


# Subramanyam Revisited: Creating a New Model for Information Literacy Instruction

Sheila R. Curl

Krishna Subramanyam arranged scientific and technical literature in a circular model in the 1970s. As a pedagogical construct, the circle conceptualizes the processes of producing and consuming information. Although more than twenty years old, the model is still valid. Can it be adapted to help undergraduate students of today's information literacy curriculum understand the structure of the information they need to be able to use to succeed as students and as professionals? This paper presents the model, the revision, and its application to the information literacy curriculum for engineering and technology students.

n the first chapter of his 1981 book, *Scientific & Technical Information Sources*, Krishna Subramanyam presented a deceptively simple model of the "evolution of scientific information."<sup>1</sup> In this model, information produced as part of the research and development process develops clockwise around the circle. Individuals move counterclockwise around the same circle to consume information products or to conduct research. This feature makes it ideal to use in designing information literacy instruction. Subramanyam's model has been used by science and engineering librarians to provide a framework for designing bibliographic instruction for years. Although the book and the encyclopedia articles it sprang from have been widely cited, no one has revisited the model or described its use or application to bibliographic instruction.

This paper describes the original model and the revision used as a model for undergraduate instruction for engineering technology students. It addresses the importance of fitting the instruction to the audience and the adaptability of the model itself.

There are other models of the literature of science and technology (for example, those presented by R. T. Bottle, Brian Vickery, and William D. Garvey), but these linear models are not as useful as Subramanyam's circular model.<sup>2-4</sup>

Why look at models? Many studies report that engineers spend a considerable amount of time retrieving, using, and communicating information. In 1991, Jean Michel made the following generalization:

documentalists and other information specialists do not understand the real information needs of engi-

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Sheila R. Curl is the Assistant Professor of Library Science and Head of the Siegesmund Engineering Library at Purdue University; e-mail: curl@purdue.edu.

neers, and remain ignorant of their information acquisition process.<sup>5</sup>

In a survey, Gloria J. Leckie asked science and engineering faculty to evaluate the usefulness of library instruction. Only 33 percent of the respondents chose to answer this section of the survey; of those, 77 percent replied that the library instruction was useful and 21 percent were unsure.<sup>6</sup> Research by Thomas E. Pinelli, R. O. Barclay, and J. M. Kennedy indicated that entry-level engineers lack the information use skills needed for a successful engineering career.<sup>7</sup> Because these entry-level engineers are former undergraduate students, there is clearly need for improvement in library information literacy efforts.

### The Scientific Literature Model

The structure of scientific literature can best be understood by tracing the progression of scientific information from ... the idea stage until the new information generated is disseminated through various channels and eventually becomes an integral part of prior scientific knowledge.<sup>8</sup>

Subramanyam's intended audience for his book was technical librarians and students of technical information. He worked to integrate the inventory and expository approaches to guides to the literature. Comprehensive inventory-type guides to the literature are designed as working tools for the reference librarian and the bibliographer. Examples of the inventory type of literature guide are A. J. Walford and Eugene P. Sheehy.<sup>9,10</sup> Expository guides to the literature emphasize the exposition of the various forms of the literature and the search procedures (for example, Susan Ardis and Charles R. Lord).<sup>11,12</sup> Subramanyam suggested that the huge and growing amount of scientific and technical information could best be grasped by understanding the process of scientific and technical communication

as well as the relationship between information needs and information sources.

When it appeared, Subramanyam's book received mixed reviews. Eric Marshall said the diagrams "oversimplify the practical situation" and illustrate the "ideal search process."<sup>13</sup> H. H. Wellisch in *Library Quarterly* castigated Subramanyam, saying the search process diagram was "quite unrealistic and misleading." He explained that in reference questions, one

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does not normally start with tertiary resources but, rather, with secondary sources with which the reference person is well acquainted.<sup>14</sup> As with any model, this model attempts to present one interpretation of a complex process for the edification of individuals not familiar with the process (library school students), in this case the literature of science and technology, one of the most bibliographically complex of all scholarly literatures. That a model must of necessity tend to oversimplify or idealize a process does not mean the creator of the model or the model itself is wrong.

Librarians unfamiliar with a particular subject area often consult a tertiary resource in order to direct patrons or take the next step themselves. Individuals with different skill levels and needs should be directed and/or instructed to use the tool that fits their need—primary, secondary, or tertiary.

User instruction efforts often approach research methodology as if it had a beginning, middle, and end. Even Subramanyam articulated this attitude: "The literature search begins with tertiary resources and ends up with enough primary documents relevant to the question."<sup>15</sup> In fact, it is the question that begins the circle. Research becomes a fluid, iterative process that constantly circles back on itself.

In its simplest form, the search process resembles Subramanyam's diagram in figure 1. This model follows the process through tertiary, secondary, and primary sources but lacks the indicator of information flow from the tertiary source back to the user. This is the indicator that reproduces the activities that occur every day in offices, labs, and libraries around the world. Scientific and technical researchers rely heavily on tertiary information in the form of handbooks, tables, directories, and reviews.

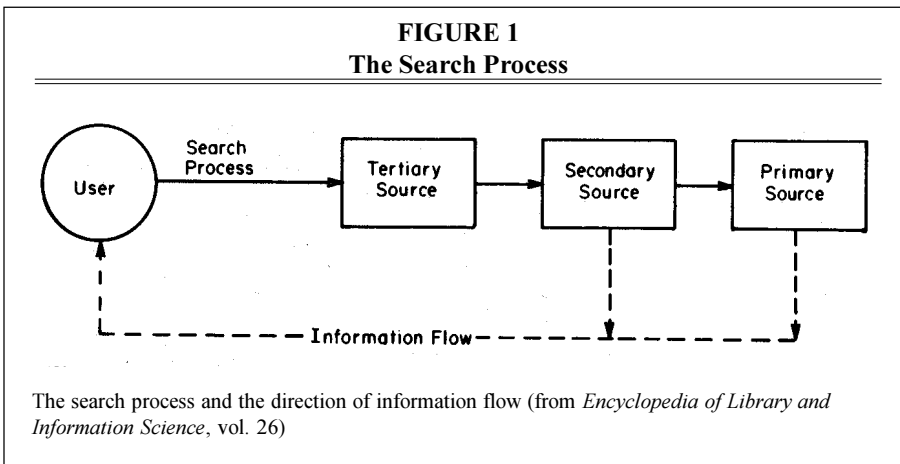
In revising Subramanyam's model, a structure appropriate for use in designing undergraduate instruction emerged. The circular model was attractive because of the way it comes around on itself again and again. This model was turned one segment to the right, and the twelve entries became eight.

This adaptation is based on analyzing Subramanyam's model and revising it based on the current environment and the needs of a different audience (undergraduate engineering students).

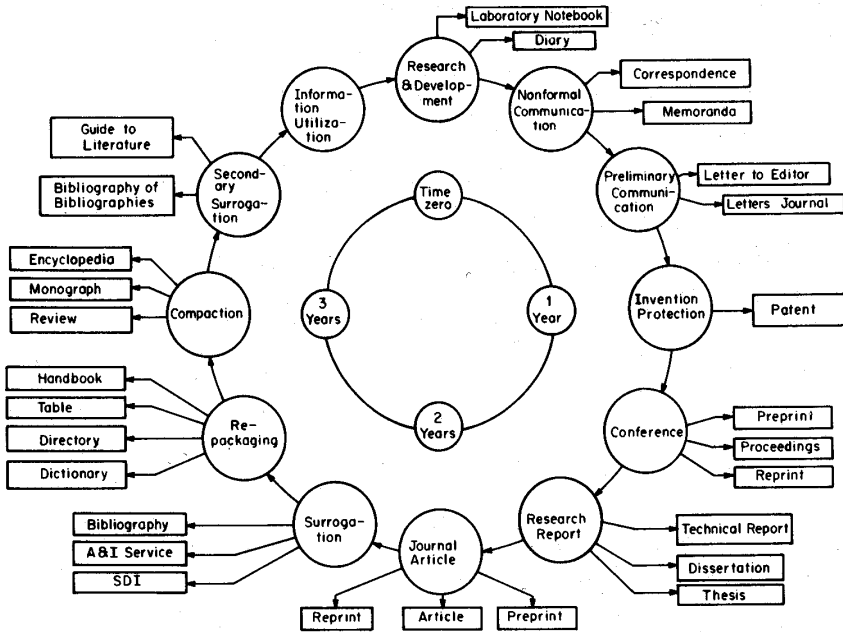
Subramanyam's model, a series of twelve circles arranged in a circle, begins with the idea-generation stage of the research process and progresses to what he calls the information utilization stage (figure 2). Along the way, Subramanyam identifies the primary (nonformal communication, preliminary communication, invention protection, conference, research

report, journal article), secondary (surrogation), and tertiary (repackaging, compaction, secondary surrogation) sources of information. Attached to each circle in the model are the bibliographic packages produced as part of that activity. The time frame, in years, appears in the center of the circle between the research and the bibliographic products it creates. Each step in a clockwise direction around the circle takes us further in time from the original research.

Subramanyam mentions that the information creation process begins with an idea but omits the idea stage from the model. He mentions the information need in discussing the use of the scientific literature but does not return to it. His model is drawn as a circle but is not circular. Rather, it is more U-shaped. Information utilization does not lead to research and development, but an information need does. The element needed to transform the U-shape into a circle is the identification of an information need. Subramanyam talks about information as the product of the research effort, but the result of satisfying an information need can be new information, a new product or service, a new process, or an improvement of an existing process. "Engineers consume information, transform it, and produce a product that is information bearing; however, the information is no longer in verbal form."<sup>16</sup> This information may be verbal, visual, or tacit.



**FIGURE 2**  
**Subramanyam's Model**



The evolution of scientific information. (from *Encyclopedia of Library and Information Science*, vol. 26)

To access information on these physical products, one must go beyond traditional models of library research—forming the thesis statement and then finding background information and books, journal articles, and newspaper articles to support the thesis. It is important to remember that the overwhelming majority of engineering and technology undergraduate students go into industry upon graduation, not into graduate programs. Thus, instruction must be tailored to help them be successful in their undergraduate careers and professional lives.

**Description of Subramanyam's Model**

The twelve o'clock position in Subramanyam's circle represents research and development. The products of this activity include laboratory notebooks and diaries, sources rarely seen outside the laboratory unless they are supporting liti-

gation, but they form the basis of future publications.

At one o'clock is nonformal communication. This includes correspondence between the researcher and colleagues inside and outside his research group and memoranda sent within the larger organization. Outsiders will not have access to this information unless it is shared by one of the correspondents (sender or receiver).

Preliminary communication of the results is at two o'clock. This moves the information from the gray literature to the true primary literature of the discipline. Here, the author receives feedback from selected colleagues or mentors; the information can be shared in a letters journal or as a short communication in a refereed journal. Results can be picked up by an abstracting and indexing service for the first time. Researchers outside the author's

invisible college find out about it through current awareness services or SDI.

The researcher may want to seek invention protection, three o'clock on the circle. Many countries deny patent protection if the information was published or presented anywhere before the patent application was filed. In the United States, inventors have a year to file after publication or presentation. The patent or published patent application becomes part of the primary literature when the patent-granting institution publishes it. Approximately 70 to 80 percent of the information published in patents does not appear anywhere else in the technical literature.<sup>17</sup>

At four o'clock is conference literature. In engineering, this format runs a close second to the periodical literature in importance. Many professional societies sponsor annual meetings to present original research. Conference papers appear in a variety of formats, most commonly as preprints, proceedings, and reprints. The major abstracting and indexing services cover many conferences.

Five o'clock is the research report, which includes dissertations, theses, and technical reports written to satisfy a government or corporate funding agency. Engineers in industry, with its competitive pressures, are more likely to publish their findings only within the corporation.<sup>18</sup> Many corporations develop extensive archives of internal technical reports, which should not be ignored by the insider.

Librarians often focus on refereed journals, but professional, technical, and trade journals are used as well. These are at the six o'clock position. Subramanyam also includes computer programs, trade catalogs, and standards and specifications in the primary literature of science and technology.

The seven o'clock position introduces the secondary sources and is called surrogation. This includes abstracting and indexing services, bibliographic databases, catalogs, and bibliographies. Many databases now contain or link to the full text of the article identified in the

search and from there to articles referenced in the bibliography. This blending of secondary and primary resources streamlines the search but can confuse the unsophisticated researcher.

At eight o'clock, repackaging of information into handbooks, tables, and directories begins. These tools provide rapid access to specific pieces of information and end up on bookshelves and desktops in the offices and labs of individuals throughout an organization.

Nine o'clock is compaction. The information has been integrated with existing knowledge and published as monographs, treatises, textbooks, and encyclopedias.

Secondary surrogation is located at the ten o'clock position. These sources are necessary because of the proliferation of the primary and secondary literature of the sciences. This circle includes lists of indexing and abstracting services, guides to the literature, and bibliographies of bibliographies. Librarians and others unfamiliar with a particular segment of knowledge or who are new to a field use these sources most often.

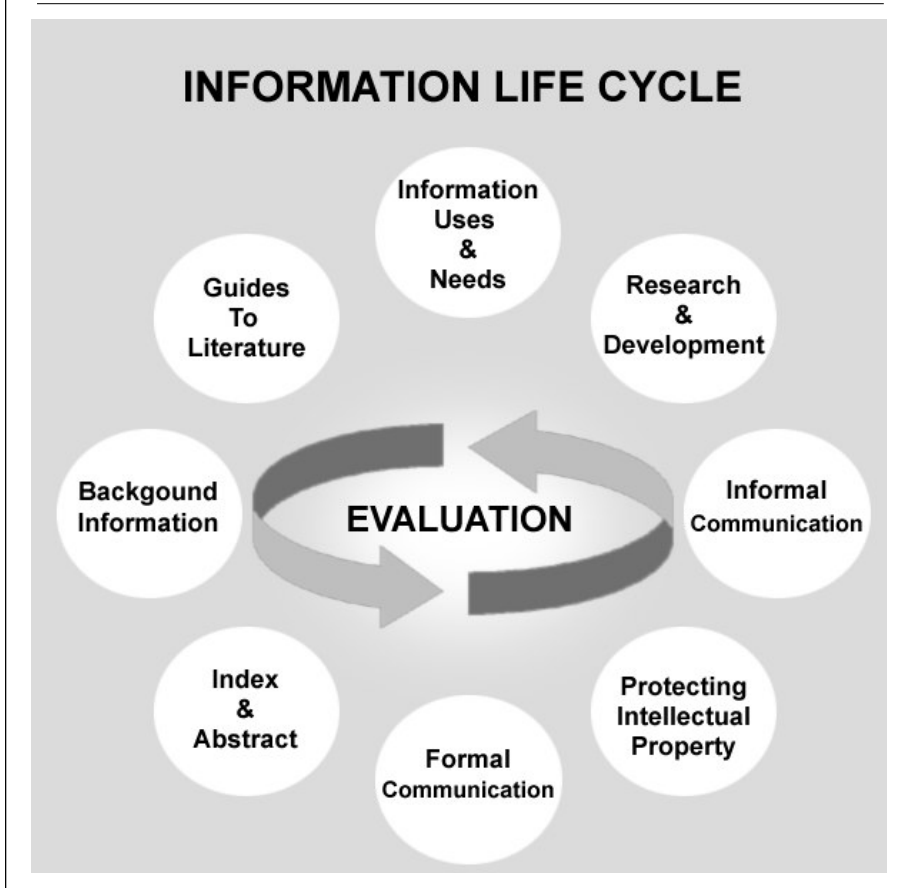
Subramanyam saved information utilization for the eleven o'clock position. It is here that the revision of the circle begins.

### Revising the Model

The goal of information literacy instruction for engineering students, the development of information-savvy professionals rather than "little librarians," requires a model that works for the education of the undergraduate engineering student. Utilizing this model, originally developed for the education of information professionals, a structure more appropriate for use in designing undergraduate instruction emerged.

The revised model begins at twelve o'clock with information uses and needs. These are followed by research and development, informal communication, intellectual property protection, formal communication, abstracting and indexing services, background information (hand-

FIGURE 3  
Information Life Cycle



books and encyclopedias), and guides to the literature. At that point the circle becomes complete, leading back to information uses and needs.

### Information Literacy Model

The processes of information production and consumption always begin with an information need. As figure 3 shows, this is the twelve o'clock position on the information literacy model. Someone wants to build a better mousetrap, or market research shows that the population is ripe for a new widget. A team begins working on it. At this point, the designers may be working in both directions around the circle at once. Moving counterclockwise, they examine what has been done before,

especially in their own firm or industry. Senior researchers and mentors may be tapped for their knowledge and insight. At the same time the team members begin to work on their own ideas, they are applying the tacit knowledge they have gained in their education and professional experience. During this process, they are keeping records of their progress. They may keep lab notebooks or diaries containing a record of mistakes and successes, blind alleys they have followed, and productive efforts. Only individuals attached to the work itself usually see these documents.

Moving into informal communication there is now a product. Dissemination efforts may include department seminars,

reports to the larger organization, and in certain environments reports to colleagues outside the parent organization, but distribution is still fairly narrow. After developers have begun to send reports and memoranda to a department head, documents are likely to become part of the corporate archive or library.

Intellectual property protection includes patents (processes, products, compositions of matter and improvements thereof), trademarks (products or services), trade secrets, and/or copyrights (creative efforts). Some activities skip this step entirely; in other cases, this circle forms its own complete process. Research in this literature may occur at several points in the design process. Patent research is conducted to investigate patentability, avoid infringement, invalidate another's patent, and/or determine the state of the art.

Formal communication includes conference papers, research and technical reports, journal articles and their preprints and reprints, and books. Some of these information products go through the peer review process. Examples of this literature may include preliminary reports of research in *Science* or a letters journal, product announcements in trade journals, reports written to satisfy funding agencies, review articles in scholarly journals, and books. Some disciplines emphasize one type of formal communication over others; others use the entire range.

Abstracting and indexing services cover a range of bibliographic tools from Wilson titles in print and online to review journals, catalogs, citation indexes and indexes to product catalogs, industry standards, and data sets. Abstracting and indexing services range from those aimed at a primary school audience to narrowly focused titles serving researchers in fluid dynamics. Resources on the Internet fit in here as well, such as amazon.com, fatbrain.com, and freetradezone.com. New technologies such as bots and spiders and push-and-pull technology are changing the way we look for informa-

tion, but these technologies are beyond the scope of this article.

Background information includes the remaining secondary and tertiary tools of a discipline: handbooks, directories, textbooks, and encyclopedias. Hybrid (Internet) portals that provide access to a number of types of information on a given area belong here as well. *ComputerSelectWeb* is a good example of this type of resource; it contains full text

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or abstracts of articles appearing in major computer industry journals and newspapers; descriptions and specifications of hardware and software products; and profiles of computer companies. Guides to the literature cover an entire subject area or are specific to an individual course and a particular collection. They can be arranged by subdiscipline or by type of resource. Moreover, they can be excellent resources in adapting the model discussed here for use in other subject areas.

This model describes the scientific and technical literature, but with some modification it can be useful in understanding most disciplines. Not every discipline requires the same circles, nor is the consumer of information products forced to follow each step in the journey to the information needed. After students become familiar with the models for their discipline, they can match their information need to the appropriate points on the circle.

**Focus on the User**

Users need models of real-world information so that they see the utility of the information resources in their course work and their careers. For instance, assignments given to students by their engineering and technology professors do not fit the model of doing "library" research

taught in college composition or speech classes. The questions students need to be able to answer demonstrate the importance of handbooks, standards and specifications, and manufacturer's literature. Instead, students are being taught a boilerplate method of library research that will not meet needs beyond those of initial classes. Melvin Voight identified and described three ways that scientists and engineers approach information: the everyday approach, the current approach, and the exhaustive approach.<sup>19</sup> He tied particular types of information resources to each approach.

#### *The Everyday Approach*

The everyday approach is when the individual needs a specific piece of information essential to his or her product, process, or project or to an understanding of that work. These are the fact questions (melting point, boiling point, modulus of elasticity, pinout, product, manufacturer) that library staff deal with in reference transactions in scientific and technical libraries when the researcher does not have the information in his or her office or lab. In effect, library staff working with the everyday approach engage in bibliographic instruction one person at a time. By embracing the educational mission of the college or university library, they tie the question with the appropriate fact tool rather than just answer the question. This interaction would improve the opportunity for success the next time that user encounters a similar information need.

#### *The Current Approach*

In the current approach, the individual attempts to keep abreast of developments in her or his field. Here, the researcher browses the research and professional journals in the field, talking to colleagues or attending seminars. Perhaps the researcher arranges for a table of contents service with a secretary, the library, or *Current Contents*. Databases and publishers' Web sites can automate the dissemination of new research through updates to saved searches or automated table of

contents services. The current approach, relying heavily on the invisible college and regular conference attendance, becomes vital to the research scientist and professional in almost every field. Students in the professions are encouraged to join professional societies and receive their publications to remain current, often through deeply discounted membership rates.

#### *The Exhaustive Approach*

The exhaustive approach is the focus of many of our bibliographic instruction efforts. Although this approach accounts for only a small percentage of the information needs of this group, it is where librarians concentrate their efforts.<sup>20</sup> This involves finding and checking through all relevant information on a given subject. This approach is used when a researcher starts work on a new investigation or is ready to report the results of that investigation in a paper. However, according to Voight, this approach is more important in the pure sciences than in the applied areas and is least important in engineering.

In an exhaustive search, every possible resource is exploited: periodicals, handbooks, reviews, treatises, bibliographic databases, and colleagues. Clearly, the user instruction efforts library staff make should keep in mind the discipline being served and the approach that best suits the need.

#### **Information Literacy Discussions**

Over the years, numerous attempts have been made to articulate and standardize the information skills needed by students. Hannelore B. Rader has been reviewing the user instruction literature for twenty-five years:

Throughout the 25 year period, academic librarians developed the concept of user instruction from library orientation to library instruction to course-integrated user instruction to information skills instruction.<sup>21</sup>



Many colleges and universities have an information literacy curriculum that guides instruction interactions. During the 1990s, one of the most written- and talked-about topics of discussion was information literacy. A quick search of *Library Literature* yielded 199 articles written between 1995 and the present. With publication of the *ACRL Information Literacy Competency Standards* in 2000, there will no doubt be many more.<sup>22</sup>

Poping Lin's article on information competencies for engineers takes its impetus from the Secretary [of Labor]'s Commission on Achieving Necessary Skills Workplace Know-How and research done in information-related behaviors of engineers at MIT.<sup>23</sup> The Department of Labor study includes as a competency "acquires and uses information." Lin proposed that instruction go beyond library research methods that serve the lifelong learner and move into information competency to produce professionals who can maintain an edge in today's highly competitive world. She encouraged librarians to move beyond the literature channel and into the other eight information channels used by this group: vendors, customers, external sources, technical staff, company research, group discussion, experimentation, and other corporate divisions.

With its focus on nonformal communication, technical reports, and vendor literature, the information literacy model proposed here can give engineering educators a structure and a process for information competency instruction that will maximize the student's chance of success when she or he goes into industry.

### The Model in the Twenty-first Century

Some might think that the recent developments in information technology would make this model obsolete. Subramanyam was resilient enough; he was able to foresee full-text resources and

the interactive nature of information in the twenty-first century. In the final chapter, he looked to the future and remarked on the impact the computer had already had on information delivery. He cited Martha Williams' four phases in the history and development of computerized databases:

In phase 4 ... electronic online access will be provided to databases containing texts of primary journals and abstracting and indexing services.<sup>24</sup>

The information packages described in Subramanyam's model have not changed; only the mode and pace of delivery has changed. Just as the pace of change has accelerated, the pace of the dissemination has accelerated. Preprints of conference papers and journal articles become available earlier in the process than ever before. Online preprint archives illustrate the tension present in scholarly communication today. In some disciplines, these online archives are recognized and accepted channels for scholarly publication; in others, they are not. Consequently, this will need to be taken into account by the librarian who wants to adapt the model for use in another subject.

### Conclusion

As in other bibliographies, the resources listed in *Scientific and Technical Information Sources* became dated quickly. However, the circular model Subramanyam presented in the first chapter is still vibrant and useful. It should remain a model studied by students of the scientific and technical literature because of the way it brings order and meaning to a very complex literature. Anyone with an interest in this literature recognizes the significance of the circular model almost immediately. It embeds the scientific and technical literature firmly in the community that produces it and describes the natural cycle of creating and consuming information.

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### Notes

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