Toward A Model For Nursing Informatics

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Purpose: *To propose a new model for the development of nursing informatics based on historical precedent.*

Significance: *Nursing informatics is expanding rapidly. The proposed model aids in understanding the areas of research, relating them to each other, and it shows areas where work is missing or should be extended.*

Organizing Framework: *Nursing informatics as the interaction of cognitive science, computer science, and information science resting on a base of nursing science.*

Implications: *As this model is tested, it can act as an organizing framework to understand and relate studies of nursing informatics and give organization for future research, education, and development.*

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Nursing informatics is developing as a discipline. Many authorities outside nursing may not understand the uniqueness of nursing informatics. For example, Shortliffe, at the 1993 meeting of the Symposium for Computer Applications in Medical Care (SCAMC), stated that application of medical informatics techniques to nursing problems could solve all of nursing's informatics problems. In April 1994, Weinberg (personal communication) raised questions about developments in the field of informatics. During a discussion on the Internet, he wondered aloud whether the term "medical informatics" was not sufficient. Nurses were forthright in responding. However, their responses did not produce a clear view of nursing informatics.

Historical Definitions

Graves and Corcoran (1989) provided one of the most useful definitions of nursing informatics:

> A combination of computer science, information science, and nursing science designed to assist in the management and processing of nursing data, information, and knowledge to support the practice of nursing and the delivery of nursing care (p. 227).

This definition is important because it highlights the multidisciplinary nature of nursing informatics and clearly indicates that the goal of nursing informatics is the delivery of nursing care. This definition is the core of recent publications by the American Nurses' Association (1994, 1995).

Hannah, Ball, and Edwards (1994), defined nursing informatics as:

> The use of information technologies in relation to those functions within the purview of nursing, and that are carried out by nurses when performing their duties. Therefore, any use of information technologies by nurses in relation to the care of their patients, the administration of health care facilities, or the educational preparation of individuals to practice the discipline is considered nursing informatics (p. 3).

This definition takes a more functional approach than the one by Graves and Corcoran. Debate between the roles of technology and science creates a major theme in discussions of nursing informatics. Ryan and Nagle (1994) identified six criteria for determining a "science of information." According to these authors, information science should:

1. Derive from observations of the functions, structures, dynamic behavior, and statistical features of information and the symbols used to represent information.
2. Respect the distinction between limited symbol combinations and the rich human understanding they are used to represent.
3. Fit with our established understanding of nature including the existence of complex living organisms, together with social groups of such organisms.
4. Offer a context into which established but hitherto isolated theoretical aspects of information engineering, e.g., automation theory can be fitted.
5. Offer useful guidance to those engaged in the design of information systems to serve organized groups of people in the most cost-effective way.

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6. Offer useful and verifiable evidence regarding the scope and limitations of artificial intelligence and consequently should offer useful guidance to those engaged in selecting, supporting, and undertaking exploratory enterprises in the field of information engineering (p. 405).

Ryan and Nagle focus on the data, information, and knowledge that are critical to the role of the informaticist. They focus less on technology than on conceptual understanding and the demands of practice. They indicate that nursing informatics has to meet the criteria for an established science if it is to continue to progress.

Many nurses do not have a consistent view about the primacy of computer science and technology and its effect on nursing informatics. For some, computer science is the essence of information technology and hence the core component of informatics. For others, nursing practice constitutes the core of informatics. An historical view of definitions helps to underscore some current concerns.

In 1985, Hannah defined nursing informatics as follows:

> The use of information technology in relation to any of the functions which are within the purview of nursing and which are carried out by nurses. Hence, any use of information technology by nurses in relation to the care of patients or the educational preparation of individuals to practice in the discipline is considered nursing informatics (p. 181).

For Hannah, the focus is on information technology and its use in practice. For many, the core of information technology is identical with computer technology. The result has been a virtual interchangability of the two terms. Schwirian (1986) adopted this view of nursing informatics and suggested that this view be the central focus for the profession because it contributes to (a) knowledge, (b) communication of knowledge, and (c) knowledge in clinical practice. Schwirian (1986) proposed a model of the nursing informatics pyramid with nursing informatics at the base of the pyramid then intersected with information, computer, and user. Goals provided the outcome of nursing informatics but remained outside the purview of nursing informatics itself.

By 1989, Brennan argued for keeping the nurse in nursing informatics and to view nurses as users and the goal of nursing practice as integral. Necessary in the evaluation criteria were professional role and practice. This view was in response to Zielstorff, Abraham, Werley, Saba, and Schwirian (1990) who created a list of criteria giving primacy to technology, modified from similar criteria in medical informatics by Shortliffe.

While not explicating a definition of nursing informatics, Sinclair (1989) described some of the curricular difficulties in nursing informatics. Sinclair's is a technical view of the informatics curriculum in which a secondary objective focusing on content related to nursing practice is required to bring relevance to the student when using computers and telecommunications.

McLaughlin, Taylor, Bliss-Holtz, Sayers, and Nickle (1990) argued that nursing theory must direct all nursing information systems, noting that without a theoretical model, meaningless data will overwhelm information systems. They state that, without theory, information systems will focus only on current practice and not evolve toward a more comprehensive view of nursing practice. They emphasize both the technical needs of database development and the need to conceptually model the types of data and its organization within the database. McLaughlin and colleagues (1990) open new domains for nursing informatics. They discuss the critical need for definitions, criteria, and decision-making in addition to the development of data bases.

Ford (1990) reported that machines, such as computers, have an essentially dehumanizing effect and this effect has a negative value in nursing. Ford also discussed how computers used for monitoring and recording can increase the time available for nurses to perform patient-centered activities. This sense of the instrumental nature of computers has generated much literature about nurses' attitudes toward the use of computers.

Advances in Nursing Science devoted a complete issue to nursing informatics in 1990. Chinn (1990) noted:

> Nursing clearly needs better information, organized in ways that serve the interest of the discipline. The technology to organize and communicate information is already developed, if not yet refined and accessible. Still, the fundamental questions remain for the discipline—What information do we want to draw on? How will we define the terms? How will we obtain the information? How will we organize it? To what end? What are the philosophic and theoretical views that inform and shape the choices (p. vi)?

Chinn indicated that the issues in informatics are conceptual and organizational—not technological. However, it may be that she too easily dismisses the technology necessary for organization and delivery of nursing information. *Advances* contained eight articles on such topics as the nature of expertise (Thompson, Ryan, Kitzman, 1990), diffusion of technology, (Romano, 1990), the nursing intervention lexicon and taxonomy (Grobe, 1990), and a research knowledge system (Graves, 1990). Little space was given to discussions of the underlying technology.

McGonigle and Eggers (1991) described a 15-credit certificate program in nursing informatics. They originally defined nursing informatics as:

> The synthesis of nursing science, information management science, and computer science to enhance the input, retrieval, manipulation, and/or distribution of nursing data (p. 184).

In the outline of their program, they addressed the content of five courses. The first was designed for the student to interact effectively with the computer; the second examined the use of electronic communications. The third course expanded the use of databases, spreadsheets, and word processing. The fourth and fifth courses focused on the evaluation of information brokerages and the use of learned skills in developing computer-based education.

Despite the broad conceptual level of the McGonigle-Eggers' (1991) definition, their courses focused largely on the instrumental aspects of informatics. The core of the program focused on the student's ability to learn to use and to manipulate a computer using existing computer programs. The instrumental aspects of the computer appear to have taken precedence, and the knowledge modeling and conceptual developments are

secondary. This approach parallels that of Sinclair (1989).

Schlehofer (1992) suggested that the core requirement of informatics is to manage clinical decisions. Therefore, a new model of data and processes must be derived, which direct health care decisions and actions. Schlehofer further suggested that nursing is unique in the range of information that is incorporated into decision-making and necessitates access to information from throughout an organization. Schlehofer identified the following seven criteria for clinical systems: (a) Collect, record in real time, vital signs and hemodynamic values. (b) Document transactions, that is planned activities, and unforeseen events as well. (c) Provide convincing evidence of delivery of nursing care according to appropriate standards. (d) Collect data for quality monitoring and provide cuing mechanisms to foster desired results. (e) Facilitate the daily administrative aspects of nursing. (f) Provide tools for reducing repetitive documentation. (g) Print patient reports on demand as well as on a set schedule (p. 7-8). From the informatics definition perspective, it is important to note that Schlehofer shifts from computer technology to functional performance of a system. However, her approach does not address whether the development of information systems is the only goal of nursing informatics.

Noll and Murphy (1993) discussed integrating nursing informatics into a graduate curriculum. As a base, they cited Hannah's (1985) definition of nursing informatics as the use of information technologies in relation to any of the functions of nursing. They stated that three activities should be included in a graduate research course: (a) selection and use of appropriate on-line information sources; (b) use of databases and spreadsheets to facilitate data management and organization; and (c) data transfer for statistical analysis. However, Noll and Murphy focus on the instrumental nature of computer use involving the need for computer competency in the research process.

In summary, three main themes related to the definition of nursing informatics have been described. Some authors recognize all three themes. Others recognize only one or two.

The first theme is the use and position of the computer and computer science. Some define informatics in terms of computer technology. From this perspective, everything that occurs in informatics derives from insights and changes in computer technology, which is the core of both teaching and understanding informatics.

The second theme focuses on conceptual issues and defines the key concepts that organize and represent nursing knowledge. The focus for many authors is to augment and enhance nursing practice, but not every author has agreed on what constitutes the core concepts. The conceptual focus is a counterpoint to the points based largely on computer science.

The third theme is functional performance in which computer science and conceptual development are secondary. The focus is not on the computer directly, but rather how it helps nurses to enter, organize, or retrieve information. Critique is not on the structure of the system itself, but on how well it functions for the nurses using it. In this thematic category, questions are phrased differently: "Is the information available?" "Is the response time appropriate?" "Does the system interact with other information systems in the environment?"

Each theme has been useful. But none captures the entire scope of nursing informatics.

New Model For Nursing Informatics

As a definition for nursing informatics evolves, it is necessary to answer these questions: What is causing informatics to fracture and break into sub-components? Do discipline-specific informatics exist and if so, how do they relate to each other (Weinberg, 1994)? The proposed definition of nursing informatics responds to these questions, proposes a framework for the future, and reflects historical considerations.

One assumption is that informatics is multidisciplinary. The core components of informatics include computer science, information science, and cognitive science. The area bounded by the intersections of these three disciplines forms the domain of informatics.

The move from a generic model of informatics to a discipline-specific informatics requires the addition of the discipline's science. **Figure 1** shows that representation as a three-dimensional model. The base is nursing science upon which rests the model for informatics. Some have suggested that educational theory forms another basis for the development of a discipline specific informatics.

In the model, the intersected spheres, which form the core of informatics, rest on the base of nursing science. Nursing informatics is the interaction between the discipline-specific science, in this case nursing science, and the area of informatics. The model helps to clarify a number of problems related to informatics and some of the components. According to Stillings and colleagues (1987), cognitive science is an interdisciplinary field that results from the convergence of psychology, linguistics,

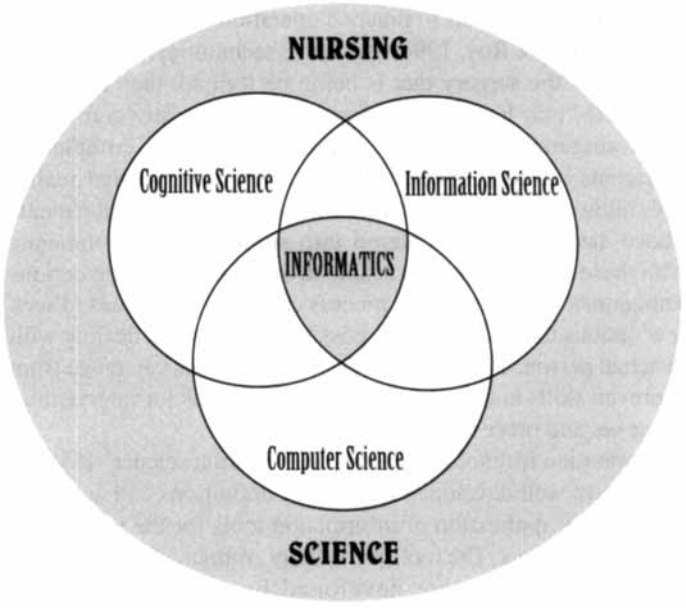

Figure 1: Nursing informatics model.

computer science, philosophy, and neuroscience. The focus of cognitive science is understanding of the mind and the phenomena the mind addresses. The result is that cognitive science covers a wide range from perception to thinking, understanding, and remembering. While many authors in cognitive science use computers, others simply observe and interact with children to understand the uptake and use of language and language skills. Some equate all of cognitive science with information processing and see the two as coextensive.

Gardner (1985) defines cognitive science as:

> A contemporary, empirically based effort to answer long standing epistemological questions—particularly those concerned with the nature of knowledge, its components, its sources, its development, and its deployment...I apply the term chiefly to efforts to explain human knowledge. (p. 6).

Gardner implies that there are other types of knowledge and other representations of knowledge that are not inherently the focus of human knowledge and therefore not part of cognitive science. This contrasts with other authors who attempt to understand computer intelligence not just as a model of human intelligence, but as a separate entity. This interdisciplinary science forms the basis for much of the work in information technology and knowledge structuring.

Computer science includes development of both hardware and software. Development of new tools has radically altered our understanding of knowledge and knowledge representations. The transition in the past 10 years has been from centralized computer systems to distributed workstations and personal computers. Most recently, we have seen the rise of networks, distributed architectures, and the ability to display video and graphic images on demand.

Computer hardware doubles in power approximately every 18 months. Software evolves more slowly. Hardware developments are allowing for implementation of virtual reality stations. Virtual reality allows surgeons to practice operations on virtual patients (Merril, Raju, & Roy, 1994). With this technology, it is possible to "record" the surgery that is being performed, then allow the surgeon to "play back" and critique the procedure just completed. Other surgeons can attempt alternative ways of completing operations in order to select the best approach. Virtual reality tools allow a clinician to interact with simulated and real patients whose data have been entered into simulation environments. With these tools, a clinician is able to explore therapeutic options without risk to a patient. The process challenges clinicians to seek new options that would not be possible if they were dealing with an actual person. The results of these explorations can range from improved skills to the expanding of new options for intervention by nurses and other clinicians.

Information technology (IT) and information science (IS) may be the least well developed in terms of definitions and domains. The focus is application of information tools for the solution of business problems. The tools are usually computer-based and use hardware and software developed by computer science. Information science adds an understanding of how the organizational environments are structured and how information flows in that environment. For example, nursing data, information, and knowledge needed for an acute-care institution may be different in form and structure than that needed for a community-based or home-based organization.

Those who work with IT develop interfaces to bring information to the end user. Designers and researchers of interface elements must be aware of perception—from how eyes see to how brains interpret. The aspect ratio, ratio of the length of an X-axis to the length of a Y-axis, on a graph can change the way clinicians understand data. The use of color for a warning or alert requires that designers understand the uses and meanings of different colors for each of the cultural groups likely to use the interface. This understanding is independent of the underlying data being displayed by the interface. However, for clinicians using the system, it will be the interaction of all of the components that affect clinical judgment. These elements of interface design are central to IT understanding.

Cognitive science has helped clarify IT. Research is underway to determine the proper amount of information that should be available to health-care providers in given situations. The sheer amount of data, information, and knowledge that would be available from a longitudinal, computerized patient record could easily immobilize a clinician and preclude the ability to intervene. At the same time, the very availability of the data places a personal and professional burden on clinicians that would not occur if the information were unavailable. Likewise, developments in computer science are changing the tools available for users of IT. In the near future, wireless work stations may allow instantaneous access to patient data.

The availability of data and the technology that supports it will continue to change the way clinicians practice. When a clinician orders tests and the cost of the tests are included as part of the ordering process, the number of expensive tests has been shown to decrease. The addition of a decision support system to the ordering system for blood products has been shown to decrease cost and improve the appropriateness of using blood products (Connelly, Sielaff, & Willard, 1995).

Informatics will change the way clinicians understand the information that is available to them. The sheer volume of knowledge will require that data be automatically preprocessed before it is delivered to clinicians. Questions related to how much data should be displayed, how data will be sampled, and what algorithms should be used to preprocess data should be answered.

Summary

The three themes identified have been integrated into a comprehensive model for nursing informatics. Each of the three themes—the use and position of computers, conceptual issues, and system performance—were the starting point for inclusion of computer science, cognitive science, and information science. Using this model, it is clear that research is needed at each intersection.

The model seems to address questions originally asked by Weinberg (1994). Maturation of informatics has made clear to

practitioners that it is no longer possible to keep pace with all of informatics' domains. The model indicates how the various domains will evolve and what areas of informatics they address. As with the development of any multidisciplinary science, the evolution will not be simple and linear; rather it will be uneven and driven by events.

In areas where various health disciplines share data, information, or knowledge, there will be shared areas of informatics as well. For nursing, the model proposes a broad range of study and application. The problems recognized as research needs by an expert panel from the National Institute for Nursing Research (1993) described many of the topics that require investigation. The model can provide a framework. 

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