



60 YEARS OF THE BEST IN INFORMATION RESEARCH

On user studies and information needs

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Abstract

Purpose – Apart from information retrieval there is virtually no other area of information science that has occasioned as much research effort and writing as “user studies”. Within user studies the investigation of “information needs” has been the subject of much debate and no little confusion. The aim of this paper is to attempt to reduce this confusion by devoting attention to the definition of some concepts and by proposing the basis for a theory of the motivations for information-seeking behaviour.

Design/methodology/approach – The paper describes the issues of user studies and information needs within the context of information science.

Findings – The paper finds that the problem seems to lie, not so much with the lack of a single definition, as with a failure to use a definition appropriate to the level, and purpose of the investigation.

Originality/value – The analysis may be used as a springboard to research based upon a wider, holistic view of the information user.

Keywords Information science, Information retrieval, User studies

Paper type Research paper

Introduction

Apart from information retrieval there is virtually no other area of information science that has occasioned as much research effort and writing as “user studies”. Within user studies the investigation of “information needs” has been the subject of much debate and no little confusion. The aim of this paper is to attempt to reduce this confusion by devoting attention to the definition of some concepts and by proposing the basis for a theory of the motivations for information-seeking behaviour.

The ideas in this paper have been developed over a number of years – in fact, since wrestling with the concept of “information need” with students at the University of Maryland in 1971! Oral presentations of earlier papers were made at an IBICT seminar in Rio de Janeiro and at a research seminar at Sheffield University Postgraduate School of Librarianship and Information Science, both in 1979, and I am grateful to the participants at these meetings for their discussion of the issues. Further, useful comments have been made on earlier drafts of this paper by three colleagues, Professor Wilfred Saunders, Norman Roberts and David Streatfield, and, most recently and very helpfully, by an anonymous referee. I am aware of the imperfections that remain, however, and accept full responsibility for them.

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Information

Part of the difficulty with “information needs” lies with the troublesome concept “information”. Numerous definitions have been evolved, seeking to distinguish, for example, among “data”, “information” and “knowledge”, and recently there have been attempts at a single concept of information for information science.

However, the problem seems to lie, not so much with the lack of a single definition as with a failure to use a definition appropriate to the level and purpose of the investigation. The word “information” is used, in the context of user-studies research, to denote a physical entity or phenomenon (as in the case of questions relating to the number of books read in a period of time, the number of journals subscribed to, etc.), the channel of communication through which messages are transferred (as when we speak of the incidence of oral versus written information), or the factual data, empirically determined and presented in a document or transmitted orally.

The situation is further complicated by the fact that distinctions may or may not be made among “facts”, “advice” and “opinion”. The distinction, of course, is that the first of these is assumed (not always correctly) to be free of value judgements, whereas value judgements almost certainly affect advice and opinion.

These multiple uses of the term “information” cause confusion because researchers sometimes fail to distinguish between one sense and another, or simply leave the reader to discover which sense is meant by reading the paper or report. Even then it is sometimes unclear which of the senses the researcher had in mind when setting the research objectives.

User studies

Figure 1 presents a way of thinking of the field, “user studies”; its aim is not to “model” information-seeking behaviour but to draw attention to the interrelationships among concepts used in the field. The figure suggests that information-seeking behaviour results from the recognition of some need, perceived by the user. That behaviour may take several forms: for example, the user may make demands upon formal systems that

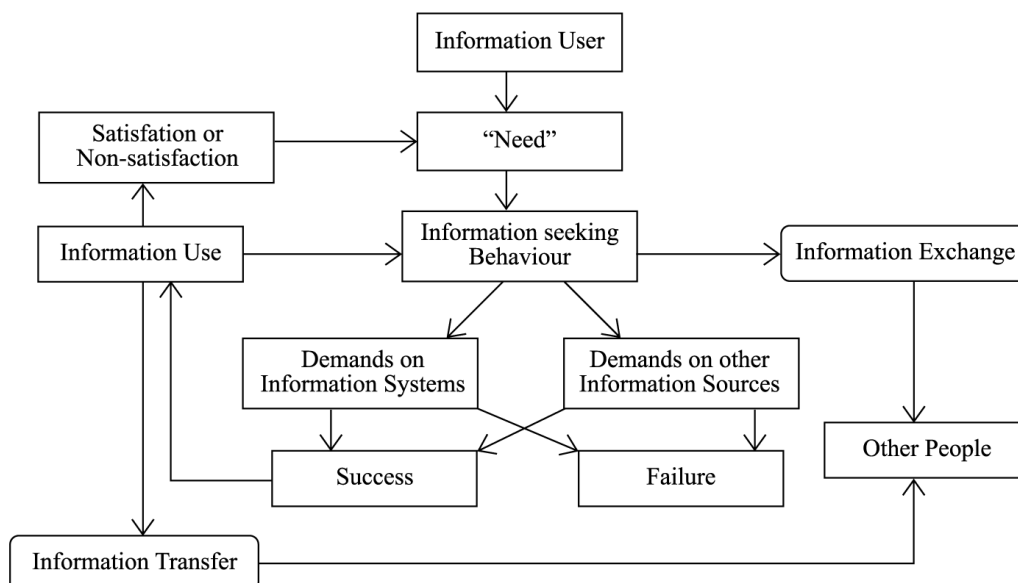


Figure 1.
A model of information
behaviour

are customarily defined as information systems (such as libraries, on-line services, Prestel or information centres), or upon systems which may perform information functions in addition to a primary, non-information function (such as estate agents' offices or car sales agencies, both of which are concerned with selling, but which may be used to obtain information on current prices, areas of "suitable" housing, or details of cars that hold their second-hand value).

Alternatively, the user may seek information from other people, rather than from systems, and this is expressed in the diagram as involving "information exchange". The use of the word "exchange" is intended to draw attention to the element of reciprocity, recognized by sociologists and social psychologists as a fundamental aspect of human interaction. In terms of information behaviour, the idea of reciprocity may be fairly weak in some cases (as when a junior scientist seeks information from a senior but hierarchically equal colleague) but in other cases may be so strong that the process is inhibited, as when a subordinate person in a hierarchy fears to reveal his ignorance to a superior.

In any of the above cases of information-seeking behaviour, "failure" may be experienced: this is indicated in the diagram for the use of systems but, of course, it may also be experienced when seeking information from other people.

Whatever the source of the information it will at some point be "used", if only in the sense of being evaluated to discover its relationship to the user's need. That "use" may satisfy or fail to satisfy the need and, in either event, may also be recognized as being of potential relevance to the need of another person and, consequently, may be "transferred" to such a person.

Although all of these areas are of potential interest to the field of user studies, attention has been given in the past chiefly to the demands people make upon formal information systems. Curiously, information use (which ought to point most directly to the needs experienced by people) is one of the most neglected areas; and "information exchange" as defined here has tended to fall within the sphere of interest of sociologists and organizational theorists rather than within that of information scientists.

"Information" in the figure may be understood in any of the senses mentioned earlier. Thus, in information exchange, an individual may be looking for facts, advice or opinions, and may receive any of these either in writing or orally. Sometimes the channel itself may be of overriding significance, as when orally given advice may be preferred over anything in writing. Again, a user may be interested in a specific document as a physical entity, as in the expression of a need to view variant copies of an incunabulum. In information transfer it may be a fact, an opinion or a piece of advice that is transferred orally, or a physical document "containing" the fact, opinion or advice may be given to another person. We can choose to study the facts, ideas, advice or opinions, or the nature and distribution of the documentary "containers". In any event, when the term "user study" is employed the specific sub-field should be specified, and the aspect or aspects of "information" under consideration should be defined.

Information needs

Within the field of user studies the investigation of "information needs" has presented seemingly intractable problems. If we date user studies from 1948 and the Royal Society Scientific Information Conference (Royal Society, 1948), with its several surveys of users' information-seeking behaviour, then the progress towards some

theoretical understanding of the concept of “information need” has been slow. This fact is recognized by virtually every commentator on the subject from Menzel (1960); and Paisley (1965) through the various authors in the ARIST volumes, to Ford’s review of 1977. As well as drawing attention to this fact, the authors have tried to discover why it is so and have generally concluded that the reason lies in inadequate methodology and the failure to do research that is “cumulative”. Attention has also been paid to the definitional problem of “information need”[1] and the difficulty of separating the concept from “wants”, “expressed demand”, “satisfied demand” and so on. However, while much of this work is very useful, the problem remains generally unresolved.

Partly, this is the result of a failure to identify the context within which information needs investigations are carried out. Figure 2[2] is an attempt to show some of the possible contexts. (Figure 1 may be thought of as a sub-graph of Figure 2, centred on the user.) It is difficult in any two-dimensional diagram to convey the complexity of the “real” world and abstract elements of that real world. The “universe of knowledge”, for example, is an abstract concept, which embraces all knowledge-related objects, events and phenomena and, as such, clearly interacts with the “physical universe”. To show the complex interactions of the physical and abstract universes, however, would involve a multi-dimensional diagram which would be extremely difficult, if not impossible, to express upon a sheet of paper. Accepting that difficulty, however, the “user’s life world” can be defined as the totality of experiences centred upon the individual as an information user. Within this life-world one important sub-world will be the world of work, within which will exist various “reference groups” with which the user identifies: fellow professionals, the peer group within an organization and so on.

The user will be in contact with a variety of “information systems”, only one of which is shown in the diagram, hence the indicated overlap with the user and his life-world. Within the information system two subsystems are shown: the “mediator” (generally a living system, i.e. a human being) and the “technology”, used here in the

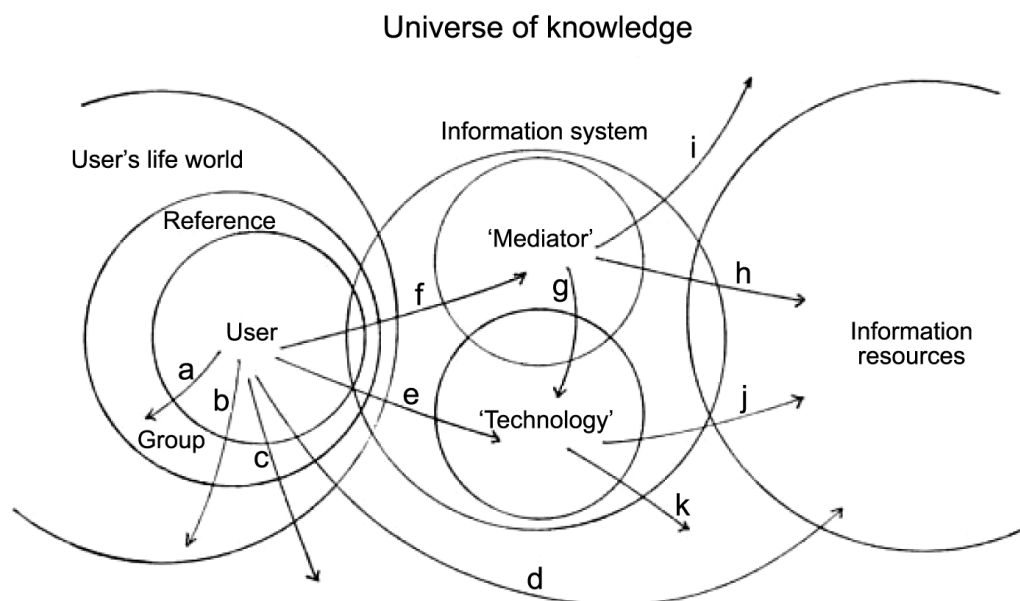


Figure 2.
The context of information seeking

general sense of whatever combination of techniques, tools and machines constitute the information-searching subsystem.

The information system must have access to various “embodiments of know-ledge”, phrased in this general way to indicate that such embodiments may be documents or living people.

The lettered paths on the diagram are intended to show some of the possible search paths that may be used by the information seeker directly or used on his behalf by the information system and its subsystems. The paths are not comprehensive of all possible search paths; however, they do identify four relevant groups:

- (1) Paths a, b, c and d identify search strategies by a user independent of any information system, and will be referred to as “Category a” paths.
- (2) Paths e and f identify search paths involving either a mediator or an information system’s technology (manual card file, computer terminal, etc.) – Category b paths.
- (3) Paths g, h and i identify search strategies employed by a mediator to satisfy a user’s demand for information – Category c.
- (4) Paths j and k identify strategies employed by a sophisticated technology on behalf of either the user or the mediator – Category d. As an example of this latter category, a system could be envisaged in which a computer network could be searched at the initiative of any computer, which is a member of that system. The network might include files of knowledge in the process of creation, such as research data files, computer conference files, etc.

If we choose to investigate any of these categories of search strategies we are clearly investigating “information-seeking behaviour” rather than the user’s need for information. Equally clearly, our motives for investigating search processes may be to make inferences about need, or it may be to uncover facts relating to other variables related to the design, development or adaptation of information systems.

Thus, we may wish to investigate Category a strategies to discover whether they are undertaken in ignorance of formal information systems, or because they are more efficient (for example, simply in terms of speed of delivery of a response) or more effective (for example, in terms of the quality of the information provided, or its currency). Such studies may never address the central question of “information need”, that is, why the user decides to seek information, what purpose he believes it will serve and to what use it is actually put when received. However, the data derived from such studies may be of considerable use in discovering whether it is possible to redesign existing formal information systems so that they are more efficient or more effective.

Similarly, the search processes involved in Categories b and c may be studied to find out how efficiently the mediator, or the “technology”, is performing, and Category d searches may be studied for similar reasons.

As noted above, the study of information-seeking behaviour can stand on its own as an area of applied research where the motive for the investigation is prag-matically related to system design and development. A different motivation is involved if we wish to understand why the information seeker behaves as he does. This is an area of basic research and, although the resulting knowledge may have practical applications, there is no necessity that it should.

However, many (if not most) “information scientists” are practitioners in information work or information systems management, and they look to studies of information “needs” for guidance on aspects of systems design, development and operation. A confusion then arises between what is intended by information needs research and what is expected of such research. As a consequence, basic research may fail to be funded because referees do not find in the proposals indications of potential practical applications, which were never intended by the researcher.

There is another confusion, possibly more basic, in the association of the two words “information” and “need”. This association imbues the resulting concept with connotations of a basic “need” qualitatively similar to other basic “human needs”. However, if we examine the literature on human needs we find that this concept is divided by psychologists[3] into three categories:

- (1) Physiological needs, such as the need for food, water, shelter, etc.
- (2) Affective needs (sometimes called psychological or emotional needs) such as the need for attainment, for domination, etc.
- (3) Cognitive needs, such as the need to plan, to learn a skill, etc.

It will be quickly recognized that these three categories are interrelated: physiological needs may trigger affective and/or cognitive needs; affective needs may give rise to cognitive needs; and problems relating to the satisfaction of cognitive needs (such as a failure to satisfy needs, or fear of disclosing needs) may result in affective needs (for example, for reassurance). These interrelationships are shown in Figure 3, which suggests that, as part of the search for the satisfaction of these needs, an individual

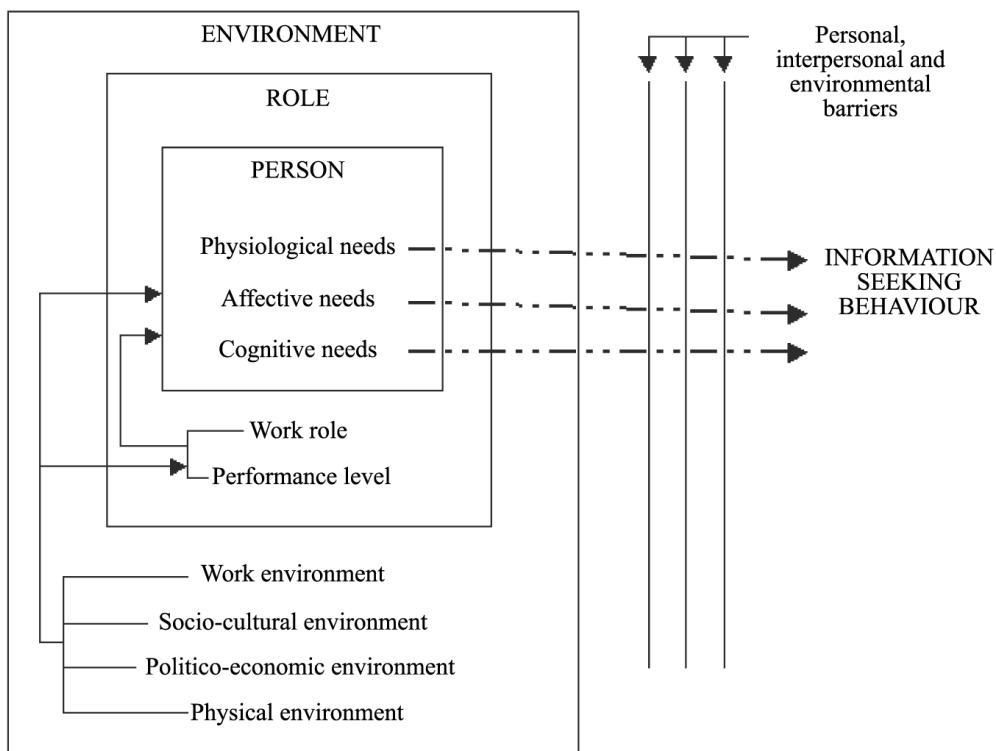


Figure 3. Information needs and seeking

may engage in information-seeking behaviour. Indeed, it may be advisable to remove the term “information needs” from our professional vocabulary and to speak instead of “information seeking towards the satisfaction of needs“.

This is not to suggest that some affective or cognitive need will immediately “trigger” the response of information seeking. Many factors other than the existence of a need will play a part: the importance of satisfying the need, the penalty incurred by acting in the absence of full information, the availability of information sources and the costs of using them, and so forth. Many decisions are taken with incomplete information or on the basis of beliefs, whether we call these prejudices, faith or ideology. So, information-seeking may not occur at all, or there may be a time delay between the recognition of the need and the information-seeking acts; or, in the case of affective needs, neither the need nor its satisfaction may be consciously recognized by the actor; or a cognitive need of fairly low salience may be satisfied by chance days, months or even years after it has been recognized, or the availability of the information may bring about the recognition of a previously unrecognized cognitive need. These factors are crudely represented in Figure 3 as personal, interpersonal and environmental barriers to information seeking.

If we take the earlier analysis of the ways in which the word “information” is used we can see that the different senses are more or less related to the above needs. Thus – the factual data, or subject content, of a document may satisfy cognitive needs, and this is the usual sense in which we think about the use to which information is put. The attempts at single definitions of “information” are also couched solely in cognitive terms. For example, Belkin (1978), notes that his concept of an information recipient’s “anomalous state of knowledge” leads to “an explicitly cognitive view of the situation with which information science is concerned” (p. 80) and Wersig’s (1971), view of information as reduction in the uncertainty involved in problematic situations similarly connotes cognitive changes in the recipient of a communication. However, as Hollnagel (1980), writes:

Information science is concerned with the use of information by humans ... And it is concerned specifically with the way in which humans search for information, systematically as well as unsystematically. The basis for information science is therefore to be found in our experience of using and searching for information ... (p. 184).

Because the situations in which information is sought and used are *social* situations, however, purely cognitive conceptions of information need are probably adequate for some research purposes in information science, but not for all. Information may also satisfy affective needs, such as the need for security[4], for achievement, or for dominance:

- The channel of communication, particularly the choice of oral channels over written channels, may well be guided by affective needs as much, if not more than, by cognitive needs. For example, in seeking information from a superior, someone may be more interested in being recognized and accepted as a particular kind of person than in the actual subject content of the message; in other words, he may be seeking approval or recognition. The oral transfer of information to others may also be done for affective reasons; for example, to establish dominance over others by reminding them that you are better informed and, therefore, in some sense superior.

- The physical document may satisfy an affective need, as when someone collects rare bindings, or illustrated books, because of their beauty. Under extreme circumstances documents may serve physiological needs, as when the tramp on the park bench covers himself, with newspapers, to avoid freezing to death.

If, as suggested here, the full range of human, personal needs is at the root of motivation towards information-seeking behaviour, it must also be recognized that these needs arise out of the roles an individual fills in social life. So far as specialized information systems are concerned, the most relevant of these roles is “work role”, that is, the set of activities, responsibilities etc. of an individual, usually in some organizational setting, in pursuit of earnings and other satisfactions[5].

At the work-role level it will be clear that the performance of particular tasks, and the processes of planning and decision-making, will be the principal generators of cognitive needs; while the nature of the organization, coupled with the individual’s personality structure, will create affective needs such as the need for achievement, for self-expression and self-actualization[6]. The particular pattern of needs and the resulting form of information-seeking behaviour will be a function of all of these factors, plus factors such as the organizational level at which a role is performed and the “climate” of the organization[7].

Again, the search for determining factors related to needs and information-seeking behaviour must be broadened to include aspects of the environment within which the work-role is performed. The immediate work-environment and its “climate” has been mentioned above, but the socio-cultural environment, and the physical environment, will all have an impact in particular ways. The relationships will be too numerous to detail here, but examples can be given:

- The economic climate and the differential stratification of resources will define some work environments as “information-poor” and others as “information-rich”, with consequent effects upon the probability of information-seeking behaviour and the choice of channel of communication.
- The political system may define certain types of information as forbidden to particular groups (including the general public) and, consequently, the non-availability of this material may affect performance in specific work roles.
- The physical environment will have a clear effect upon the nature of some categories of tasks and upon the consequent cognitive needs. For example, questions emerging out of drilling for oil in the North Sea are likely to differ in many cases from those that emerge out of drilling in Saudi Arabia.

Figure 3 shows the probable interrelationships among personal needs and these other factors, the aim of which is to suggest that when we talk of users’ “information needs” we should not have in mind some conception of a fundamental, innate, cognitive or emotional “need” for information, but a conception of information (facts, data, opinion, advice) as one means towards the end of satisfying such fundamental needs. In the past a great deal of user studies research has suffered from a concentration on the means by which people discover information (often analysed in terms of the information researcher’s view of how the user ought to have been seeking information) rather than upon the ends served by the information-seeking behaviour. It is this bias in past research that has led to dissatisfaction with the results of user studies research, since the service implications of the results have been far from clear. There are, of course, exceptions; the Baltimore study of the information needs of the ordinary citizen

avoided the means versus ends trap by building the interview schedule around the idea of problems experienced in everyday life, for which information-seeking using formal information systems might or might not be appropriate. What emerges from the Baltimore study is certainly compatible with the view presented in this paper but, again, information needs are presented in largely cognitive terms (although the existence of non-cognitive barriers is recognized) and the affective dimension of the user's situation is lacking.

Consequences

The analysis presented above is not intended to be merely definitional; the aim is to suggest that the analysis may be used as a springboard to research based upon a wider, holistic view of the information user. In such a wider view the individual would be perceived not merely as driven to seek information for cognitive ends, but as living and working in social settings which create their own motivations to seek information to help satisfy largely affective needs. There would need to be a consequent shift in the focus of research from an examination of the information sources and systems used by the information-seeker to an exploration of the role of information in the user's everyday life in his work organization or social setting.

The consequences of a shift in focus could be fundamental for information research in at least three respects. First, there are consequences for the methods to be employed in research. The vast majority of studies of "information needs" has been conducted under a relatively crude conception of the "scientific method", using self-completed questionnaires as the main data-collection instrument. Social researchers of many kinds have become disenchanted with this model of research and are turning increasingly to a consideration of "qualitative research" either as a complete alternative to quantitative research or, at least, as a preliminary[8]. The methods employed in qualitative research overlap to some extent those of traditional "quantitative" research in the social sciences in that they include interviewing, but qualitative research is likely to use less formally structured interviewing procedures and may, in addition, use methods such as observation, free-flowing discussion, and the analysis of documents (personal or organizational) and conversational analysis. Under one school of thought, "Qualitative research . . . is concerned with developing concepts rather than applying pre-existing concepts", and given the state of theory in information science (that is, its undeveloped state) it can well be argued that "developing concepts" is what is needed. Qualitative research seems particularly appropriate to the study of the needs underlying information-seeking behaviour because:

- Our concern is with uncovering the facts of the everyday life of the people being investigated.
- By uncovering those facts we aim to understand the needs that exist which press the individual towards information-seeking behaviour.
- By better understanding of those needs we are able better to understand what meaning information has in the everyday life of people.
- By all of the foregoing we should have a better understanding of the user and be able to design more effective information systems.

The second consequence for information research of the proposed shift in focus is that, before a generally applicable theory of information-seeking behaviour can be evolved, the context of the research must be narrowed so that crucial determining factors can be

identified and analysed. There can be little use, for example, in a national survey of the “information needs” of any group (chemists, botanists, economists, etc.) if members of these groups are undertaking widely differing kinds of tasks in totally different organizations with varying levels of information provision. If we wish to uncover the determining factors of behaviour we must do so by first undertaking in-depth studies of well-defined categories of persons, developing explanatory concepts and then testing these concepts in related but different settings.

The third consequence for research would be a need to widen our conceptual perspectives of the user and his behaviour. It seems unlikely that information-seeking behaviour can be explained by purely “information” concepts. Belkin notes that:

The most commonly proposed information concept for information science . . . is that of Shannon . . . This is hardly surprising, since Shannon’s information concept is almost the only formalized, mathematical, and successfully implemented concept ever proposed for any purpose (p. 66).

However, the communication model proposed by Shannon, with its elements: source, channel, message, coder, decoder, receiver and noise, was never intended as an information-science model nor as a behavioural science model, and, consequently, can tell us nothing about the information user and his needs. The concepts we need for explanation, or for development within our own emergent discipline, multi-discipline, or whatever it may be, need to be drawn from psychology, social psychology and sociology, as much as from communication theory.

There are other consequences for information science defined here as a multi-disciplinary field rather than as a single-discipline, theoretical science. Roberts (1976), has drawn attention to the need to pay more than lip service to the suggestion that, in some respects at least, information science is a social science. The proposed shift of focus suggested here would support that proposition by insisting upon the more intelligent use of social research methods for the development of models from the point of view of the philosophy of social (rather than physical) science. It would require that such models pay more attention to the behavioural and organizational contexts of information seeking than hitherto, and to the totality of types of information resources and information transfer mechanisms. Information science is likely to make more progress in this way than by seeking to evolve on the basis of physical science notions of a discipline alone.

An “information science” firmly founded upon an understanding of information users in the context of their work or social life is also likely to be of more use to the information practitioner, by pointing the way to practical innovations in information services, and to potentially beneficial associations with other communication or information-related subsystems. It does little injustice to the historic record to suggest that information services have developed more by copying previously existing examples than by genuine analysis of the needs of potential users. In particular, the transfer of techniques from special libraries in science and technology to information units in the vastly different environments of public service bureaucracies, voluntary organizations, business concerns and central government, has been carried on without any serious questioning as to whether these different contexts of information provision require different means of service delivery or, indeed, whether information itself needs re-definition. An orientation towards the user in the true sense, that is, avoiding preconceptions about what he or she will perceive to be “information”, while concentrating upon the problems that create cognitive and/or affective needs, must

result in a greater humility about the potential value of traditional information practices and a greater willingness to innovate and experiment.

The result of a more truly user-oriented, innovative, experimental information profession should be a reduction in the marginality of information service. Scientific research generally recognizes the significance of services which provide access to the external research literature, but when such services are adopted by different kinds of organization with little or no adaptation in the light of a proper analysis of the needs of users or of their relationship with organizational communication systems, information services become increasingly marginal to the organization's functioning. Evidence for this can be found in industry, where, when economic pressures have been intense, numerous special libraries and information systems have been abolished or subject to severe staff redundancies.

The answer to this does not lie simply in manoeuvring for a more central reporting position in the organization, but in analysing the total range of information services that may be appropriate to meeting the needs of members of the organization. In all probability this may mean closer association, to the point of merger, with other organizational subsystems that have an "information" mission – indeed, as a result of developments in information technology, the trend has already begun.

There are, finally, consequences of all of the foregoing for "information science" as a profession and for professional education in the field. No sooner had information science (in this professional sense) emerged out of special librarianship, than it found what appeared to be the central ground occupied by computer scientists, system analysts, management information system designers, and most recently, database entrepreneurs. Soon, office automation through word-processors and other applications of micro-technology will be extending their influence into areas information scientists, as practitioners have believed to be theirs. The only sensible response to this is a widening of the concept of the "information profession" and an acceptance of the need for consultation and co-operation with other groups, the better to serve the needs of the information user. That there is potential for this can be seen in the increased disenchantment with crudely designed management information systems and the increased awareness that, in designing such systems, the technology involved is only part of the total system, and that the user, hitherto somewhat neglected, is an important element[9].

As for the impact on professional education, there are several things to consider. First, if the social situation of the user is as significant as suggested in this paper, and if the need for more care in the use of social research methods (both quantitative and qualitative) is accepted, then curricula should become more concerned with the social and organizational contexts of information-seeking and information use, and should pay more attention to general theories of communication (mass media, organizational, person-to-person), and to social research methods and their philosophical basis.

However, if a shift takes place towards a new information profession, revision of existing curricula in information science will not be enough and, certainly, the mere addition of one or two courses to a curriculum will be far from sufficient. The members of that wider profession will be drawn from many disciplines, and the most fruitful development (and, in these hard times, possibly the most cost-effective) could be the incorporation of "information science" subjects into the graduate schools of a variety of different disciplines. With luck this could be achieved by designing joint programmes with other departments within a teaching institution, coupled with increased service teaching to undergraduate courses in particular fields. If this development does not

take place, that is if planning does not begin now or in the near future, the result may be a gradual diminution of the role of schools of librarianship and information science in the education of the new information professional.

Notes

1. See, for example, Line (1974, p. 87); Roberts (1975); and, for a philosophical view drawn to my attention, by Colin Harris: White (1974).
2. An earlier version of this diagram was used by the author in a discussion at IRFIS 3, Oslo, Norway, 1979, and was modified as a result of the participants' comments. It has been further modified since that meeting.
3. See, for example, the entry for the word "need" in *Encyclopaedia of Psychology* (Eysenck *et al.*, 1972).
4. The significance of affective needs was first drawn to the author's attention when carrying out evaluation interviews with the users of a current awareness bulletin; see Wilson (1979).
5. It is recognized, of course, that social roles other than work role may influence information system design in other contexts. Thus, a citizens' information service ought to be designed in full awareness of the implications for information seeking of social roles such as house-owner, tenant, parent or voter.
6. See, for a review of the literature on motivation and work: Katz and Kahn (1978).
7. "Organizational climate" is a rather fuzzy concept (see, for a review, Payne and Pugh (1976), and whilst work conducted in some types of organization indicates a relationship between climate and information-seeking behaviour, e.g. Olson (1977), other work finds no such relationship, e.g. Wilson *et al.* (1979).
8. Evidence for this interest has appeared in many sources from the emergence of "ethno-methodology" in the late 1960s (Garfinkel (1967) to Douglas (1976); and, more recently, in a symposium on the subject organized by the Social Science Research Council (Baxter, 1979a) and another symposium (Baxter, 1979b).
9. See, for example, Lucas (1975).

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