AD-A251967

NASA/DoD Aerospace Knowledge Diffusion Research Project

Paper Thirteen:

The Information-Seeking Habits and Practices of Engineers

Reprinted from Science & Technology Libraries
Volume 11, No. 3 (Spring) 1991: 5-25.

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The Information-Seeking Habits and Practices of Engineers

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INTRODUCTION

There are many different information user communities. The differences between them may be great. Even within similar or related user communities there may be considerable differences among users. Thus, to meet the information needs of the user communities, information professionals must first understand the nature of the user community and become familiar with the information-seeking habits and practices of the user. Generally, this has not been the case in science and technology. Information professionals have assumed certain similarities between science and technology and scientists and engineers.

The two communities and user groups are not the same and the argument that a scientist is a more generic term merely evades the fundamental issue. The practice of lumping the two groups [engineers and scientists] together is self-defeating in information [production, transfer, and] use studies because confusion over the characteristics of the sample has led to what appears to be conflicting results and to a greater difficulty in developing normative measures for improving information systems in either science or technology.

Further, the terms engineer and scientist are not synonymous. The difference in work environment and personal/professional goals between the engineer and scientist proves to be an important factor in determining their information-seeking habits and practices. This review paper explores the science/technology and scientist/engineer dichotomy and focuses on the information-seeking habits and practices of the engineer.

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BACKGROUND

In their treatise, *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Landau and Rosenberg[22] describe technological innovation as *the* critical factor in the long-term economic growth of modern industrial societies that functions successfully *only* within a larger social environment that provides an effective combination of incentives and complementary inputs into the innovation process. Technological innovation is a process in which the communication of STI is critical to the success of the enterprise.[12,35]

"*Technology*, unlike science, is an extroverted activity; it involves a search for workable solutions to problems. When it finds solutions that are workable and effective, it does not pursue the *why?* very hard. Moreover, the output of technology is a product, process, or service. *Science*, by contrast, is an introverted activity. It studies problems that are usually generated internally by logical discrepancies or internal inconsistencies or by anomalous observations that cannot be accounted for within the present intellectual framework."[22] Technology is a process dominated by engineers, as opposed to scientists, which "leads to different philosophies and habits not only about contributing to the technical literature but also to using the technical literature and other sources of information."[17] Consequently, an understanding of the relationship between science and technology and the information-seeking habits and practices of engineers is essential to the development and provision of information services for engineers.

THE NATURE OF SCIENCE AND TECHNOLOGY

The relationship between science and technology is often expressed as a continuous process or normal progression from basic research (science) through applied research (technology) to development (utilization). This relationship is based on the widely held assumption that technology grows out of or is dependent upon science for its development. However, the belief that technological change is somehow based on scientific advance has been challenged in recent years. Substantial evidence exists that refutes the relationship between science and technology.

Schmookler[32] has attempted to show that the variation in inventive activity between different American industries is explicable in terms of the variation in demand, concluding that economic growth determines the rate of inventive activity rather than the reverse. Price,[25] in his investigation of citation patterns in both scientific and technical journals, found that scientific literature is cumulative and builds upon itself, whereas technical literature is not and does not build upon itself. Citations to previous work are fewer in technical journals and are often the author's own work.

Price[25] concluded that science and technology progress independently of one another. Technology builds upon its own prior developments and advances in a manner independent of any link with the current scientific frontier and often without any necessity for an understanding of the basic science underlying it.

In summarizing the differences between science and technology, Price[25] makes the following 12 points. *First*, science has a cumulating, close-knit structure; that is, new knowledge seems to flow from highly related and rather recent pieces of old knowledge, as displayed in the literature. *Second*, this property is what distinguishes science from technology and from humanistic scholarship. *Third*, this property accounts for many known social phenomena in science and also for its surefootedness and high rate of exponential growth. *Fourth*, technology shares with science the same high growth rate, but shows quite complementary social phenomena, particularly in its attitude to the literature. *Fifth*, technology therefore may have a similar, cumulating, close-knit structure to that of science, but it is of the state of the art rather than of the literature. *Sixth*, science and technology each therefore have their own separate cumulating structures. *Seventh*, a direct flow from the research front of science to that of technology, or vice versa, occurs only in special and traumatic cases since the structures are separate.

Eighth, it is probable that research-front technology is strongly related only to that part of scientific knowledge that has been packed down as part of ambient learning and education, not to research-front science. *Ninth*, research-front science is similarly related only to the ambient technological knowledge of the previous generation of students, not to the research front of the technological state of the art and its innovation. *Tenth*, this reciprocal relation between science and technology, involving the research front of one and the accrued archive of the other, is nevertheless sufficient to keep the two in phase in their separate growths within each otherwise independent cumulation. *Eleventh*, it is therefore naive to regard technology as applied science or clinical practice as applied medical science. *Twelfth*, because of this, one should be aware of any claims that a particular scientific research is needed for particular technological breakthroughs, and vice versa. Both cumulations can only be supported for their own separate ends.

Allen,[2] who studied the transfer of technology and the dissemination of technological information in R&D organizations, finds little evidence to support the relationship between science and technology as a continuous relationship. Allen concludes that the relationship between science and technology is best described as a series of interactions that are based on need rather than on a normal progression.

Allen[2] states that the independent nature of science and technology (S&T) and the different functions performed by engineers and scientists directly influence the flow of information in science and technology. Science and technology are ardent consumers of information. Both engineers and scientists require large quantities of information to perform their work. At this level, there is a strong similarity between the information input needs of engineers and scientists. However, the difference between engineers and scientists in terms of information processing becomes apparent upon examination of their outputs.[2]

According to Allen[2] information processing in S&T is depicted in the form of an input-output model. Scientists use information to produce information. From a system standpoint, the input and output, which are both verbal, are compatible. The output from one stage is in a form required for the next stage. Engineers use information to produce some physical change in the world. Engineers consume information, transform it, and produce a product that is information bearing; however, the information is no longer in verbal form. Whereas scientists consume and produce information in the form of human language, engineers transform information from a verbal format to a physically encoded form. Verbal information is produced only as a by-product to document the hardware and other physical products produced.

According to Allen,[2] there is an inherent compatibility between the inputs and outputs of the information-processing system of science. He further states that since both are in a verbal format, the output of one stage is in the format required for the next stage. The problem of supplying information to the scientist becomes a matter of collecting and organizing these outputs and making them accessible. Since science operates for the most part on the premise of free and open access to information, the problem of collecting outputs is made easier.

In technology, however, there is an inherent incompatibility between inputs and outputs. Since outputs are usually in a form different from inputs, they usually cannot serve as inputs for the next stage. Further, the outputs are usually in two parts, one physically encoded and the other verbally encoded. The verbally encoded part usually cannot serve as input for the next stage because it is a by-product of the process and is itself incomplete.[2] Those unacquainted with the development of the hardware or physical product therefore require some human intervention to supplement and interpret the information contained in the documentation.[1] Since technology operates to a large extent on the premise of restricted access to information, the problem of collecting the documentation and obtaining the necessary human intervention becomes difficult.[12]

DISTINGUISHING ENGINEERS FROM SCIENTISTS

In their study of the values and career orientation of engineering and science undergraduate students, Krulee and Nadler[21] found that engineering and science students have certain aspirations in common: to better themselves and to achieve a higher socioeconomic status than that of their parents. They reported that science students place a higher value on independence and on learning for its own sake while engineering students are more concerned with success and professional preparation. Many engineering students expect their families to be more important than their careers as a source of satisfaction, but the reverse pattern is more typical for science students.

Krulee and Nadler[21] also determined that engineering students are less concerned than science students with what one does in a given position and more concerned with the certainty of the rewards to be obtained. They reported that, overall, engineering students place less emphasis on independence, career satisfaction, and the inherent interest their specialty holds for them and place more value on success, family life, and avoiding a low-level job. Engineering students appear to be prepared to sacrifice some of their independence and opportunities for innovation in order to realize their primary objectives. Engineering students are more willing to accept positions that will involve them in complex organizational responsibilities and they assume that success in such positions will depend upon practical knowledge, administrative ability, and human relation skills.[21]

In his study of engineers in industry, Ritti[27] found marked contrast between the work goals of engineers and scientists. Ritti draws the following three conclusions from his study: (1) the goals of engineers in industry are very much in line with meeting schedules, developing products that will be successful in the marketplace, and helping the company expand its activities; (2) while both engineers and scientists desire career development or advancement, for the engineer advancement is tied to activities within the organization, while advancement for the scientist is dependent upon the reputation established outside of the organization; and (3) while publication of results and professional autonomy are clearly valued goals of the Ph.D. scientist, they are clearly the least valued goals of the baccalaureate engineer.

Allen[1] states that the type of person who is attracted to a career in engineering is fundamentally different from the type of person who pursues a career as a scientist. He writes that "perhaps the single most important difference between the two is the level of education. Engineers are generally educated to the baccalaureate level; some have a master's degree while some have no college degree. The research scientist is usually assumed to have a doctorate. The long, complex process of academic socialization involved in obtaining the Ph.D. is bound to result in persons who differ considerably in their lifeviews." According to Allen,[1] these differences in values and attitudes toward work will almost certainly be reflected in the behavior of the individual, especially in their use and production of information.

According to Blade,[6] engineers and scientists differ in training, values, and methods of thought. Further, Blade states that the following differences exist in their individual creative processes and in their creative products: (1) scientists are concerned with discovering and explaining nature; engineers use and exploit nature; (2) scientists are searching for theories and principles; engineers seek to develop and make things; (3) scientists are seeking a result for its own ends; engineers are engaged in solving a problem for the practical operating results; and (4) scientists create new unities of thought; engineers invent things and solve problems. Blade states that "this is a different order of creativity."

Finally, communication in engineering and science are fundamentally different. Communication patterns differ because of the fundamental differences between engineering and science and because of the social systems associated with the two disciplines. With one exception, the following characteristics of the social systems as they apply to the engineer and scientist are based on Holmfeld's[16] investigation of the communication behavior of engineers and scientists.

Engineer

- Contribution is [technical] knowledge used to produce end-items or products.
- New and original knowledge is not a requirement.
- Reward is monetary or materialistic and serves as an inducement to continue to make further contributions to technical knowledge.
- Seeking rewards that are not part of the social system of technology is quite proper and also encouraged.
- The value of technical knowledge lies in its value as a commodity of indirect exchange.
- Exchange networks found in the social system of technology are based on end-item products, not knowledge.
- Strong norms against free exchange or open access to knowledge with others outside of the organization exist in the social system of technology.
- Restriction, security classification, and proprietary claims to knowledge characterize the social system of technology.

Scientist

- Contribution is new and original knowledge.
- Reward is social approval in the form of professional [collegial] recognition.
- Recognition is established through publication and claim of discovery.
- A well-developed communication system based on unrestricted access is imperative to recognition and claim of discovery.
- Since recognition and priority of discovery are critical, strong norms against any restriction to free and open communication exist in the social system of science.
- Seeking rewards that are not part of the social system of science in return for scientific contribution is not considered proper within the social system of science.
- Exchange networks commonly referred to as "invisible colleges" exist in the social system of science; in these networks the commodities are knowledge and recognition.[26,10]

INFLUENCE ON INFORMATION-SEEKING HABITS AND PRACTICES OF ENGINEERS

The nature of science and technology and differences between engineers and scientists influence their information-seeking habits, practices, needs, and preferences and have significant implications for planning information services for these two groups.[36] Taylor,[37] who quotes Brinberg,[7] offers the following characteristics for engineers and scientists: "Unlike scientists, the goal of the engineer is to produce or design a product, process, or system; not to publish and make original contributions to the literature. Engineers, unlike scientists, work within time constraints; they are not interested in theory, source data, and guides to the literature nearly so much as they are in reliable answers to specific questions. Engineers prefer informal sources of information, especially conversations with individuals *within* their organization. Finally, engineers tend to minimize loss rather than maximize gain when seeking information."

Anthony et al.,[4] suggest that engineers may have psychological traits that predispose them to solve problems alone or with the help of colleagues rather than finding answers in the literature. They further state that "engineers like to solve their own problems. They draw on past experiences, use the trial and error method, and ask colleagues known to be efficient and reliable instead of searching or having someone search the literature for them. They are highly independent and self-reliant without being positively antisocial."

According to Allen,[2] "Engineers read less than scientists, they use literature and libraries less, and seldom use information services which are directly oriented to them. They are more likely to use specific forms of literature such as handbooks, standards, specifications, and technical reports." What an engineer usually wants, according to Cairns and Compton,[8] is "a specific answer, in terms and format that are intelligible to him—not a collection of documents that he must sift, evaluate, and translate before he can apply them." Young and Harriott[38] report that "the engineer's search for information seems to be based more on a need for specific problem solving than around a search for general opportunity. When engineers use the library, it is more in a personal-search mode, generally not involving the professional (but "nontechnical") librarian." Young and Harriot conclude by saying that "when engineers need technical information, they usually use the most accessible sources rather than searching for the highest quality sources. These accessible sources are respected colleagues, vendors, a familiar but possibly out dated text, and internal company [technical] reports. He [the engineer] prefers informal information networks to the more formal search of publicly available and cataloged information."

Evidence exists to support the hypothesis that differences between science and technology and scientists and engineers directly influence information-seeking habits, practices, needs, and preferences. The results of a study conducted by the System Development Corporation[36] determined that "an individual differs systematically from others in his use of STI" for a variety of reasons. Chief among these are five institutional variables—type of researcher, engineer or scientist; type of discipline, basic or applied; stage of project, task, or problem completeness; the kind of organization, fundamentally thought of as academia, government, and industry; and the years of professional work experience."

Studies, such as the work performed by O'Gara,[23] indicate that information-seeking habits, practices, needs, and preferences are influenced by certain sociometric variables. O'Gara found a positive correlation between physical proximity to an information source and its use. King et al.,[19] report a positive correlation between the number of visits to a library and proximity of the user.

Gerstberger and Allen,[13] in their study of engineers and their choice of an information channel, note the following:

> Engineers, in selecting among information channels, act in a manner which is intended not to maximize gain, but rather to minimize loss. The loss to be minimized is the cost in terms of effort, either physical or psychological, which must be expended in order to gain access to an information channel.

Their behavior appears to follow a "law of least effort."[39] According to this law, individuals, when choosing among several paths to a goal, will base their decision upon the single criterion of "least average rate of probable work." According to Gerstberger and Allen, engineers appear to be governed or influenced by a principle closely related to this law. They attempt to minimize effort in terms of work required to gain access to an information channel. Gerstberger and Allen reached the following conclusions:

1. Accessibility is the single most important determinant of the overall extent to which an information channel or source is used by an engineer.
2. Both accessibility and perceived technical quality influence the choice of the first source.
3. The perception of accessibility is influenced by experience. The more experience engineers have with an information channel or source, the more accessible they perceive it to be.

Gerstberger and Allen[13] conclude their discussion by stating that "any assumption that engineers act in accord with a simple instrumental learning model in which they turn most frequently to those information channels which reward them most often should now clearly be laid to rest." Rosenberg's[28] findings also support the conclusions by Gerstberger and Allen that accessibility almost exclusively determines the frequency of use of information channels. Rosenberg concludes that researchers minimize the cost of obtaining information while sacrificing the quality of the information received. In his study of the *Factors Related to the Use of Technical Information in Engineering Problem Solving*, Kaufman[18] reports that engineers rated *technical quality* or *reliability* followed by *relevance* as the criteria used in choosing the most useful information source. However, *accessibility* appears to be used most often for selecting an information source *even if that source* proved to be the least useful.

THE INFORMATION-SEEKING HABITS AND PRACTICES OF ENGINEERS

Studies specifically concerned with the information-seeking habits and practices of engineers were reviewed to further develop the conceptual framework for this paper. Research studies deemed significant are listed in the "Overview of Engineering STI Studies" and are discussed in some detail. Although not comprehensive, data from these studies are used to further develop the concept of "different" information-seeking habits and practices for engineers and scientists. (See Figure 1.)

Herner

Herner's[15] is one of the first "user" studies that is specifically concerned with "differences" in information-seeking habits and practices. He reports significant differences in terms of researchers performing "basic and applied" research, researchers performing "academic and industry" type duties, and their information-seeking habits and practices. Herner says that researchers performing "basic or academic" duties make greater use of formal information channels or sources, depend mainly on the library for their published material, and maintain a significant number of contacts outside of the organization.

Researchers performing "applied or industry" duties make greater use of informal channels or sources, depend on their personal collections of information and colleagues for information,

FIGURE 1. Overview of Engineering STI Studies

Year	Principal Investigator	Research Method	Population	Sample Frame	Sample Design	Sample Size	Percentage Response Rate (number responding)	Description
1954	Herner	Structured interview	All scientific and technical personnel at Johns Hopkins	Unknown	Unknown	600	100	Survey to determine the information-gathering methods of scientific and technical personnel at Johns Hopkins
1970	Rosenbloom and Wolek	Self-administered questionnaire	Members of 5 industrial R&D organizations	2 430	Census	2 430	71 (1 735)	Survey to determine how engineers and scientists in industrial research and development organizations acquire STI
			Members of 4 IEEE interest groups	Unknown	Probability	Unknown	Unknown (1 034)	
1977	Allen	Record analysis Self-administered questionnaire	Unknown	Unknown	Unknown	Unknown	Unknown (1 153)	Survey to determine technology transfer and the dissemination of technological information in research and development organizations
1980	Kremer	Self-administered questionnaire	All design engineers at one engineering design firm	73	Census	73	82 (60)	Survey to identify and evaluate the information channels used by engineers in a design company
1981	Shuchman	Structured interview Self-administered questionnaire	Engineers in 89 R&D and non-R&D organizations	14 797	Probability	3 371	39 (1 315)	Survey to determine information used and production in engineering
1983	Kaufman	Self-administered questionnaire	Engineers in six technology-based organizations	147	Census	147	100 (147)	Survey to determine the use of technical information in technical problem solving

make significantly less use of the library than do their counterparts, and maintain fewer contacts outside of the organization. Applied or industry researchers make substantial use of handbooks, standards, and technical reports. They also read less and do less of their reading in the library than do their counterparts.[15]

Rosenbloom and Wolek

Rosenbloom and Wolek[29] conducted one of the first "large-scale" industry studies that was specifically concerned with the flow of STI within R&D organizations. They report three significant and fundamental differences between engineers and scientists:

(1) engineers tend to make substantially greater use of information sources *within* the organization than do scientists; (2) scientists make considerably greater use of the professional (formal) literature than do engineers; and (3) scientists are more likely than engineers to acquire information as a consequence of activities directed toward general competence rather than a specific task.

In terms of interpersonal communication, the engineers in the Rosenbloom and Wolek (1970) study recorded a higher incidence of interpersonal communication with people in other parts of their own corporation, whereas scientists recorded a greater incidence of interpersonal communication with individuals employed outside their own corporation. When using the literature, the engineers tend to consult in-house technical reports or trade publications, while the scientists tend to make greater use of the professional [formal] literature.

Rosenbloom and Wolek[29] report certain similarities between engineers and scientists as follows. The propensity to use alternative types of technical information sources is related to the purposes that will give meaning to the use of that information. Work that has a professional focus draws heavily on sources of information external to the user's organization. Work that has an operational focus seldom draws on external sources, relying heavily on information that is available within the employing organization. Those engineers and scientists engaged in professional work commonly emphasize the simplicity, precision, and analytical or empirical rigor of the information source. Conversely, those engineers and scientists engaged in operational work typically emphasize the value of communication with others who understand and are experienced in the same real context of work.

Allen

Allen's[2] study of technology transfer and the dissemination of technological information within the R&D organization is the result of a 10-year investigation. Allen describes the study, which began as a "user study," as a systems-level approach to the problem of communication in technology. Allen's work is considered by many information professionals to be the seminal work on the flow of technical information within R&D organizations.

Allen[2] was among the first to produce evidence supporting different information-seeking habits and practices for engineers and scientists. These differences, Allen notes, lead to different philosophies and habits regarding the use of the technical literature and other sources of information by engineers. The most significant of Allen's findings is the relative lack of importance of the technical literature in terms of generating new ideas and in problem definition, the importance of personal contacts and discussions between engineers, the existence of technological "gatekeepers," and the importance of the technical report. Allen states that "the unpublished report is the single most important informal literature source; it is the principal written vehicle for transferring information in technology."

Kremer

Kremer's[20] study was undertaken to gain insight on how technical information flows through formal and informal channels among engineers in a design company. The engineers in her study are not involved in R&D. Kremer's findings are summarized as follows.

In terms of information habits, personal files are the most frequently consulted source for needed information. The reason given most frequently to search for information is problem solving; colleagues within the company are contacted first for needed information, followed by colleagues outside of the company. In terms of the technical literature, handbooks are considered most important, followed by standards and specifications. Libraries are not considered to be important sources of information and are used infrequently by company engineers.

Regardless of age and work experience, design engineers demonstrate a decided preference for internal sources of information. The perceived accessibility, ease of use, technical quality, and amount of experience a design engineer has had with an information source strongly influence the selection of an information source. Technological gatekeepers were found to exist among design engineers;

they are high technical performers and a high percentage are first line supervisors.

Shuchman

Shuchman's[33] study is a broad-based investigation of information transfer in engineering. The respondents represented 14 industries and the following major disciplines: civil, electrical, mechanical, industrial, chemical and environmental, and aeronautical. Seven percent, or 93 respondents, were aeronautical engineers. The engineers in Shuchman's study, regardless of discipline, display a strong preference for informal sources of information. Further, these engineers rarely find all the information they need for solving technical problems in one source; the major difficulty engineers encounter in finding the information they need to do their job is identifying a specific piece of missing data and then learning who has it.

In terms of information sources and solving technical problems, Shuchman (1981) reports that engineers first consult their personal store of technical information, followed in order by informal discussions with colleagues, discussions with supervisors, use of internal technical reports, and contact with a "key" person in the organization who usually knows where the needed information may be located. Shuchman stated that technical libraries and librarians are used by a small proportion of the engineering profession.

In general, Shuchman[33] states engineers do not regard information technology as an important adjunct to the process of producing, transferring, and using information. While technological gatekeepers appear to exist across the broad range of engineering disciplines, their function and significance is not uniform; considering the totality of engineering, gatekeepers account for only a small part of the information transfer process.

Kaufman

Kaufman's[18] study is concerned with the factors relating to the use of technical information by engineers in problem solving. The study reported that, in terms of information sources, engineers consult their personal collections first, followed by colleagues and then by formal literature sources. In terms of formal literature sources used for technical problem solving, engineers use technical reports, followed in order by books, monographs, and technical handbooks.

Most sources of information, according to Kaufman,[18] are found primarily through an intentional search of written information, followed by personal knowledge and then by asking someone. The study purports that the criteria used in selecting all information sources, in descending order of frequency, are accessibility, familiarity or experience, technical quality, relevance, comprehensiveness, ease of use, and expense. The various information sources are used by engineers for specific purposes. Librarians and information specialists are primarily utilized to find leads to information sources. On-line computer searches are used primarily to define the problem. The technical literature is used primarily to learn techniques applicable to dealing with the problem. Personal experience is used primarily to find solutions to the problem. Kaufman[18] reports that the criteria used in selecting the most useful information sources, in descending order of frequency, are technical quality or reliability, relevance, accessibility, familiarity or experience, comprehensiveness, ease of use, and expense. In terms of the effectiveness, efficiency, and usefulness of the various information sources, personal experience is rated as the most effective in accomplishing the purpose for which it is used; librarians and information specialists receive the lowest rating for efficiency and effectiveness. Most engineers use several different types of information sources in problem solving; however, engineers do depend on their personal experience more often than on any single specific information source.

DISCUSSION

The ability of engineers to identify, acquire, and utilize scientific and technical information (STI) is of paramount importance to the efficiency of technological innovation and the R&D process. Testimony to the central role of STI in the R&D process is found in numerous studies. These studies show, among other things, that engineers and scientists, and aerospace engineers and scientists in particular, devote more time, on the average, to the communication of technical information than to any other scientific or technical activity.[12,24]

A number of studies have found strong relationships between the communication of STI and technical performance at both the individual[3,14,30] and group levels.[9,31,34] As Fischer[12] concludes, "The role of scientific and technical communication is thus central to the success of the innovation process, in general, and the management of R&D activities, in particular." But as Solomon and Tornatzky[35] point out, "While STI, its transfer and utilization, is crucial to technological innovation [and competitiveness], linkages between [the] various sectors of the technology infrastructure are weak and/or poorly defined."

Economists, such as David,[11] point out that "technological innovation is the primary, if not the only means of improving industrial productivity. It is the force propelling the American economy forward and a process [that is] inextricably linked to knowledge transfer and diffusion." In spite of its importance to the U.S. economy and the balance of trade, very little is known about technological innovation and the diffusion of knowledge both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the social system involved in technological innovation.

Therefore, it is likely that an understanding of the process by which STI is communicated through certain channels over time among the members of the technological social system would contribute to stimulating technological innovation, maximizing the R&D process, increasing R&D productivity, and improving and maintaining the professional competence of U.S. engineers.

However, despite the vast amount of STI available to potential users, several major barriers to effective knowledge diffusion exist.[5] *First*, the very low level of support for knowledge transfer in comparison to knowledge production suggests that dissemination efforts are not viewed as an important component of the R&D process. *Second*, there are mounting reports from users about difficulties in getting appropriate information in forms useful for problem solving and decision making. *Third*, rapid advances in many areas of S&T knowledge can be fully exploited only if they are quickly translated into further research and application. Although the United States dominates basic R&D, foreign competitors may be better able to apply the results. *Fourth*, current mechanisms are often inadequate to help the user assess the quality of available information. *Fifth*, the characteristics of actual usage behavior are not sufficiently taken into account in making available useful and easily retrieved information. These deficiencies must be remedied if the results of R&D are to be successfully applied to innovation, problem solving, and productivity.

CONCLUDING REMARKS

Only by maximizing the R&D process can the United States maintain and possibly recapture its international competitive edge. Key to this goal is the provision of information services and products which meet the information needs of engineers. Evidence exists which indicates that traditional information services and products may, in fact, not be meeting the information needs of engineers. The primary reason(s) for this deficiency is three fold. First, the specific information needs of engineers are neither not well known nor well understood. Second, what is known about the information-seeking habits and practices of engineers has not been applied to existing engineering information services. Third, information professionals continue to over emphasize technology instead of concentrating on the quality of the information itself and the ability of the information to meet the needs of the user.

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