	0.410	.909	-0.72	1.08
		DNK/NA	0.900	0.690	.433	-0.61	2.41
	No	Yes	-0.179	0.410	.909	-1.08	0.72
		DNK/NA	0.721	0.610	.502	-0.62	2.06
	DNK/NA	Yes	-0.900	0.690	.433	-2.41	0.61
		No	-0.721	0.610	.502	-2.06	0.62
GS	Yes	No	0.523	0.449	.511	-0.46	1.51
		DNK/NA	0.750	0.756	.614	-0.91	2.41
	No	Yes	-0.523	0.449	.511	-1.51	0.46
		DNK/NA	0.227	0.668	.944	-1.24	1.69
	DNK/NA	Yes	-0.750	0.756	.614	-2.41	0.91
		No	-0.227	0.668	.944	-1.69	1.24
GED	Yes	No	0.421	0.273	.314	-0.18	1.02
		DNK/NA	0.700	0.461	.323	-0.31	1.71
	No	Yes	-0.421	0.273	.314	-1.02	0.18
		DNK/NA	0.279	0.407	.791	-0.61	1.17
	DNK/NA	Yes	-0.700	0.461	.323	-1.71	0.31
		No	-0.279	0.407	.791	-1.17	0.61
TT	Yes	No	-0.107	0.414	.967	-1.02	0.80
		DNK/NA	0.800	0.698	.523	-0.73	2.33
	No	Yes	0.107	0.414	.967	-0.80	1.02
		DNK/NA	0.907	0.617	.347	-0.45	2.26

Search Engine	Database Use (I)	Database Use (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
	DNK/NA	Yes	-0.800	0.698	.523	-2.33	0.73
		No	-0.907	0.617	.347	-2.26	0.45

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet; DNK/NA = Do Not Know/Not Applicable.

Table S27. Descriptive Statistics for the Search Engines' Overall Relevance Ranking Grouped by Form of Search Performed

Search Engine	Form of Search[a]	*N*	Mean	*SD*	Std. Error	95% Confidence Interval for Mean Lower	Upper
SD	Known Item	3	2.67	0.577	0.333	1.23	4.10
	Specific Info.	18	2.17	0.514	0.121	1.91	2.42
	General Info.	31	1.81	1.078	0.194	1.41	2.20
	Explore	7	2.14	0.690	0.261	1.50	2.78
	Total	59	2.00	0.891	0.116	1.77	2.23
AN	Known Item	3	1.00	1.732	1.000	-3.30	5.30
	Specific Info.	17	0.29	0.849	0.206	-0.14	0.73
	General Info.	31	0.90	1.248	0.224	0.45	1.36
	Explore	6	1.17	1.472	0.601	-0.38	2.71
	Total	57	0.75	1.199	0.159	0.44	1.07
GS	Known Item	3	2.00	1.732	1.000	-2.30	6.30
	Specific Info.	17	1.29	1.359	0.329	0.60	1.99
	General Info.	31	1.00	1.291	0.232	0.53	1.47
	Explore	6	0.67	0.816	0.333	-0.19	1.52
	Total	57	1.11	1.291	0.171	0.76	1.45
GED	Known Item	3	1.00	1.732	1.000	-3.30	5.30
	Specific Info.	17	0.29	0.686	0.166	-0.06	0.65
	General Info.	31	0.39	0.919	0.165	0.05	0.72
	Explore	6	0.33	0.516	0.211	-0.21	0.88
	Total	57	0.39	0.861	0.114	0.16	0.61
TT	Known Item	3	1.00	1.732	1.000	-3.30	5.30
	Specific Info.	17	0.41	0.795	0.193	0.00	0.82
	General Info.	31	0.90	1.248	0.224	0.45	1.36
	Explore	6	1.50	1.378	0.563	0.05	2.95
	Total	57	0.82	1.182	0.157	0.51	1.14

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S27 (continued)

[a]Form of search performed from Meadow, Boyce, and Kraft (2000, p. 273).

Table S28. ANOVA for the Search Engines' Overall Relevance Ranking Grouped by Form of Search Performed

Search Engine		Sum of Squares	*df*	Mean Square	*F*	*p*
SD	Between Groups	3.137	3	1.046	1.342	.270
	Within Groups	42.863	55	0.779		
	Total	46.000	58			
AN	Between Groups	5.489	3	1.830	1.292	.287
	Within Groups	75.072	53	1.416		
	Total	80.561	56			
GS	Between Groups	4.506	3	1.502	0.896	.450
	Within Groups	88.863	53	1.677		
	Total	93.368	56			
GED	Between Groups	1.291	3	0.430	0.567	.639
	Within Groups	40.218	53	0.759		
	Total	41.509	56			
TT	Between Groups	5.918	3	1.973	1.446	.240
	Within Groups	72.327	53	1.365		
	Total	78.246	56			

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

Table S29. Scheffé Post-Hoc Tests of the Search Engines' Overall Relevance Ranking Grouped by Form of Search Performed

Search Engine	Form of Search[a] (I)	Form of Search (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
						Lower	Upper
SD	Known Item	Specific Info.	0.500	0.551	.843	-0.91	1.91
		General Info.	0.860	0.534	.464	-0.51	2.23
		Explore	0.524	0.609	.864	-1.04	2.08
	Specific Info.	Known Item	-0.500	0.551	.843	-1.91	0.91
		General Info.	0.360	0.262	.597	-0.31	1.03
		Explore	0.024	0.393	1.000	-0.98	1.03
	General Info.	Known Item	-0.860	0.534	.464	-2.23	0.51
		Specific Info.	-0.360	0.262	.597	-1.03	0.31
		Explore	-0.336	0.369	.842	-1.28	0.61
	Explore	Known Item	-0.524	0.609	.864	-2.08	1.04
		Specific Info.	-0.024	0.393	1.000	-1.03	0.98
		General Info.	0.336	0.369	.842	-0.61	1.28

Search Engine	Form of Search[a] (I)	Form of Search (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
AN	Known Item	Specific Info.	0.706	0.745	.826	-1.20	2.62
		General Info.	0.097	0.720	.999	-1.75	1.94
		Explore	-0.167	0.842	.998	-2.32	1.99
	Specific Info.	Known Item	-0.706	0.745	.826	-2.62	1.20
		General Info.	-0.609	0.359	.419	-1.53	0.31
		Explore	-0.873	0.565	.502	-2.32	0.58
	General Info.	Known Item	-0.097	0.720	.999	-1.94	1.75
		Specific Info.	0.609	0.359	.419	-0.31	1.53
		Explore	-0.263	0.531	.969	-1.62	1.10
	Explore	Known Item	0.167	0.842	.998	-1.99	2.32
		Specific Info.	0.873	0.565	.502	-0.58	2.32
		General Info.	0.263	0.531	.969	-1.10	1.62
GS	Known Item	Specific Info.	0.706	0.811	.859	-1.37	2.78
		General Info.	1.000	0.783	.654	-1.01	3.01
		Explore	1.333	0.916	.552	-1.01	3.68
	Specific Info.	Known Item	-0.706	0.811	.859	-2.78	1.37
		General Info.	0.294	0.391	.904	-0.71	1.30
		Explore	0.627	0.615	.791	-0.95	2.20
	General Info.	Known Item	-1.000	0.783	.654	-3.01	1.01
		Specific Info.	-0.294	0.391	.904	-1.30	0.71
		Explore	0.333	0.578	.953	-1.15	1.81
	Explore	Known Item	-1.333	0.916	.552	-3.68	1.01
		Specific Info.	-0.627	0.615	.791	-2.20	0.95
		General Info.	-0.333	0.578	.953	-1.81	1.15
GED	Known Item	Specific Info.	0.706	0.546	.645	-0.69	2.10
		General Info.	0.613	0.527	.717	-0.74	1.96
		Explore	0.667	0.616	.760	-0.91	2.25
	Specific Info.	Known Item	-0.706	0.546	.645	-2.10	0.69
		General Info.	-0.093	0.263	.989	-0.77	0.58
		Explore	-0.039	0.414	1.000	-1.10	1.02
	General Info.	Known Item	-0.613	0.527	.717	-1.96	0.74
		Specific Info.	0.093	0.263	.989	-0.58	0.77
		Explore	0.054	0.389	.999	-0.94	1.05
	Explore	Known Item	-0.667	0.616	.760	-2.25	0.91
		Specific Info.	0.039	0.414	1.000	-1.02	1.10
		General Info.	-0.054	0.389	.999	-1.05	0.94
TT	Known Item	Specific Info.	0.588	0.732	.885	-1.29	2.46
		General Info.	0.097	0.706	.999	-1.71	1.91
		Explore	-0.500	0.826	.947	-2.62	1.62
	Specific Info.	Known Item	-0.588	0.732	.885	-2.46	1.29
		General Info.	-0.491	0.353	.588	-1.40	0.41

Search Engine	Form of Search[a] (I)	Form of Search (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval Lower	Upper
	General Info.	Explore	-1.088	0.555	.290	-2.51	0.33
		Known Item	-0.097	0.706	.999	-1.91	1.71
		Specific Info.	0.491	0.353	.588	-0.41	1.40
	Explore	Explore	-0.597	0.521	.727	-1.93	0.74
		Known Item	0.500	0.826	.947	-1.62	2.62
		Specific Info.	1.088	0.555	.290	-0.33	2.51
		General Info.	0.597	0.521	.727	-0.74	1.93

Note. SD = Standards Directory; AN = ANSI NSSN; GS = GlobalSpec; GED = Global Engineering Documents; TT = Thomson's Techstreet.

[a]Form of search performed from Meadow, Boyce, and Kraft (2000, p. 273).

Appendix T

ANOVA and Multiple Comparisons of the Mean for the Standards Directory

Table T1. ANOVA Examining the Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Years for Company	*N*	Mean	*SD*
0 to 5	24	1.83	0.816
6 to 10	12	2.50	0.905
11 to 15	10	2.10	0.876
16 to 20	8	2.25	0.463
21 to 25	3	0.67	1.155
Total	57	2.02	0.896

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	9.582	4	2.396	3.519	.013
Within Groups	35.400	52	0.681		
Total	44.982	56			

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table T2. Scheffé Post-Hoc Tests Examining the Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline for the Company

Years for Company (I)	Years for Company (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
0 to 5	6 to 10	-0.667	0.292	.280	-10.60	0.26
	11 to 15	-0.267	0.311	.946	-10.26	0.73
	16 to 20	-0.417	0.337	.820	-10.49	0.66
	21 to 25	1.167	0.505	.270	-00.45	20.78

Years for Company (I)	Years for Company (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
6 to 10	0 to 5	0.667	0.292	.280	-00.26	10.60
	11 to 15	0.400	0.353	.863	-00.73	10.53
	16 to 20	0.250	0.377	.978	-00.95	10.45
	21 to 25	1.833	0.533	.028	0.13	30.53
11 to 15	0 to 5	0.267	0.311	.946	-00.73	10.26
	6 to 10	-0.400	0.353	.863	-10.53	0.73
	16 to 20	-0.150	0.391	.997	-10.40	10.10
	21 to 25	1.433	0.543	.155	-00.30	30.17
16 to 20	0 to 5	0.417	0.337	.820	-00.66	10.49
	6 to 10	-0.250	0.377	.978	-10.45	0.95
	11 to 15	0.150	0.391	.997	-10.10	10.40
	21 to 25	1.583	0.559	.107	-00.20	30.37
21 to 25	0 to 5	-1.167	0.505	.270	-20.78	0.45
	6 to 10	-1.833	0.533	.028	-30.53	-0.13
	11 to 15	-1.433	0.543	.155	-30.17	0.30
	16 to 20	-1.583	0.559	.107	-30.37	0.20

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table T3. ANOVA Examining the Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Years in Discipline	*N*	Mean	*SD*
0 to 5	7	1.57	0.787
6 to 10	9	2.11	0.782
11 to 15	8	2.38	10.061
16 to 20	9	1.67	10.225
21 to 25	10	2.30	0.483
26 to 30	10	2.00	0.816
31 to 35	4	2.25	0.500
Total	57	2.04	.865

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	4.602	6	0.767	1.027	.419
Within Groups	37.328	50	0.747		
Total	41.930	56			

Table T3 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table T4. Scheffé Post-Hoc Tests Examining the Mean of the Standards Directory's Overall Relevance Ranking Grouped by Years Participants Worked in Discipline Overall

Years in Discipline (I)	Years in Discipline (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
0 to 5	6 to 10	-0.540	0.435	.955	-2.15	1.07
	11 to 15	-0.804	0.447	.777	-2.46	0.85
	16 to 20	-0.095	0.435	1.000	-1.71	1.52
	21 to 25	-0.729	0.426	.814	-2.31	0.85
	26 to 30	-0.429	0.426	.984	-2.01	1.15
	31 to 35	-0.679	0.542	.952	-2.68	1.33
6 to 10	0 to 5	0.540	0.435	.955	-1.07	2.15
	11 to 15	-0.264	0.420	.999	-1.82	1.29
	16 to 20	0.444	0.407	.976	-1.06	1.95
	21 to 25	-0.189	0.397	1.000	-1.66	1.28
	26 to 30	0.111	0.397	1.000	-1.36	1.58
	31 to 35	-0.139	0.519	1.000	-2.06	1.78
11 to 15	0 to 5	0.804	0.447	.777	-0.85	2.46
	6 to 10	0.264	0.420	.999	-1.29	1.82
	16 to 20	0.708	0.420	.824	-0.85	2.26
	21 to 25	0.075	0.410	1.000	-1.44	1.59
	26 to 30	0.375	0.410	.990	-1.14	1.89
	31 to 35	0.125	0.529	1.000	-1.83	2.08
16 to 20	0 to 5	0.095	0.435	1.000	-1.52	1.71
	6 to 10	-0.444	0.407	.976	-1.95	1.06
	11 to 15	-0.708	0.420	.824	-2.26	0.85
	21 to 25	-0.633	0.397	.859	-2.10	0.84
	26 to 30	-0.333	0.397	.994	-1.80	1.14
	31 to 35	-0.583	0.519	.972	-2.51	1.34
21 to 25	0 to 5	0.729	0.426	.814	-0.85	2.31
	6 to 10	0.189	0.397	1.000	-1.28	1.66
	11 to 15	-0.075	0.410	1.000	-1.59	1.44
	16 to 20	0.633	0.397	.859	-0.84	2.10
	26 to 30	0.300	0.386	.996	-1.13	1.73
	31 to 35	0.050	0.511	1.000	-1.84	1.94
26 to 30	0 to 5	0.429	0.426	.984	-1.15	2.01

Years in Discipline (I)	Years in Discipline (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
	6 to 10	-0.111	0.397	1.000	-1.58	1.36
	11 to 15	-0.375	0.410	.990	-1.89	1.14
	16 to 20	0.333	0.397	.994	-1.14	1.80
	21 to 25	-0.300	0.386	.996	-1.73	1.13
	31 to 35	-0.250	0.511	1.000	-2.14	1.64
31 to 35	0 to 5	0.679	0.542	.952	-1.33	2.68
	6 to 10	0.139	0.519	1.000	-1.78	2.06
	11 to 15	-0.125	0.529	1.000	-2.08	1.83
	16 to 20	0.583	0.519	.972	-1.34	2.51
	21 to 25	-0.050	0.511	1.000	-1.94	1.84
	26 to 30	0.250	0.511	1.000	-1.64	2.14

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0.

Table T5. ANOVA Examining the Extent to Which Work was Considered Standards-Based Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	4.667	2.160
Marginally Relevant	5	2.800	1.304
Fairly Relevant	31	5.290	1.321
Highly Relevant	17	4.882	1.409
Total	59	4.898	1.561

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	27.10	3	9.03	4.35	.008
Within Groups	114.29	55	2.08		
Total	141.39	58			

Note. Scale from 1: very limited to 7: highly.

Table T6. Scheffé Post-Hoc Tests of the Extent to Which Work was Considered Standards-Based Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	1.87	0.87	.22	-0.65	4.38
	Fairly	-0.62	0.64	.82	-2.48	1.23
	Highly	-0.22	0.68	.99	-2.19	1.76
Marginally	Irrelevant	-1.87	0.87	.22	-4.38	0.65
	Fairly	-2.49	0.69	.01	-4.49	-0.49
	Highly	-2.08	0.73	.06	-4.20	0.03
Fairly	Irrelevant	0.62	0.64	.82	-1.23	2.48
	Marginally	2.49	0.69	.01	0.49	4.49
	Highly	0.41	0.44	.83	-0.85	1.66
Highly	Irrelevant	0.22	0.68	.99	-1.76	2.19
	Marginally	2.08	0.73	.06	-0.03	4.20
	Fairly	-0.41	0.44	.83	-1.66	0.85

Note. Scale from 1: very limited to 7: highly.

Table T7. ANOVA Examining the Helpfulness of the Standards Directory Grouped by Participants' Primary Occupation

Primary Occupation	*N*	Mean	*SD*
Engineer (Applied)	23	4.39	1.62
Engineer (Management)	16	5.63	1.45
Other Technical Disc./Profession	19	5.47	1.31
Total	59	5.03	1.60

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	18.60	2	9.30	4.26	.0190
Within Groups	119.97	55	2.18		
Total	138.57	57			

Note. Scale from 1: hindrance to 7: helpful.

Table T8. Scheffé Post-Hoc Tests of the Helpfulness of the Standards Directory Grouped by Participants' Primary Occupation

Primary Occupation (I)	Primary Occupation (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Engineer (Applied)	Engineer (Management)	-1.23	0.48	.04	-2.44	-0.02
	Other Technical Discipline/ Profession	-1.08	0.46	.07	-2.23	0.07
Engineer (Management)	Engineer (Applied)	1.23	0.48	.04	0.02	2.44
	Other Tech. Discipline/ Profession	0.15	0.50	.96	-1.11	1.41
Other Technical Discipline/ Profession	Engineer (Applied)	1.08	0.46	.07	-0.07	2.23
	Engineer (Management)	-0.15	0.50	.96	-1.41	1.11

Note. Scale from 1: hindrance to 7: helpful.

Table T9. ANOVA Examining the Intuitiveness of the Standards Directory's Interface Grouped by Participants' Primary Occupation

Primary Occupation	*N*	Mean	*SD*
Engineer (Applied)	23	4.61	1.34
Engineer (Management)	16	5.63	1.09
Other Technical Disc./Profession	19	5.05	1.08
Total	59	5.00	1.26

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	9.76	2	4.88	3.43	.0394
Within Groups	78.18	55	1.42		
Total	87.93	57			

Note. Scale from 1: awkward to 7: intuitive.

Table T10. Scheffé Post-Hoc Tests of the Intuitiveness of the Standards Directory's Interface Grouped by Participants' Primary Occupation

Primary Occupation (I)	Primary Occupation (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Engineer (Applied)	Engineer (Management)	-1.02	0.39	.04	-1.99	-0.04
	Other Technical Discipline/ Profession	-0.44	0.37	.49	-1.37	0.49
Engineer (Management)	Engineer (Applied)	1.02	0.39	.04	0.04	1.99
	Other Tech. Discipline/ Profession	0.57	0.40	.37	-0.45	1.59
Other Technical Discipline/ Profession	Engineer (Applied)	0.44	0.37	.49	-0.49	1.37
	Engineer (Management)	-0.57	0.40	.37	-1.59	0.45

Note. Scale from 1: awkward to 7: intuitive.

Table T11. Independent *t*-Tests Comparing the Means of the Standards Directory's Overall Relevance Ranking Grouped by Whether Participants Limited Their Search to a Discipline Before or After They Performed Their Search

Limited Search	*N*	Mean[a]	*SD*	Std. Error Mean
Before	24	2.04	0.690	0.141
After	24	1.79	1.215	0.248

EVA	Levene's Test for Equality of Variances.		*t*-Test for Equality of Means						
			t	*df*	*p*[a]	MD	SED	95% Confidence Interval of the Difference	
	F	Sig.						Lower	Upper
Yes	13.853	.001	0.876	46	.385	0.250	0.285	-0.324	0.824
No			0.876	36.444	0.387	0.250	0.285	-0.328	0.828

Table T11 (continued)

Note. Values used for overall relevance ranking were highly relevant: 3, fairly relevant: 2, marginally relevant: 1, and irrelevant: 0. EVA = equal variances assumed; MD = mean difference; SED = standard error difference.

[a]2-tailed.

Table T12. ANOVA Examining the Effectiveness as it Related to the Form of Search Performed Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.857	2.340
Marginally Relevant	5	3.800	1.643
Fairly Relevant	30	4.933	1.484
Highly Relevant	17	5.882	1.219
Total	59	4.864	1.776

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	51.63	3	17.21	7.21	.0004
Within Groups	131.29	55	2.39		
Total	182.92	58			

Note. Scale from 1: ineffective to 7: effective.

Table T13. Scheffé Post-Hoc Tests of the Effectiveness as it Related to the Form of Search Performed Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-0.94	0.90	0.78	-3.55	1.67
	Fairly	-2.08	0.65	0.02	-3.95	-0.21
	Highly	-3.03	0.69	0.00	-5.03	-1.02
Marginally	Irrelevant	0.94	0.90	0.78	-1.67	3.55
	Fairly	-1.13	0.75	0.52	-3.29	1.02
	Highly	-2.08	0.79	0.08	-4.35	0.18
Fairly	Irrelevant	2.08	0.65	0.02	0.21	3.95
	Marginally	1.13	0.75	0.52	-1.02	3.29
	Highly	-0.95	0.47	0.26	-2.30	0.40
Highly	Irrelevant	3.03	0.69	0.00	1.02	5.03

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
	Marginally	2.08	0.79	0.08	-0.18	4.35
	Fairly	0.95	0.47	0.26	-0.40	2.30

Note. Scale from 1: ineffective to 7: effective.

Table T14. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.000	1.155
Marginally Relevant	4	4.750	0.957
Fairly Relevant	30	4.833	1.206
Highly Relevant	16	5.563	0.964
Total	57	4.684	1.525

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	63.46	3	21.15	16.77	.0000
Within Groups	66.85	53	1.26		
Total	130.32	56			

Note. Scale from 1: rigid to 7: flexible.

Table T15. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-2.75	0.70	.00	-4.78	-0.72
	Fairly	-2.83	0.47	.00	-4.19	-1.47
	Highly	-3.56	0.51	.00	-5.03	-2.09
Marginally	Irrelevant	2.75	0.70	.00	0.72	4.78
	Fairly	-0.08	0.60	1.00	-1.81	1.64
	Highly	-0.81	0.63	.64	-2.63	1.00
Fairly	Irrelevant	2.83	0.47	.00	1.47	4.19
	Marginally	0.08	0.60	1.00	-1.64	1.81
	Highly	-0.73	0.35	.23	-1.73	0.27
Highly	Irrelevant	3.56	0.51	.00	2.09	5.03
	Marginally	0.81	0.63	.64	-1.00	2.63

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
	Fairly	0.73	0.35	.23	-0.27	1.73

Note. Scale from 1: rigid to 7: flexible.

Table T16. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	4.571	1.618
Marginally Relevant	4	5.000	2.000
Fairly Relevant	30	4.833	1.416
Highly Relevant	17	5.588	1.502
Total	58	4.810	1.627

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	10.14	3	3.38	2.47	.0718
Within Groups	75.42	55	1.37		
Total	85.56	58			

Note. Scale from 1: difficult to 7: easy.

Table T17. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	0.37	0.69	.96	-1.61	2.35
	Fairly	-0.76	0.49	.50	-2.18	0.66
	Highly	-0.96	0.53	.35	-2.47	0.56
Marginally	Irrelevant	-0.37	0.69	.96	-2.35	1.61
	Fairly	-1.13	0.57	.27	-2.76	0.50
	Highly	-1.33	0.60	.19	-3.05	0.39
Fairly	Irrelevant	0.76	0.49	.50	-0.66	2.18
	Marginally	1.13	0.57	.27	-0.50	2.76
	Highly	-0.20	0.36	.96	-1.22	0.83
Highly	Irrelevant	0.96	0.53	.35	-0.56	2.47
	Marginally	1.33	0.60	.19	-0.39	3.05
	Fairly	0.20	0.36	.96	-0.83	1.22

Table T17 (continued)

Note. Scale from 1: difficult to 7: easy.

Table T18. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.714	0.756
Marginally Relevant	4	5.000	2.000
Fairly Relevant	30	4.833	1.416
Highly Relevant	17	5.588	1.502
Total	58	4.810	1.627

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	41.20	3	13.73	6.76	.0006
Within Groups	109.71	54	2.03		
Total	150.91	57			

Note. Scale from 1: frustrating to 7: satisfying.

Table T19. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-2.29	0.89	.10	-4.86	0.29
	Fairly	-2.12	0.60	.01	-3.85	-0.39
	Highly	-2.87	0.64	.00	-4.72	-1.03
Marginally	Irrelevant	2.29	0.89	.10	-0.29	4.86
	Fairly	0.17	0.76	1.00	-2.02	2.36
	Highly	-0.59	0.79	.91	-2.87	1.70
Fairly	Irrelevant	2.12	0.60	.01	0.39	3.85
	Marginally	-0.17	0.76	1.00	-2.36	2.02
	Highly	-0.75	0.43	.39	-2.00	0.49
Highly	Irrelevant	2.87	0.64	.00	1.03	4.72
	Marginally	0.59	0.79	.91	-1.70	2.87
	Fairly	0.75	0.43	.39	-0.49	2.00

Note. Scale from 1: frustrating to 7: satisfying.

Table T20. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean[a]	*SD*
Irrelevant	7	4.714	1.254
Marginally Relevant	5	5.000	1.414
Fairly Relevant	29	4.897	1.047
Highly Relevant	16	5.313	1.250
Total	57	5.000	1.150

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	2.44	3	0.81	0.60	.6156
Within Groups	71.56	53	1.35		
Total	74.00	56			

[a]Scale from 1: awkward to 7: intuitive.

Table T21. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-0.29	0.68	.98	-2.25	1.68
	Fairly	-0.18	0.49	.99	-1.60	1.23
	Highly	-0.60	0.53	.73	-2.12	0.92
Marginally	Irrelevant	0.29	0.68	.98	-1.68	2.25
	Fairly	0.10	0.56	1.00	-1.52	1.73
	Highly	-0.31	0.60	.96	-2.03	1.41
Fairly	Irrelevant	0.18	0.49	.99	-1.23	1.60
	Marginally	-0.10	0.56	1.00	-1.73	1.52
	Highly	-0.42	0.36	.73	-1.46	0.63
Highly	Irrelevant	0.60	0.53	.73	-0.92	2.12
	Marginally	0.31	0.60	.96	-1.41	2.03
	Fairly	0.42	0.36	.73	-0.63	1.46

Note. Scale from 1: awkward to 7: intuitive.

Table T22. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.429	1.134
Marginally Relevant	5	4.400	1.817

Overall Relevance	*N*	Mean	*SD*
Fairly Relevant	30	5.133	1.358
Highly Relevant	16	5.938	0.680
Total	58	4.966	1.589

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	62.61	3	20.87	13.86	.0000
Within Groups	81.32	54	1.51		
Total	143.93	57			

Note. Scale from 1: inadequate to 7: adequate.

Table T23. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.97	0.72	.07	-4.04	0.10
	Fairly	-2.70	0.52	.00	-4.19	-1.22
	Highly	-3.51	0.56	.00	-5.11	-1.90
Marginally	Irrelevant	1.97	0.72	.07	-0.10	4.04
	Fairly	-0.73	0.59	.68	-2.44	0.98
	Highly	-1.54	0.63	.13	-3.35	0.28
Fairly	Irrelevant	2.70	0.52	.00	1.22	4.19
	Marginally	0.73	0.59	.68	-0.98	2.44
	Highly	-0.80	0.38	.23	-1.90	0.29
Highly	Irrelevant	3.51	0.56	.00	1.90	5.11
	Marginally	1.54	0.63	.13	-0.28	3.35
	Fairly	0.80	0.38	.23	-0.29	1.90

Note. Scale from 1: inadequate to 7: adequate.

Table T24. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	2.500	1.761
Marginally Relevant	5	4.800	1.643
Fairly Relevant	28	5.536	1.138
Highly Relevant	16	6.063	0.443
Total	55	5.291	1.511

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	59.14	3	19.71	15.66	.0000
Within Groups	64.20	51	1.26		
Total	123.35	54			

Note. Scale from 1: useless to 7: helpful.

Table T25. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference[a] (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-2.30	0.68	.02	-4.26	-0.34
	Fairly	-3.04	0.50	.00	-4.50	-1.58
	Highly	-3.56	0.54	.00	-5.12	-2.01
Marginally	Irrelevant	2.30	0.68	.02	0.34	4.26
	Fairly	-0.74	0.54	.61	-2.31	0.84
	Highly	-1.26	0.57	.20	-2.92	0.40
Fairly	Irrelevant	3.04	0.50	.00	1.58	4.50
	Marginally	0.74	0.54	.61	-0.84	2.31
	Highly	-0.53	0.35	.53	-1.54	0.49
Highly	Irrelevant	3.56	0.54	.00	2.01	5.12
	Marginally	1.26	0.57	.20	-0.40	2.92
	Fairly	0.53	0.35	.53	-0.49	1.54

Note. Scale from 1: useless to 7: helpful.

Table T26. ANOVA Examining the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.143	1.215
Marginally Relevant	5	4.200	1.095
Fairly Relevant	28	4.893	1.166
Highly Relevant	16	5.500	0.730
Total	56	4.786	1.261

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	29.09	3	9.70	8.64	.0001
Within Groups	58.34	52	1.12		

	Sum of Squares	*df*	Mean Square	*F*	*p*
Total	87.43	55			

Note. Scale from 1: terrible to 7: wonderful.

Table T27. Scheffé Post-Hoc Tests of the Overall Reaction to the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.06	0.62	.41	-2.85	0.73
	Fairly	-1.75	0.45	.00	-3.04	-0.46
	Highly	-2.36	0.48	.00	-3.74	-0.97
Marginally	Irrelevant	1.06	0.62	.41	-0.73	2.85
	Fairly	-0.69	0.51	.61	-2.18	0.79
	Highly	-1.30	0.54	.14	-2.87	0.27
Fairly	Irrelevant	1.75	0.45	.00	0.46	3.04
	Marginally	0.69	0.51	.61	-0.79	2.18
	Highly	-0.61	0.33	.35	-1.57	0.35
Highly	Irrelevant	2.36	0.48	.00	0.97	3.74
	Marginally	1.30	0.54	.14	-0.27	2.87
	Fairly	0.61	0.33	.35	-0.35	1.57

Note. Scale from 1: terrible to 7: wonderful.

Table T28. ANOVA Examining the Helpfulness of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.714	1.976
Marginally Relevant	4	4.500	1.915
Fairly Relevant	31	5.065	1.124
Highly Relevant	17	6.059	1.088
Total	59	5.034	1.597

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	56.69	3	18.90	11.39	.0000
Within Groups	91.24	55	1.66		
Total	147.93	58			

Note. Scale from 1: hindrance to 7: helpful.

Table T29. Scheffé Post-Hoc Tests of the Helpfulness of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.79	0.81	.19	-4.11	0.54
	Fairly	-2.35	0.54	.00	-3.90	-0.80
	Highly	-3.34	0.58	.00	-5.01	-1.68
Marginally	Irrelevant	1.79	0.81	.19	-0.54	4.11
	Fairly	-0.56	0.68	.88	-2.54	1.41
	Highly	-1.56	0.72	.20	-3.62	0.51
Fairly	Irrelevant	2.35	0.54	.00	0.80	3.90
	Marginally	0.56	0.68	.88	-1.41	2.54
	Highly	-0.99	0.39	.10	-2.12	0.13
Highly	Irrelevant	3.34	0.58	.00	1.68	5.01
	Marginally	1.56	0.72	.20	-0.51	3.62
	Fairly	0.99	0.39	.10	-0.13	2.12

Note. Scale from 1: hindrance to 7: helpful.

Table T30. ANOVA Examining the Intuitiveness of the Standards Directory's Interface Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	4.714	1.604
Marginally Relevant	5	4.400	1.817
Fairly Relevant	31	5.032	1.016
Highly Relevant	16	5.250	1.390
Total	59	5.000	1.259

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	3.40	3	1.13	0.70	.5535
Within Groups	88.60	55	1.61		
Total	92.00	58			

Note. Scale from 1: awkward to 7: intuitive.

Table T31. Scheffé Post-Hoc Tests of the Intuitiveness of the Standards Directory's Interface Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	0.31	0.74	.98	-1.83	2.46
	Fairly	-0.32	0.53	.95	-1.85	1.21
	Highly	-0.54	0.58	.83	-2.19	1.12
Marginally	Irrelevant	-0.31	0.74	.98	-2.46	1.83
	Fairly	-0.63	0.61	.78	-2.40	1.13
	Highly	-0.85	0.65	.64	-2.73	1.03
Fairly	Irrelevant	0.32	0.53	.95	-1.21	1.85
	Marginally	0.63	0.61	.78	-1.13	2.40
	Highly	-0.22	0.39	.96	-1.34	0.91
Highly	Irrelevant	0.54	0.58	.83	-1.12	2.19
	Marginally	0.85	0.65	.64	-1.03	2.73
	Fairly	0.22	0.39	.96	-0.91	1.34

Note. Scale from 1: awkward to 7: intuitive.

Table T32. ANOVA Examining the Helpfulness of the Standards Directory's Overall Functionality Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.286	1.380
Marginally Relevant	4	3.250	0.500
Fairly Relevant	31	5.452	0.723
Highly Relevant	17	6.118	0.697
Total	59	5.119	1.475

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	90.55	3	30.18	46.60	.0000
Within Groups	35.62	55	0.65		
Total	126.17	58			

Note. Scale from 1: less helpful to 7: more helpful.

Table T33. Scheffé Post-Hoc Tests of the Helpfulness of the Standards Directory's Overall Functionality Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-0.96	0.50	.31	-2.42	0.49
	Fairly	-3.17	0.34	.00	-4.14	-2.19
	Highly	-3.83	0.36	.00	-4.87	-2.79
Marginally	Irrelevant	0.96	0.50	.31	-0.49	2.42
	Fairly	-2.20	0.43	.00	-3.43	-0.97
	Highly	-2.87	0.45	.00	-4.16	-1.58
Fairly	Irrelevant	3.17	0.34	.00	2.19	4.14
	Marginally	2.20	0.43	.00	0.97	3.43
	Highly	-0.67	0.24	.07	-1.37	0.03
Highly	Irrelevant	3.83	0.36	.00	2.79	4.87
	Marginally	2.87	0.45	.00	1.58	4.16
	Fairly	0.67	0.24	.07	-0.03	1.37

Note. Scale from 1: less helpful to 7: more helpful.

Table T34. ANOVA Examining the Overall Alignment with Engineering Practice of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	3.333	1.366
Marginally Relevant	4	4.500	1.732
Fairly Relevant	31	5.387	0.803
Highly Relevant	17	5.235	1.091
Total	58	5.069	1.183

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	22.98	3	7.66	7.29	.0003
Within Groups	56.75	54	1.05		
Total	79.72	57			

Note. Scale from 1: less aligned to 7: more aligned.

Table T35. Scheffé Post-Hoc Tests of the Overall Alignment with Engineering Practice of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.17	0.66	.38	-3.08	0.74
	Fairly	-2.05	0.46	.00	-3.37	-0.73
	Highly	-1.90	0.49	.00	-3.31	-0.50
Marginally	Irrelevant	1.17	0.66	.38	-0.74	3.08
	Fairly	-0.89	0.54	.46	-2.46	0.68
	Highly	-0.74	0.57	.65	-2.38	0.91
Fairly	Irrelevant	2.05	0.46	.00	0.73	3.37
	Marginally	0.89	0.54	.46	-0.68	2.46
	Highly	0.15	0.31	.97	-0.74	1.04
Highly	Irrelevant	1.90	0.49	.00	0.50	3.31
	Marginally	0.74	0.57	.65	-0.91	2.38
	Fairly	-0.15	0.31	.97	-1.04	0.74

Note. Scale from 1: less aligned to 7: more aligned.

Table T36. ANOVA Examining the Helpfulness of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	2.857	1.069
Marginally Relevant	3	5.000	1.000
Fairly Relevant	28	5.143	0.970
Highly Relevant	17	5.235	0.970
Total	55	4.873	1.233

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	32.76	3	10.92	11.29	.0000
Within Groups	49.34	51	0.97		
Total	82.11	54			

Note. Scale from 1: less helpful to 7: more helpful.

Table T37. Scheffé Post-Hoc Tests of the Helpfulness of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-2.14	0.68	.03	-4.11	-0.18
	Fairly	-2.29	0.42	.00	-3.49	-1.08
	Highly	-2.38	0.44	.00	-3.66	-1.10
Marginally	Irrelevant	2.14	0.68	.03	0.18	4.11
	Fairly	-0.14	0.60	1.00	-1.87	1.58
	Highly	-0.24	0.62	.99	-2.02	1.55
Fairly	Irrelevant	2.29	0.42	.00	1.08	3.49
	Marginally	0.14	0.60	1.00	-1.58	1.87
	Highly	-0.09	0.30	.99	-0.97	0.78
Highly	Irrelevant	2.38	0.44	.00	1.10	3.66
	Marginally	0.24	0.62	.99	-1.55	2.02
	Fairly	0.09	0.30	.99	-0.78	0.97

Note. Scale from 1: less helpful to 7: more helpful.

Table T38. ANOVA Examining the Alignment with Engineering Practice of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	6	3.500	1.517
Marginally Relevant	3	5.333	0.577
Fairly Relevant	27	5.111	1.121
Highly Relevant	17	5.176	0.809
Total	53	4.962	1.160

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	14.62	3	4.87	4.32	.0089
Within Groups	55.30	49	1.13		
Total	69.92	52			

Note. Scale from 1: less aligned to 7: more aligned.

Table T39. Scheffé Post-Hoc Tests of the Alignment with Engineering Practice of the Search Manipulation Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.83	0.75	.13	-4.01	0.34
	Fairly	-1.61	0.48	.02	-3.00	-0.22
	Highly	-1.68	0.50	.02	-3.14	-0.22
Marginally	Irrelevant	1.83	0.75	.13	-0.34	4.01
	Fairly	0.22	0.65	.99	-1.65	2.09
	Highly	0.16	0.67	1.00	-1.77	2.08
Fairly	Irrelevant	1.61	0.48	.02	0.22	3.00
	Marginally	-0.22	0.65	.99	-2.09	1.65
	Highly	-0.07	0.33	1.00	-1.02	0.89
Highly	Irrelevant	1.68	0.50	.02	0.22	3.14
	Marginally	-0.16	0.67	1.00	-2.08	1.77
	Fairly	0.07	0.33	1.00	-0.89	1.02

Note. Scale from 1: less aligned to 7: more aligned.

Table T40. ANOVA Examining the Helpfulness of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.286	0.488
Marginally Relevant	3	4.333	0.577
Fairly Relevant	27	4.963	1.055
Highly Relevant	15	5.667	0.976
Total	52	4.904	1.192

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	28.13	3	9.38	10.14	.0000
Within Groups	44.39	48	0.92		
Total	72.52	51			

Note. Scale from 1: less helpful to 7: more helpful.

Table T41. Scheffé Post-Hoc Tests of the Helpfulness of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.05	0.66	.48	-2.97	0.88
	Fairly	-1.68	0.41	.00	-2.86	-0.50
	Highly	-2.38	0.44	.00	-3.66	-1.11
Marginally	Irrelevant	1.05	0.66	.48	-0.88	2.97
	Fairly	-0.63	0.59	.76	-2.33	1.07
	Highly	-1.33	0.61	.20	-3.10	0.43
Fairly	Irrelevant	1.68	0.41	.00	0.50	2.86
	Marginally	0.63	0.59	.76	-1.07	2.33
	Highly	-0.70	0.31	.18	-1.60	0.19
Highly	Irrelevant	2.38	0.44	.00	1.11	3.66
	Marginally	1.33	0.61	.20	-0.43	3.10
	Fairly	0.70	0.31	.18	-0.19	1.60

Note. Scale from 1: less helpful to 7: more helpful.

Table T42. ANOVA Examining the Alignment with Engineering Practice of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Overall Relevance	*N*	Mean	*SD*
Irrelevant	7	3.143	0.690
Marginally Relevant	3	4.333	0.577
Fairly Relevant	27	5.222	0.892
Highly Relevant	15	5.467	0.990
Total	52	4.962	1.154

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	30.00	3	10.00	12.66	.0000
Within Groups	37.92	48	0.79		
Total	67.92	51			

Note. Scale from 1: less aligned to 7: more aligned.

Table T43. Scheffé Post-Hoc Tests of the Alignment with Engineering Practice of the Browsing Features of the Standards Directory Grouped by the Overall Relevance Ranking of the Standards Directory

Standards Directory Relevance (I)	Standards Directory Relevance (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Irrelevant	Marginally	-1.19	0.61	.30	-2.97	0.59
	Fairly	-2.08	0.38	.00	-3.17	-0.99
	Highly	-2.32	0.41	.00	-3.50	-1.15
Marginally	Irrelevant	1.19	0.61	.30	-0.59	2.97
	Fairly	-0.89	0.54	.45	-2.46	0.68
	Highly	-1.13	0.56	.27	-2.76	0.50
Fairly	Irrelevant	2.08	0.38	.00	0.99	3.17
	Marginally	0.89	0.54	.45	-0.68	2.46
	Highly	-0.24	0.29	.87	-1.07	0.58
Highly	Irrelevant	2.32	0.41	.00	1.15	3.50
	Marginally	1.13	0.56	.27	-0.50	2.76
	Fairly	0.24	0.29	.87	-0.58	1.07

Note. Scale from 1: less aligned to 7: more aligned.

Appendix U

ANOVA, *t*-tests, and Multiple Comparisons of the Mean between Demographic Groups

Table U1. Independent *t*-Tests Comparing the Mean of the Extent to Which Work was Considered Standards-Based Grouped by Whether Participants were Licensed Professionals

Licensed Professional	*N*	Mean[a]	*SD*	Std. Error Mean
No	35	4.43	1.461	0.247
Yes	23	5.61	1.500	0.313

EVA	Levene's Test for Equality of Variances.		*t*-Test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	*t*	*df*	*p*[a]	MD	SED	Lower	Upper
Yes	0.146	.704	-2.978	56	.004	-1.180	0.396	-1.974	-0.386
No			-2.962	46.337	.005	-1.180	0.398	-1.982	-0.378

Note. EVA = equal variances assumed; MD = mean difference; SED = standard error difference.

[a]2-tailed.

Table U2. Independent *t*-Tests Comparing the Mean of the Extent to Which Work was Considered Standards-Based Grouped by Whether Participants had Published in their Field of Expertise

Published in Field	*N*	Mean[a]	*SD*	Std. Error Mean
No	48	4.83	1.562	0.225
Yes	10	5.30	1.636	0.517

EVA	Levene's Test for Equality of Variances.		t-Test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	*t*	*df*	p^a	MD	SED	Lower	Upper
Yes	0.021	.885	-0.853	56	.397	-0.467	0.547	-1.563	0.629
No			-0.827	12.654	.424	-0.467	0.564	-1.689	0.756

Note. EVA = equal variances assumed; MD = mean difference; SED = standard error difference.

[a]2-tailed.

Table U3. Independent *t*-Tests Comparing the Mean of Whether Participants were Licensed Professionals Grouped by Whether Participants had Published in their Field of Expertise

Published in Field	*N*	Mean[a]	*SD*	Std. Error Mean
No	47	0.34	0.479	0.070
Yes	10	0.70	0.483	0.153

EVA	Levene's Test for Equality of Variances.		t-Test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	*t*	*df*	p^a	MD	SED	Lower	Upper
Yes	0.272	.604	-2.153	55	.036	-0.360	0.167	-0.694	-0.025
No			-2.141	13.048	.052	-0.360	0.168	-0.722	0.003

Note. EVA = equal variances assumed; MD = mean difference; SED = standard error difference.

[a]2-tailed.

Table U4. ANOVA Examining the Mean of Whether Participants had Published in their Field of Expertise Grouped by the Highest Degree Awarded

Highest Degree[a]	*N*	Mean	*SD*	Std. Error
Associate's	4	0.00	0.000	0.000
Bachelor's	27	0.11	0.320	0.062
Master's	21	0.24	0.436	0.095
Doctorate	2	1.00	0.000	0.000
Total	54	0.19	0.392	0.053

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	1.672	3	0.557	4.303	.009
Within Groups	6.476	50	0.130		
Total	8.148	53			

Note. Values used for nominal scale were no: 0 and yes: 1.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases.

Table U5. Scheffé Post-Hoc Tests of Whether Participants had Published in their Field of Expertise Grouped by the Highest Degree Awarded

Highest Degree Awarded[a] (I)	Highest Degree Awarded (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Associate's	Bachelor's	-0.111	0.193	.953	-0.67	0.45
	Master's	-0.238	0.196	.691	-0.81	0.33
	Doctorate	-1.000	0.312	.024	-1.90	-0.10
Bachelor's	Associate's	0.111	0.193	.953	-0.45	0.67
	Master's	-0.127	0.105	.691	-0.43	0.18
	Doctorate	-0.889	0.264	.016	-1.65	-0.13
Master's	Associate's	0.238	0.196	.691	-0.33	0.81
	Bachelor's	0.127	0.105	.691	-0.18	0.43
	Doctorate	-0.762	0.266	.054	-1.53	0.01
Doctorate	Associate's	1.000	0.312	.024	0.10	1.90
	Bachelor's	0.889	0.264	.016	0.13	1.65
	Master's	0.762	0.266	.054	-0.01	1.53

Note. Values used for nominal scale were no: 0 and yes: 1.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases.

Table U6. ANOVA Examining the Mean of Extent to Which Work was Considered Standards-Based Grouped by the Highest Degree Awarded

Highest Degree[a]	*N*	Mean[b]	*SD*	Std. Error
Associate's	4	3.50	1.291	0.645
Bachelor's	28	5.25	1.295	0.245
Master's	21	4.52	1.750	0.382
Doctorate	2	6.50	0.707	0.500
Total	55	4.89	1.560	0.210

	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Groups	19.357	3	6.452	2.938	.042
Within Groups	111.988	51	2.196		
Total	131.345	54			

Note. Values used for nominal scale were no: 0 and yes: 1.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases.

Table U7. Scheffé Post-Hoc Tests of the Extent to Which Work was Considered Standards-Based Grouped by the Highest Degree Awarded

Highest Degree Awarded[a] (I)	Highest Degree Awarded (J)	Mean Difference (I-J)	Std. Error	*p*	95% Confidence Interval	
					Lower	Upper
Associate's	Bachelor's	-1.750	0.792	.195	-4.04	0.54
	Master's	-1.024	0.808	.661	-3.36	1.31
	Doctorate	-3.000	1.283	.155	-6.71	0.71
Bachelor's	Associate's	1.750	0.792	.195	-0.54	4.04
	Master's	0.726	0.428	.418	-0.51	1.96
	Doctorate	-1.250	1.085	.723	-4.39	1.89
Master's	Associate's	1.024	0.808	.661	-1.31	3.36
	Bachelor's	-0.726	0.428	.418	-1.96	0.51
	Doctorate	-1.976	1.097	.365	-5.15	1.19
Doctorate	Associate's	3.000	1.283	.155	-0.71	6.71
	Bachelor's	1.250	1.085	.723	-1.89	4.39
	Master's	1.976	1.097	.365	-1.19	5.15

Note. Scale from 1: very limited to 7: highly.

[a]High School as the highest awarded degree was left out of the analysis due to fewer than two cases.

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