Information Science: Toward the Development of a True Scientific Discipline

It is pointed out that if information science is to be considered a "true" science similar to physics or chemistry then it must have a set of concepts and analytical expressions which apply to the flow of information in a general way. Such expressions should be relatively independent of the particular context or application under consideration. Definitions of a rigorous nature for the fundamental quantities involved must be established. These must have general applicability and must be related to other known and measurable quantities. It is desirable also that they be capable of quantification. In several previous papers, the author and a colleague have described a model of a generalized information system which has wide, and perhaps universal applicability. This paper elaborates on this model and indicates the range of its applicability. Several fundamental quantities are defined specifically in a way which allows for quantification. It is pointed out in this paper that this model can be the basis for the development of a "true" science of information with all of the necessary requirements for a science. By the use of this model and the definition of a "true" science, the goals and requirements for a curriculum in information science are thus established. Various applications of information science must then exist in much the same way that many applications of physics exist. In the latter case, the applications usually give rise to various branches of engineering. In the case of information science, one of the applications is librarianship—although many others exist as well. Some of these are referred to in the paper. In particular, science information as a subset of information science is discussed. Within this context, information is defined as data of value in decision making. Quantitative measures of information can be obtained by relating information to specific observable actions which can be measured physically.

M. C. YOVITS

Department of Computer and Information Science
The Ohio State University
Columbus, Ohio 43210

• Introduction

In several previous papers which are referred to subsequently, the author and a colleague have described a model of a generalized information system which has wide and perhaps universal applicability. It was proposed that the science of information or "information science" can be viewed as the study of such generalized systems. It is the purpose of this paper to elaborate on the generalized model proposed, to indicate and extend the range of applicability of the model, to explain how the model can be used as the basis for a "true" science, and to define the goals and requirements of a curriculum in information science accordingly.

The term "science" has been, over the last few years, loosely applied to a number of different fields which have not classically been considered as sciences. For example, in addition to information science, there is computer science, library science, management science, administrative science, military science, space science, as well as many others. No real thought is generally given to the significance of calling a field of study or research a science. Frequently, what is of concern is generally a field of endeavor in which people of reasonably common interests are participating. The term science is appended without any real understanding of the implication, meaning, or significance of using this term.

* Research sponsored in part by the National Science Foundation through grant No. GN-534 from the Office of Science Information Service to the Computer and Information Science Research Center, The Ohio State University.

We will leave in detail to the philosopher of science or the historian of science the specific requirements or sufficient conditions for a field to be called a science. However, it is clear that there are a number of necessary conditions. There are also clearly a number of desirable conditions which should be fulfilled.

It is necessary, of course, that there must be some distinguishable body of knowledge. This condition generally is fulfilled when a group of people of common interests are working on problems of similar nature. However, this is not a sufficient condition to declare a field a science. There must be in addition some general concepts and principles and analytical expressions which are either known or believed to exist that define the boundaries of the science. These relationships should be general and they should be relatively independent of the various applications of the discipline. It must certainly be possible to establish, and to define rigorously in some way the fundamental quantities involved. The quantities should be measurable. It is also desirable that they be capable of quantification and also be definable in terms of other known and measurable quantities. These definitions naturally must be amenable to the scientific method which implies that under identical conditions an experiment will always give identical results. These are, of course, not the *only* necessary and desirable conditions and are probably not themselves sufficient to define a field of science rigorously. They are, however, conditions which must be addressed.

As an example of a scientific discipline—which of course satisfies the conditions referred to above—we may consider physics. The science of physics can be defined as the study of matter and energy. There are a number of fundamental laws, concepts, and relationships which govern and define the field of physics in a very general way. There are such relationships as Newton's laws of motion, Maxwell's equations, the Hamilton-Jacobi equation, and so on. By means of these relationships it is possible to establish the essential boundaries of physics. It is also possible by means of these laws to determine and then to define and to measure unambiguously the fundamental quantities of the science: mass, time, distance, energy, etc.

It must also be clear that if a fundamental science exists then there must indeed generally be a number of different applications of the science which utilize the same general principles. These applications may stress different types of relationships, they may have environmental conditions which are greatly different, they may utilize different significant numerical values of the fundamental parameters, but they are all applications of the same science. In the case of physics, these relationships are, by and large, the various fields of engineering.

Thus, in defining the existence and extent of a science it is important at least to consider the various possible applications of that science which may be of interest. This feature will be treated in connection with the science of information later in this paper.

With regard to information and information science, these terms have been used in a variety of ways for many years now. They are used loosely, and largely in an undefined and frequently ambiguous sense.

Of course, information is sometimes used rather specifically in the sense that Shannon and Weaver (*1*) had established in their treatment of "information theory." In this sense the context of the message is of no significance and the theory is concerned with the probability of the receipt of any particular message for various conditions of the transmission system.[1] While this may be of some interest in information science it is certainly not the major nor even a very large part of information science. Such a treatment does not consider the really important areas of concern, almost all of which are involved with the context and meaning of the message.

On the other hand, information is frequently, if not generally, considered to be almost synonymous with "knowledge." It is by and large in this context that information scientists are concerned with information. It is also essentially the public understanding of the meaning as well. As in, "May I have some 'information,' please."

Although in the Shannon-Weaver sense information is indeed a quantifiable, measurable, and rigorously defined term, it has rather limited applicability. In the more general sense, although the applicability is almost universal, these qualities do not apply. Further, it seems unlikely to the author that any generalized relationships can ever be developed which are meaningful with this wide and rather nebulous definition of information. It is shown in detail later in this paper how an attempt to develop a slightly less general definition of information can give rise to a rigorously defined term which meets the requirements and desiderata indicated earlier.

If the definition of information is nebulous, varied, and nonrigorous, then the definition of information science is even more nebulous, varied, and nonrigorous. Perhaps it would be more appropriate to use the word "understanding" rather than "definition," inasmuch as few serious definitions of information science have been proposed. Without any type of a suggested formal definition, it is generally understood by the information science "community" that information science is the science concerned with the handling of information. This does not impart a great deal of information—in any sense—inasmuch as there are no acceptable general definitions of information. Furthermore, in some of the senses mentioned earlier, it is

[1] Shannon and Weaver point out in their introduction, "The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning;* that is, they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen, since this is unknown at the time of design."

yet to be shown that the formalism of a science really does exist, and if so what kinds of relationships and analytical expressions can be expected.

In addition, different scientists and practitioners involved with information science have a number of different ideas of what information science and its applications really consist of. Some look upon information science as being synonymous with library science (another science of a dubious nature). Others look upon information science as being the basic component, with librarianship as the applied component. Still others look upon information science as a basic science with many applications. Some consider information science to be synonymous with computer science, etc.

Is it, then, any wonder that there is a fundamental difficulty in establishing a generally accepted, basic, or even an applied curriculum in information science?

As mentioned at the beginning of this paper, the author and a colleague have described a model of a generalized information system which has wide and perhaps even universal applicability (*2, 3, 4*). This model will be described in considerable detail below. It will further be shown that this model is at the very heart of information science and can be used as a generalized model for defining not only information and information science but other fundamental quantities as well.

One of the motivations for the development of this model of a generalized information system was the desire to establish analytical relationships which have as wide applicability as possible. These analytical relationships may be used to generate principles and limitations of the flow and transfer of information. This model may also be used to define fundamental quantities involved in information flow, including information itself in a quantitative, rigorous, measurable, and repeatable way. These quantities are defined specifically in terms of physical and measurable quantities. In other words, it is shown that this model may be used as the basis for an information science which has wide and almost universal applicability. Indeed, insofar as potential applications are concerned, it does have universal applicability.

As has been pointed out above, the kind of definitions and relationships established by Shannon and Weaver is far too restrictive to be of general interest in the consideration of information science. On the other hand, defining information to be synonymous with knowledge—while this would be almost the broadest view that could be taken—is far too broad to lead to principles and relationships that are in some sense meaningful and useful. Given these considerations it was desired—as in any mathematical theory—to develop relationships which have as wide generality as possible, although with perhaps somewhat less than general applicability.

The questions are naturally asked, "Why is information disseminated? What is the reason for the development of information systems? Is it simply to spread knowledge?" Although the spreading of knowledge for its own sake is certainly a worthy endeavor, it must sometimes be put to some use. That use is to assist in making decisions. It then becomes clear that *information is used in order to make decisions*. Indeed, the *only* resource that is available to a decision maker is information, nothing more.

The suggested definition of information which provides the basis for this model which we are describing is *information is data of value in decision-making*. While this may delimit the total range of interest in an intellectual sense, it does have virtually universal applicability with regard to any potential applications. Further, it is claimed that any more general definition is not amenable to the quantification and the conceptualization necessary in order to establish a real science.

In the physical world, the only way in which a real parameter, say a mass or a velocity, can be measured is by an interaction with the environment. If this interaction does not exist then it is impossible—almost by definition—to measure a quantity or even to establish its existence. One can make the same statement about information. Without some type of interaction with the environment it is not possible to measure or even to know of its existence. This interaction will result in some type of a physical action which is measurable, or more precisely—observable.

Such a physical action or *observable action* will take place as a result of the decision-making process apparatus. The decision maker will recommend courses of action which are in turn executed into some set of observable actions. Since the decision maker—as previously indicated—makes his decisions solely on the basis of the information he receives, it is clear that this is the mechanism by means of which information is transformed into physical, observable actions.

The class of situations not encompassed by this model, namely, the kinds of situations where knowledge or data are transmitted without any eventual anticipation of being put to use by a decision maker may have some intellectual interest. This class of situation would appear, however, to be of little other interest. It is inherently sterile, and by its very nature will cause no interaction with the environment, thus making it logically impossible to say anything quantitative about it.

Thus it is suggested that the model to be described is sufficiently general to encompass all situations of interest. Further, it is suggested that the model represents a situation which is as general as can be represented and still establish meaningful analytical relationships describing information flow.

• The Generalized Model

The model of the generalized information system which is being referred to is shown in Fig. 1.

The system is comprised of four essential functions. There is an *Information Acquisition and Dissemination*

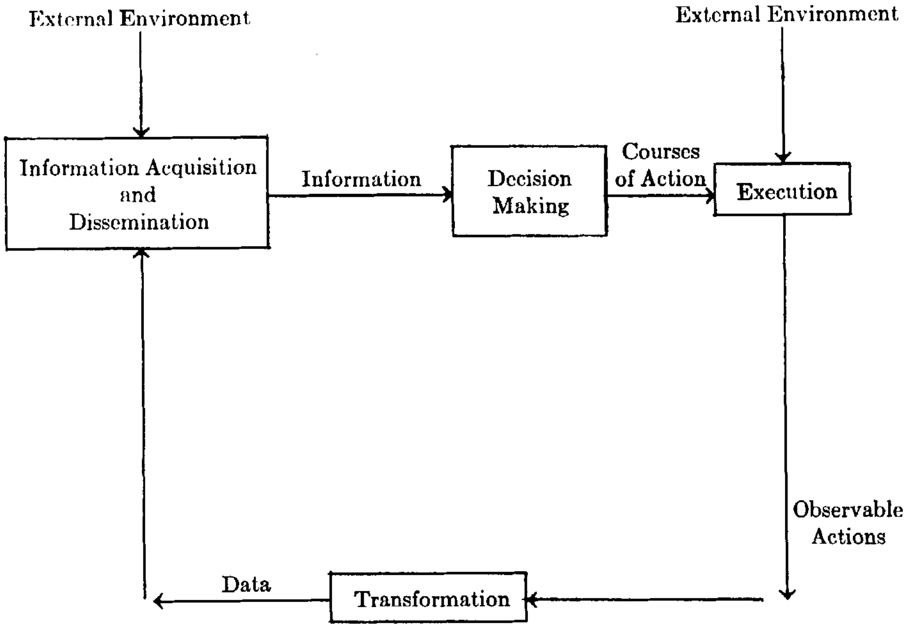

FIG. 1. Generalized information system

function (IAD), a *Decision Making* function (DM), an *Execution* function (E), and a *Transformation* function (T). As has been pointed out, virtually all situations involving the flow of information can be described by this model. These situations would include the use of information by the research scientist or the development engineer, management of a large corporation, command and control of a military engagement, or such relatively straightforward and simple activities as the switching on or off of a thermostat-furnace system.

Personal decision-making problems are described by Fig. 1. It is not even necessary or required that the decision-making process be a logical one. This model is applicable when decisions are completely irrational, as may be the case frequently. Each function is seen to collect, store, operate, and disseminate.

In any realizable and operational system all the indicated functions must be present. Further, they must be considered together in order to understand information flow or in order to establish principles, relationships, or guidelines for information flow. Just as in the analysis of any system, suboptimization or consideration of the functions independently may yield misleading or incorrect results.

In particular, the DM function is a most important one and is established as the key consideration in the entire information flow process, as has been previously indicated. The DM function represents any system component accepting an input from the IAD, and providing an output to E. The DM may be an individual person, an organization, a man-machine system or simply a machine system. In all of these cases, the DM transforms information into courses of action which are in turn transformed into observable actions. The input to the DM is information, some of which may be stored or held in memory. The DM makes decisions on the basis of the information available at some particular time. However, it is assumed that decisions are always made individually, serially, sequentially, or in parallel. Of course, the decision-making process may be delayed. This is usually the case when more information is necessary. By and large, however, the decision maker is responsible for the generation of observable actions and will eventually make decisions that will lead to these actions, as discussed earlier.

A very significant point concerns the closing of the feedback loop to the DM. In any system this loop must be closed to provide a basis for retaining or altering the courses of action disseminated and it is only on this basis of closure that the DM is able to refine or alter decisions intelligently. Such feedback is always present whether or not it is explicitly considered. Most of the presently designed so-called "information systems," however, do not consider feedback or closure to the decision maker in meaningful ways. The loop in the system is closed by the transformation of the observable actions generated by means of appropriate measuring devices into data transmitted to the IAD which are in turn disseminated to the DM.

Since information is supplied *only* in order that a decision maker can make decisions of some kind, it is most appropriate to analyze our model by starting with that particular function. The DM, as has been pointed out, may be a complex of men and machines, or it may be a single individual, or it may be solely a machine. It *collects* information from the IAD. Three basic kinds of information are collected. There is information on the particular activity under consideration (that is, data which have been obtained by transforming the observable actions resulting from operations of the E function). There is information on the external environment over which the decision maker has no control but may have knowledge. There is also other fundamental information which the decision maker may utilize. This latter category includes reports, tables, mathematical and physical constants, and appropriate relationships. The DM *stores* a data base or memory.

The DM *operates* in the following three ways. It develops a predictive model which it believes will transform the information received into the appropriate observable actions. This model developed by the DM may be an accurate one or it may be incorrect. It may even be irrational or illogical. Nevertheless, it is the way in which the DM believes that the only resource available to it, namely, information, will be transformed to observable actions. It is only after further information is available from transformations of these observable actions into data that the DM "knows" whether its model is an accurate one or not. Secondly, the DM may alter recommended courses of action using the same predictive models as further information regarding the particular activities involved or the resulting observable actions become available. Thirdly, the DM may develop new models as further information becomes available either concerning the observable actions or the external environment. In this situation the original model was incorrect or inadequate regardless of the courses of action suggested.

The DM *disseminates* courses of action (results of decisions) which are communicated to the E function.

The E function is responsible for transforming decisions into observable actions. It *collects* courses of action from the DM and perturbations from the external environment. If it were not for these perturbations from the external environment, E would be essentially deterministic and would transform decisions in a predictable way into observable actions. It is largely the action of the external environment which provides the inherent uncertainty in the process of transforming information into observable actions. There is also "internal noise" which introduces fluctuations into the observables.

The E function *stores* nothing other than its structure or design and has no memory *per se*. It is strictly a transforming process. It operates by transforming decisions into observable actions. Note that in many situations, some or even all of the functions of E may be subsumed by the DM. However, in this case the decision maker is not acting purely within the DM capacity.

Observable actions or observables are quantities which are physical in nature. As the term implies they are capable of being observed or measured. They are neither data nor information, but are *capable* of being transformed into data. This distinction is an important one conceptually. Some examples of observable actions are the heat generated by a furnace, the position of an aircraft, results of a scientific experiment, a new product developed by a manufacturing firm, or the movement of men and equipment in a military engagement. These are physical quantities, in themselves neither information nor data.

In order to become data or information, observable actions must be transformed. This is accomplished by the function which, for want of a better name, is called the T function. The T function is fundamentally a measuring device which transforms the physical observable actions to data. Thus, T *collects* observable actions, *stores* nothing, and *operates* by transforming the observables and *disseminates* data. Note that the observables cannot be utilized by a decision-maker without first being transformed into data.

This distinction between data and observable actions, although perhaps obvious, is not a trivial one. It is an important point to keep in mind. The data are *transformations* of the observable actions.

The last function remaining to be discussed in this model is the IAD function or perhaps, more accurately, the Information Acquisition, Storage, and Dissemination function. The IAD is frequently referred to as an "information system." Although it is of course a system it is, in fact, an open-loop system and, as we have shown, only a part of a much more extensive closed-loop system. As has been indicated it is important to consider the total closed system as shown in Fig. 1. The IAD is only a *part* of this system and must be treated accordingly.

The IAD function *collects* data from three different fundamental sources. It collects data on the particular activity under consideration (that is, data which have been obtained by transforming the observable actions produced). Data from the external environment are also collected. The external environment includes all the factors over which the decision maker has no direct control. Finally, the IAD collects basic data such as references, tables, reports, textbooks, relationships, etc.

The IAD *stores* a data base. Moreover, it *operates* on the data which it collects and stores in a number of different ways. The operations which the IAD performs on the data may be listed as (a) restructuring, (b) filtering or weighting, (c) selection and rejection, (d) analyzing, (e) sequencing or ordering, (f) prediction, and (g) display. There are, of course, other operations which are performed. The ones listed are typical and perhaps most important.

Finally, the IAD *disseminates* data for the use of the decision maker. These data, if used, are information within the context of our definition of information. This distinction between data and information is discussed in detail below. It is perhaps appropriate to mention that the data or information may be passively disseminated to the DM or the DM may actively interact with the IAD to obtain the appropriate information. In either case, the DM is performing some of the operational functions of the IAD. However, in doing this, the DM is not acting as a DM but as part of the IAD function, just as we have previously indicated, the DM may assume part of the E function. The IAD function thus provides the DM with the information that the decision maker needs for performing its functions in the most effective way possible.

The model of a generalized information system has now been described in detail. It is contended that all of the functions indicated must be present for any meaningful analysis of information flow. Information now can be defined and analyzed in generality by the use of this model. It is further contended that *only* in such a model does information really have any significance. General discussions of the storage of knowledge or data without reference to the potential uses lead nowhere, or provide minimal fruitfulness.

General Relations from Model

The general definition of information which has been proposed above is: "Information is data of value in decision making." Data on the other hand are transformations of observable actions. They are measurements which have been made on physical quantities. It is important to note, as has already been stressed, the distinction that information is inherently involved in the decision making process and therefore inherently involves a transformation into observable actions.

This model of a generalized information system allows us now to proceed in a rational, understandable, and logical way to provide the methodology, analysis, principles, and guidelines which it was suggested earlier in the paper could be forthcoming from this approach.

It is now possible to define information science as *the branch of study concerned with the properties of information flow in a generalized information system.* Thus, a true scientific discipline of great generality can be established and developed. Generalized relationships, concepts, definitions, and basic principles can be obtained by the study of this model. Some illustrative results will be given below.

It is very important to note that *information is a relative quantity* and cannot be defined except in terms of a specific situation with a specific set of observable actions. Then, and only then, can we define a quantitative measure for information. *Data*, on the other hand, are *absolute* and are related directly to the observables, independent of the system or uses under consideration. Once it is recognized that information is not absolute and is dependent on a specific system and set of observables, then a number of principles emerge directly.

Note that the model is largely a deterministic one except for the effect of the external environment. Lumped into the external environment are the processes over which the decision maker or executive has no control. In addition to environmental factors which may have an important effect on the transformation from courses of action to observables, we would also include such things as the actions of an opponent which would be important in a military engagement, a business situation, or in any gaming situation. It is, however, the external environment which introduces most of the uncertainty into the system.

The other major sources of noise or indeterminancy are probably: (1) the use of an incorrect predictive model by the decision maker, (2) an uncertain data base in the IAD function, and (3) use of the wrong data or incomplete information by the decision maker.

Analytical Relations from Model

Let us now very briefly indicate some of the basic analytical relationships which develop from the use of this model.

In this model it is shown that information is transformed into courses of action and thence to a set of observable actions. Since information is transformed into a set of observable actions, one might generally indicate

$$L \times I = O \tag{1}$$

or

$$I = L^{-1} \times O \tag{2}$$

where I is a matrix representing the various sources of information coming to the decision maker, O is the matrix representing the various resulting observable actions, and L is the transformation relating these quantities. Note that there is an actual L which is typical of the physical system under consideration and an L which represents the transformation predicted by the decision maker.

It is shown in Ref. 2 that for small ΔI the amount of information in a set of data may be determined by

$$\Delta I = L^{-1} \times (\Delta O) \tag{3}$$

where ΔO is the change in observable actions resulting from ΔI.

This equation defines the *amount* of information in a set of data. However, this does not necessarily say a great deal about the importance of the information. We have defined the amount of information in terms of the changes in observables without specifying that some of these changes may be of very little significance to the DM, even though they are large. This necessitates another quantity which implies a significance to the information or observables. This is appropriately called the *value* of information. The best way to treat value is probably to measure the information in terms of the elementary unit described in the following paragraph.

The *unit* of information (which as we have indicated must be relative to any particular situation) is the smallest amount of information that will produce a change in the observables. That is, it is the smallest amount of information which will cause the decision maker to change a course of action. This change will thus result in a change of observables. This smallest unit of information will be essentially a quantum of information and may be denoted as Q_0.

Then

$$Q_o = \underset{|\Delta O| > 0}{MIN} \Delta I \tag{4}$$

This is the unit of information in terms of which ΔI can be measured. We call this elementary unit an *informon.*

Note that, if the information is measured in informons, then it is a measure of the *value* of the information, since the informon is the minimum amount of information of value to the decision maker. It is possible, as we have indicated, that in some situations ΔI can be fairly large, inasmuch as some of the less-significant variables may change by only small amounts. But because it is just these significant observables with which the decision maker is primarily concerned in changing his decisions, then Q_O is also large, and the *value* of ΔI in informons is small.

In Ref. 2, several examples and applications of this generalized information system are discussed in detail. Included are: (1) a heat control system, consisting of a thermometer, a switch, and a furnace; (2) a large manufacturing firm which is planning a new product; and (3) the problem of "science information."

• Science Information

It might be of interest to indicate the relationship of "science information" to "information science" as suggested by our model. The field of science information is simply a subset of the field of information science, where the decision maker is a scientist or engineer engaging in research or development.

He will use procedures which are normally considered part of the "scientific method." In the scientific method the scientist (decision maker) develops an hypothesis which he expects will result in observable actions or physical quantities that are predictable. This hypothesis is the basic predicted model of the decision maker. It is hoped that this agrees with the real-world model. The decision maker designs experiments which are the courses of action. The external environment is, of course, the parameters over which he has no control. The experiments develop physical quantities of some sort (observable actions). These may be chemical reactions, voltages, historical trends, political developments, etc. However, if the hypothesis is at all significant, there must be real observables associated with it. There must be a way of verifying the hypothesis. These physical quantities are transformed into data which are, in turn, disseminated to the decision maker along with information about the external environment, and any other appropriate information involving similar activities of related scientists, as well as standard reference data. This information, fed back to the scientist, helps him then to decide whether his model (hypothesis) is an accurate model of the real world, whether it must be discarded, whether it must be somewhat modified, or whether further experimentation and data are needed. This *is* the scientific method. Thus, it is seen that science information is simply one example of the application of the generalized model.

In this paper it seemed very desirable to give a detailed description of the generalized model of an information system and to indicate some of the potential relationships and definitions which the use of the model will lead to. This is done because of the probable unfamiliarity of the reader with the concept of this model. Furthermore, the existence of a model of this generality and power is the key to the entire argument that a science can be based on the study of this generalized system. Additionally, this model can be the basis around which the science and a corresponding curriculum can be developed. Finally, to the author's knowledge, no other model of this generality and potential has been proposed. Accordingly, it is considered appropriate to discuss this model in detail.

• Conclusions

A powerful model of a generalized information system has been discussed. The generality of this model has been stressed and some applications and basic relationships have been indicated. Some basic definitions have been developed using this model. Others are suggested. The possibility of using this model as a basis for the development of a science called information science and the advantages thereof have been discussed in detail.

Given this type of conceptualization and set of applications for information science it is now possible to develop a set of requirements and goals for any curriculum in this field. The curriculum of course can be applications-oriented or it may be basics-oriented. It is naturally important to keep in mind that many different applications are relevant. Of course, librarianship is *one* application, but only one application. Others have been mentioned in this paper. There is, for example, management information systems, military command and control systems, biological systems, control systems, and many, many others which are able to be described by the use of this model. In any event, the goals and requirements of a curriculum in information science can be determined in a straightforward way by consideration of the generalized model and appropriate applications of interest.

It is clear, for example, that a basic curriculum in this field must be concerned first with the flow of information in this total system and the relationships which are correspondingly developed. It must be concerned with the basic quantities which are fundamental to this system. The curriculum must be concerned with the behavior of these relationships and fundamental quantities for various environmental conditions as well as other boundary conditions. The behavior for various types of applications should be studied.

A curriculum should consider, at least to some extent, the behavior of each of the boxes shown in Fig. 1. Particular attention should be paid to the DM function, which we have shown to be central to the entire system, as well as to the IAD function. Of particular concern is the interaction among these various functions. The study of the system as a whole, as well as piece by piece, is of great interest. Detailed consideration of the model will lead to further requirements for a curriculum.

Which of the curriculum goals are to be emphasized and which are to be touched only lightly must be a function of the applications that are to be emphasized as well as of the various values of the environmental parameters to be considered. To some extent this must be fairly arbitrary. The situation must be analogous to that which exists in developing a curriculum in physics or chemistry. For example, does a physics department emphasize nuclear physics, optics, or mechanics in developing a curriculum?

Further work is currently underway at Ohio State to determine specific goals and requirements for a curriculum. These goals and requirements will be used to generate specific subjects and their syllabi for various curricula in information science. It is clear that the science is a broad one with many different areas to be covered as well as many different options to be pursued. It is expected that some suggested detailed curricula will shortly be available.

References

1. SHANNON, C. E., and W. WEAVER, *The Mathematical Theory of Communication,* The University of Illinois Press, Urbana, Illinois, 1949.
2. YOVITS, M. C., and R. L. ERNST, Generalized Information System, *in* Kent, A., O. Taulbee, J. Belzer, and G. Goldstein (Eds.) *Electronic Handling of Information,* Thompson Book Company, Washington, D.C., 1967, pp. 279–290.
3. YOVITS, M. C., and R. L. ERNST, Generalized Information Systems: Consequences for Information Transfer, *in* H. B. Pepinsky (Ed.) *People and Information,* Pergamon Press, New York City, 1969. Portions of this paper were presented at the National Meeting of ASIS in Columbus, Ohio, October 1968.
4. ERNST, R. L., and M. C. YOVITS, Information Science and Decision-Making, Presented at the Boyd Conference on Decision-Making Aids, The Ohio University, Columbus, Ohio, April 1969.