Information Science: Forty Years of Teaching

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Abstract

Forty years of teaching Information Science at both the undergraduate and graduate levels has revealed that there is in fact a fundamental definition that can be used to describe the field and guide its development in the years to come. In short, that definition states "Information Science is the scholarly occupation that attempts to establish the principles and laws that govern the augmentation of human capacities through technology. This concept can be conveyed in teaching through the use of the EATPUTr system model. My long experience in the field has also revealed several basic requirements in the education of Information Science. These requirements are discussed within the paper.

1. INFORMATION SCIENCE: FORTY YEARS OF TEACHING

I still remember the first time I asked: "What is Information Science?" That was in 1960. It is now the year 2000 and the inquisitive students in my Information Science courses still ask the question. The purpose of this paper is to assert that the answer to this question has been with us for quite some time. The scholars of the past did in fact provide us with an answer. That answer is direct yet subtle, powerful yet simple, and it is that simplicity which makes it beautiful. If a "theory of everything" was to be developed for the field of Information Science, it might follow very closely from the answer to the question "What is Information Science?" conveyed in this paper. At this point in our civilization's development, when information, science, and technology play such integral roles in all aspects of life, it is essential that information scientists/professionals have a clear understanding of the significance and importance of their work, of the long lasting effects their work can have on individuals and organizations, and of the proper motivation and goals they should harbor throughout their career. The answer to "What is Information Science?" presented in this paper aims to achieve all of that, and also to guide the field safely and successfully through this millennium and the many to follow.

Information Science can be defined as the scholarly occupation that attempts to establish the principles and laws that govern the augmentation of human capacities through technology. The key term in this definition is *augmentation*. This concept of Information Science can be explained through the use of a metaphor that details the properties of the human organism, namely, sensors, neural transmitters, and brain processes. For each of these properties, technological advances serve to augment the capacity for awareness (information). Indeed humans create tools that extend their capabilities to hear, taste, smell, see, act, and be aware. Tools help in reading, calculating, understanding and carrying out intentions. Eyeglasses, binoculars, radar, satellites, hearing aids, and telephones are examples of these tools. We have libraries that store human experiences and thoughts conveyed throughout history. These are the things that augment our native endowments. When we put all these together to meet the challenges of things that happen to all of us each day in our lives, we have Data, Information, and Knowledge (DIK)systems. From this state of awareness technology further serves to extend our capacity to derive meaning, solve problems and make decisions and to take the necessary actions that are driven by events to which the human organisms responds. This concept integrates the activities and interests of librarians, computer and telecommunications scientists and technologists. I will attempt to show in this paper that this concept of Information Science has been with us since the last world war, and has been given definition in the late 1950's and certainly in 1960.

It was in 1960 when information systems and their links to computer technology first came to my attention. I was in the military and in charge of the computer division of the Electronic Systems Command, United States Air Force, Hanscom Field, Lexington, Massachusetts (1). This office was in charge of funding a multitudinous number of research projects in support of both the Air Force and the emerging space program. Our most critical task was to establish an information system for the Strategic Air Command (SAC), which at that time was prepared to counter the Soviet Union's ballistic missile threat. The formal military reference was Command and Control-the C2 systems. The Mitre Corporation, also located in Lexington, Massachusetts, in collaboration with the U.S. Air Force, Electronic

Systems Command, initiated a number of annual conferences on "Information System Science" (2). Of course, it should be noted that other services and organizations had similar programs and were also represented at these conferences. At that time, I began to fully appreciate the nature of such systems. At first it seemed as if "Information System Science" as it was called, represented a diversity of thinking and initiatives in electrical engineering, language translation, computer programming, decision-making, problem solving and automation in general, much of which related to advances in solid state physics and correspondingly, computer technology. The experience involved interaction with the Advanced Research Project Agency (ARPA) and its initiatives. ARPA had foreseen advances in computer and telecommunications technology as a way to link existing national research centers, thereby improving the collaborative efforts among scientists involved with the space program. This led to the ARPA Net, the precursor of the present Internet. Because of my military office, it was at this time that I was fortunate enough to have the good company, influence, and friendship of J.C. Licklider (3) who, among others, was at the forefront of understanding the future of computers. This was also the time when Douglas E. Englebart (4) explored how the computer could augment human intellect. It was the time when Allen Newell and Herbert Simon (5) were thinking of computers as an analog of the human mind in problem solving and decision-making. Still others like Ashby, Pitts, McCulloch, and Wiener (6) centered their interest on feedback and systems theory, and it was not long until the word "Cybernetics" emerged as a formal term for discourse about systems. Roughly a decade later in 1976, James Grier Miller (7) provided an encyclopedic rendition of these concepts in his work *Living Systems.* These developments served to crystallize my thinking as to what "Information System Science" could be about, and how this science related directly to the analysis and design of information systems. However, the picture was still not yet entirely complete. The Weinburg Report of 1963 (8) challenged the communicative habits of the scientific community. It raised questions on the prevailing capacity of the library, as an institution, to meet the challenges of the "space age" that followed the Soviet Union's launching of Sputnik. In the early 1970's, Robert G. Havelock (9) at the University of Michigan offered a new concept of library service that visualized reference work in the structure of a clinic (medical) where individual needs could be diagnosed and information and knowledge would subsequently be organized to meet the specific needs of each individual (client). This exposure made clear to me the interdisciplinary context of what could be called Information Science. If there were to be a "science" of Information, such a science would be interdisciplinary. If we were to have information systems (i.e. C2 systems) to meet the challenges (both military and non-military) of the space age, individuals had to be trained (educated) to develop an interdisciplinary "mind set." This was my motivation as head of the Psychology Department at the University of Dayton when I proposed the establishment of what could be considered the first autonomous interdisciplinary program in Information Science at that University in 1967, and later in 1970 at the Graduate School of Library and Information Science at the University of Pittsburgh.

But what would be the conceptual structure of an interdisciplinary, academic program in Information Science? The prevailing issues focused on machine (computer) processing of documents, indexing, information retrieval, cataloging, language translation, computer programming and libraries to mention a few. How could all these topics be organized to offer the new "information professional in training" a sense of conceptual integrity? How could that conceptual integrity encompass the nature of Information Science, as a theoretical and applied area of study with credence and opportunities for pursuit of a professional career?

It was Cybernetics that provided the groundwork for the academic programs in Information Science at the University of Dayton and later at the University of Pittsburgh. The coursework would emphasize that all organisms (in varying degree) are data, information and knowledge processing systems, and that data, information and knowledge processing technologies (and the institutions related to them) augment the human organisms capacity to acquire, process, and use data, information and knowledge. Within this purview, the human organism would provide the basic conceptual structure upon which all Data-Information-Knowledge (DIK) systems could be understood. It would represent the blue print for the analysis and design of Augmented Data, Information and Knowledge (ADIK) systems. Such systems would extend the human cognitive capacity for awareness (information), enabling the extension of this state to knowledge, namely meaning and understanding. ADIK systems would serve many institutions, within the culture, to meet the challenges presented by the environment and support human development and well-being. Thus rests the central concept upon which an educational program in Information Science could be configured and developed the Information Science program at the University of Dayton and at the University of Pittsburgh are such examples. The student committed to Information Science as their professional area of interest would be given a conceptual structure upon which they could relate much of their studies in theory and field applications (business, government, personal, and career development). Also within this scope, the functions of the co-disciplines of computers, libraries, and communications along with other related disciplines in the physical and behavioral sciences would find their meaning and integration in Information Science. The central focus of Information Science would be the Data, Information and Knowledge system. This system would be represented as consisting of a number of essential components, namely, events, sensors, transmitters, processors, utilization and transfer (communication) elements. These components are an analogue of the constituent parts of the human organism, and can be thoroughly examined and explained through the EATPUTr model.

The basic system component of the EATPUTr model is the **event (E**). It centralizes the activity of all other system components. It defines the objective of the system and sets the stage for the analysis and design of the system by specifying the function of the overall ADIK system activity. The next component of the EATPUTr model consists of sensors to **acquire (A)** and capture the energy from events. This energy is given representation via symbols and is then codified. The codes, when formalized (via rules), represent the datum (data). The datum (data) is captured by the sensors (which can be both human and technological) and subsequently reaches the next two components of the EATPUTr model when it is **transmitted (T)** to a data **processing (P)** component that provides the individual or organization with a state of awareness regarding the many dimensional properties of the event (8). This completes the **information (awareness) cycle**. However, the human need for responses to events extend beyond awareness (information). They extend to meaning and understanding - the need for knowledge. It became clear to me that information systems, although prerequisite and fundamental, are (albeit important) part of information systems. Thus in continuing with our analysis of the components of the EATPUTr model, information systems prepare individuals to **utilize (U**) awareness for the purpose of general development and specifically for the problem solving and decision making processes that are inherent in the properties and demands imposed by the event to which the ADIK system responds. Furthermore, once the problem is solved and decisions are made, these solutions and decisions are **transferred (Tr)** through actions that are taken in response to the event. This brings the EATPUTr model full circle, and the cycle is thus complete. From event to awareness (information answering the interrogatives what, where, when, who), to meaning and understanding (knowledge answering the interrogatives how and why), and thence to action, this is what I refer to as the **EATPUTr cycle.** The model represents an open, non-linear-feedback loop system, and it can be applied to the analysis and design of ADIK systems that respond to a multitude of events and situations, from natural disasters, commercial-governmental functions and enterprises, to general organizational functions and potential dysfunctions. Given the above concepts, the programs at the University of Dayton and at the University of Pittsburgh centered around four major areas to which the student would possess knowledge, thus enabling them to serve the dual roles of information professional and scientist.

1. Foundations: The *philosophical* basis for the concept of information (what, where, when, who) and knowledge (how, why), a history of discourse on definition and applications, and prevailing percepts about behavioral theory (cognition, neuroscience). The role of the library, computer and transmission-communications disciplines and their related sciences would be examined in detail.

2. Method: *Tools* required to deal with inputs from events, investigative methods used in the analysis of events, measurement of ADIK system efficiency and effectiveness (value-added). Methods include the study and application of normative and descriptive statistics, calculus and other mathematical methods, system analysis and design, information retrieval, cataloging, indexing, classification, information/knowledge organization, task/failure analysis, etc.

3. Technology and systems: The *state of the art* in computerization, including programming (language development), electronic displays, database processing, and systems theory (general and quantities). This area would also include the comparative study of human and technological sensors, and current state of the art in telecommunications.

4. Society and Information Science: Role and function of knowledge institutions (i.e. library, media). The *impact* of ADIK systems on the individual, on the organization and on society. This would include legal issues, privacy issues, ethical issues, demographic issues, etc. (presently known as "Social Informatics").

How has such a concept fared following the teaching of Information Science over the past forty years? There are several conclusions that can be offered.

1. It has been my observation that the interdisciplinary "mind set" is not easy to engage. Often the difficulties of interdisciplinary education are not fully appreciated by faculty members or the university. Some faculty appointed to Information Science programs has received their degrees from disciplines other than Information Science. These faculty members have the tendency to thus perceive Information Science as an extension of their field of study. This serves to mitigate the essential interdisciplinary perspective of Information Science. The development of a mindset that would prepare the students to engage in system analysis and design to meet organizational and public needs is ignored. Current undergraduate curriculum recognizes majors and minors in specific subject (discipline) areas. More often than not, the students leave their undergraduate careers with a disciplinary orientation. This lack of exposure to interdisciplinary thinking can be a significant impediment in preparing the student for their graduation and subsequent embarkation upon a career as an information scientist/professional, or graduate studies.

It should also be noted that majors and minors in Information Science are not easily found in current institutions, although there has been an increase in the number of colleges and universities offering programs in the field.

2. The foundational course that is developed as an entry course in any program (graduate or undergraduate) is a pivotal course in Information Science education. There are two views pertaining to the role of this course. The first view sees the objective of the course as an exposure of many subject matters that are considered to be the domain of information scientists. Again, the student here is asked to provide the synthesis to the respective views. Without any specific previous exposure to the field, the student is often overwhelmed by the variety of subject matter. This fuels the conviction that Information Science is no more than many things of which there is no central theme or purpose, and is a field often selected by students who are only concerned with employment opportunities upon completion of their degree(s). The second view of this course holds that there is a conceptual framework upon which the study of Information Science can be pursued. Unfortunately, as is best discerned, instructors rarely take this view.

3. There is a continual uncertainty expressed by students as to how information, library, computer and telecommunications programs relate to each other. Without a centralized construct to guide their thinking, students enrolled in Information Science programs are often unable to express cogently and meaningfully the unique expertise they can provide to field demands.

4. Interdisciplinary education requires the development of synthesis skills. This issue centers on the skills and background of the instructor in providing synthesis of subject material covering various disciplines versus the ability of the student to synthesize an assortment of subject matter in the absence of a central core concept (either in theory or practice) from which the subject assortment can be organized and synthesized. It is difficult for a novice without any field experience or former education in Information Science to synthesize a number of seemingly disparate subject areas in his first and subsequent years of study in the field.

5. A fundamental administrative problem exists between the structure of an undergraduate major in Information Science and a graduate program. The student, who pursues the graduate program, whether in the same or other institution, is often faced with repetitious material learned previously as an Information Science major at the undergraduate level.

6. The absence of textbooks that introduce the subject matter of information from an interdisciplinary perspective is a deterrent to the teaching of Information Science. Many of the textbooks on information systems analysis and design are domain oriented, primarily geared towards business applications. There is a need for textbooks that focus on the interdisciplinary nature of the science and the professional work related to it.

7. Important books that provide foundational aspects to the field of Information Science should be integrated into new texts developed for students studying Information Science. Reference is made to the NATO Advanced Study Institutes Publications (1972,1978,1982) (12), Fritz Machlup and E. Mansfield, and *The Study of Information* (13) to cite only a few that come to mind and thus can serve as illustration of the point. What results is a continual pleading of the foundational question among both faculty and students rather than using these rich sources as building blocks to a foundational course in the education of information scientists/professionals.

What are the implications of this experience to what I consider are the central interest of those who are concerned with Information System Education ? My cursory review of the past proceedings of this scholarly body (14) has led me to discern (correctly, incorrectly) that the current educational paradigm in Information Systems education centers on business applications (i.e. programming [concepts; tools], object oriented analysis, quality management, ethics, etc.) and of course curriculum development. These interests, of course, remain valid, relevant and meaningful within the current context on which information systems are currently perceived. The broader perspective however, merits consideration. Information systems possess greater power of value that go beyond the entrepreneurial perspective. I go back to the military, where information systems were a matter of national life, or extermination. The future information professionals should appreciate the full power of Information systems in the broader context, that is the ability of these systems to counter the problems of epidemics, national disasters, crime and drug addiction and other social concerns. It is this perception that leads me to consider that the most important component of an ADIK system is the event. The event, in my judgment, is the component that the future Information analyst and designers will be asked to master(15).

Conclusion

In conclusion, I propose that there is a basic concept that defines Information Science both from its theoretical and field perspective. The idea did not originate with me but was given to me by the scholars of decades ago. They convinced me that all organisms are data, information and knowledge (DIK) systems. The technology we generate augments the capacities that these living systems innately possess (ADIK)). This definition can be further conveyed through the EATPUTr model of systems analysis and design. The model enables students to clearly and lucidly see the relationships that exist between libraries, computers, communications, and other allied disciplines. This visualization and understanding can in turn be applied to the analysis and design of such systems to meet field problems of individuals and organizations.

With each passing year I take greater pleasure in knowing that I had and continue to have the opportunity to shape more minds and student views regarding the definition of Information Science. Such thoughts reduce the apprehension that I sometimes feel when I ponder the integral roles that information, science, and technology play in all our lives. The information scientist/professional who adopts the view that Information Science is, at its core, the augmentation of human capacities through technology will clearly understand the significance and importance of their work, they will understand the long lasting effects their work can have on individuals and organizations, and they will be guided throughout their career by humane motivations and goals. This in turn spells a brighter (safer) future for us, our societies, our cultures, and indeed our technological civilization.

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