Major Theories Supporting Health Care Informatics

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Learning Objectives

Upon completion of this chapter, the reader will be able to:

1. *List* major theories used in health care informatics.
2. *Describe* how selected theories and models explain and predict phenomena of importance to health care informatics practitioners.
3. *Use* selected theories to analyze problems and challenges encountered when using automation to support health care delivery.

Outline

Systems Theory
- *Characteristics of Systems*
- *Systems and the Change Process*

Information Theories
- *Shannon and Weaver's Information-Communication Model*
- *Blum's Model*

Learning Theories
- *Behavioral Theories*
- *Information Processing, or Cognitive Learning, Theories*
- *Adult Learning Theories*
- *Learning Styles*

Change Theories
- *Planned Change*
- *Diffusion of Innovation*
- *Using Change Theories*

Key Terms

adult learning theories
andragogy
attributes
automated decision support system
automated expert system
automated information system
behavioral learning theories
boundary
change theories
channel
closed system
cognitive learning theories
concepts
data
diffusion of innovation
dynamic homeostasis
early adopters
early majority
encoder
entropy
equifinality
framework
information
innovators
knowledge
laggards
late majority
lead part
learning
learning styles
model

Key Terms—cont'd

negentropy
noise
open system
phenomenon
receiver
reverberation
sender
specialization
subsystem
supersystem
system
target system
theoretical model
theory
wisdom

Web Connection

Go to the Web site at www.mosby.com/MERLIN/Englebardt/. Here you will find Web links and activities related to major theories supporting health care informatics.

A theory explains the process by which certain phenomena occur (Hawking, 1988). It begins with an observation of the specific phenomena. An example of a phenomenon is that people frequently resist change. But why and how does this phenomenon occur? A theory related to this phenomenon would explain why people resist change and predict when and how they will demonstrate resistance.

The following is the four-stage process by which most theories develop:

A specific phenomenon is noted or observed.

An idea is proposed explaining the development of the phenomenon.

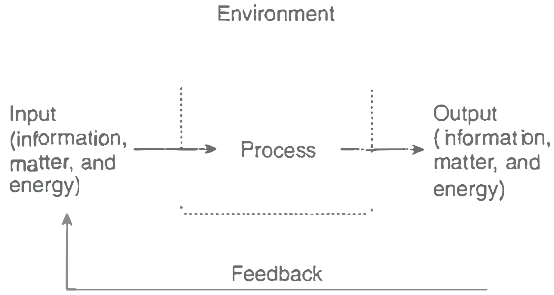
3 A model is developed to explain the operation of the phenomenon. Concepts key to explaining the phenomenon are identified, and the processes by which the concepts interact are described.

4. The model is tested, and as supporting evidence accumulates, a theory develops.

There is no single set of consistent criteria that can be applied to decide when a model becomes a theory. As a result, the terms are often used interchangeably. In other words, it is possible for one reference to refer to a phenomenon as a theory and for another reference to refer to the same phenomenon as a model. For example, one reference may refer to a communication theory and another reference may refer to a communication model, yet both references may be describing the same phenomenon. In addition, a theoretical model is often used to explain a theory. A theoretical model is a description or figure used to help visualize a theory. It includes the concepts and interactions among the concepts operating within the theory.

The building blocks of a theory are called concepts. Concepts may be abstract, such as love, or concrete, such as fruit. Concepts provide structure to a theory. For example, in Figure 1-1 the relationship among four concepts is depicted. These four concepts and the location of the concepts in the figure demonstrate the structure of the theory. The interactions among the concepts in a theory explain the function or operations of

FIGURE 1–1 Open System Interacting With the Environment



that theory. For example, the electrical system of the heart is a concrete concept. Impulses travel through this system and produce a contraction of the atria and ventricles. The concept of the heart's electrical system and the description of how it functions provide a theory that can be used to explain how the heart beats.

Because a theory explains the what and how of a phenomenon, it can provide direction for planning interventions. Continuing the cardiac example, the cardiac impulse normally begins in the sinoatrial (SA) node in the right atrium and travels across the atrioventricular (AV) node to the ventricles. In atrial fibrillation this normal process is disrupted, and impulses arise at a rapid rate from multiple sites in the atrial muscle. This can result in a fast ventricular response, or tachycardia. Drugs that block or slow the rate of impulse transmission at the AV node can be used to treat tachycardia caused by atrial fibrillation. This is an example of using a theory to understand and manage a problem.

Health care informatics, as an applied field of study, incorporates theories from information science, computer science, and cognitive science, as well as from the wide range of sciences used in the delivery of health care. As a result, health care informatics specialists draw on a wide range of theories to guide their practice. This chapter focuses on selected theories from a variety of disciplines that are of major importance to health care informatics. These theories are key to understanding and managing the challenges faced by health care informatics specialists. In analyzing the selected theories, the reader will discover that understanding these theories presents certain challenges. Some of the theories overlap, different theories are used to explain the same phenomena, and sometimes different theories have the same name. All of these challenges can be found in the theories of information (see the Information Theories section).

The one theory underlying all of the theories used in health care informatics is systems theory. Therefore this is the first theory to be discussed in this chapter.

SYSTEMS THEORY

A system is a set of related interacting parts enclosed in a boundary (Von Bertalanffy, 1975). Examples of systems include computer systems, school systems, the health care system, and a person. Systems may be living or nonliving. For example, a person is a living system, whereas a computer is a nonliving system (Joos, Nelson, & Lyness, 1985).

Systems may be either open or closed. Closed systems are enclosed in an impermeable boundary and do not interact with the environment. An example of a closed system is a chemical reaction enclosed in a glass structure with no interaction with the environment outside the glass. Open systems are enclosed in semipermeable boundaries and do interact with the environment. This chapter focuses on open systems. Open systems can be used to understand technology and the people who interact with the technology. Figure 1-1 demonstrates an open system interacting with the environment. As shown in Figure 1-1, open systems take input (information/matter/energy) from the environment, process the input, and then return output to the environment. The output then becomes feedback to the system. Concepts from systems theory can be applied in understanding the way people work with computers in a health care organization. These concepts can also be used to analyze individual elements, such as software, or the total picture of what happens when systems interact.

A common expression in computer science is "garbage in, garbage out," or "GIGO." GIGO refers to the input-output process. The counter-concept implied from this expression is that quality input is required to achieve quality output. Although this expression usually is used when referring to computer systems, it can apply to any open system. Some examples include the role of a poor diet in the development of health problems or the role of informed, active participants in selecting a health care information system. In these examples "garbage in" can result in "garbage out," or quality data can support quality output. Not only is quality input required for quality output, but also the system must have effective procedures in place for processing these data. Systems theory provides a framework for looking at the input into a system, for analyzing how the system processes that input, and for measuring and evaluating the output from the system.

Characteristics of Systems

Open systems have three types of characteristics: purpose, functions, and structure. The purpose is the reason for the system's existence. The purpose of an institution or program is often stated in the mission statement. For example, the purpose of a bachelor of science in nursing (BSN) educational program is to prepare professional nurses. Often computer systems are referred to or classified by their purpose. The purpose of a radiology system is to support the radiology department; the purpose of a laboratory system is to support the laboratory department. A scheduling system is used to schedule either clients or staff.

Purpose

It is possible for a system to have more than one purpose. For example, a family system or a hospital information system may have several different purposes. One of the purposes of a hospital information system is to provide interdepartmental communication. Another purpose is to maintain a census that can be used to bill patients for services rendered.

One of the first steps in selecting a computer system in a health care organization is to identify the purpose(s) for that system. There may be a tendency to minimize this step on the basis of the assumption that everyone already agrees on the purpose of the system. Taking the time to specify the purpose helps to ensure that the representatives from the clinical, administrative, and technology domains agree on the reasons for selecting a system and understand the scope of the project. Purpose answers the question, "Why select a system?"

Functions

Functions, on the other hand, focus on the question, "How will the system achieve its purpose?" Functions are sometimes mistaken for purpose. However, it is important to clarify why a system is needed and then to identify what functions the system will carry out. Functions are activities that a system carries out to achieve its purpose. For example, a hospital information system may achieve the interdepartmental communication purpose by maintaining an eMail program, as well as a program for order entry and results reporting. Each time an order is entered into the system, it is communicated to the appropriate department. Each time a department has results to report, they are communicated back to the clinical unit or appropriate health care provider.

When a computer system is being selected, the functions are carefully identified and defined in writing. These are listed as functional specifications. Functional specifications identify each function and describe how that function will be performed.

Structure

Systems are structured in ways that allow them to perform their functions. Structure follows function. Note how health care teams are organized. The organizational structure varies with the purpose of the organization and the functions that are to be performed. The organization of a nursing staff on a clinical unit demonstrates this concept. They may be organized using the concept of team nursing, primary nursing, or case management. In each case the purpose is to provide patient care. The staff is structured to ensure that the functions necessary for nursing care are completed.

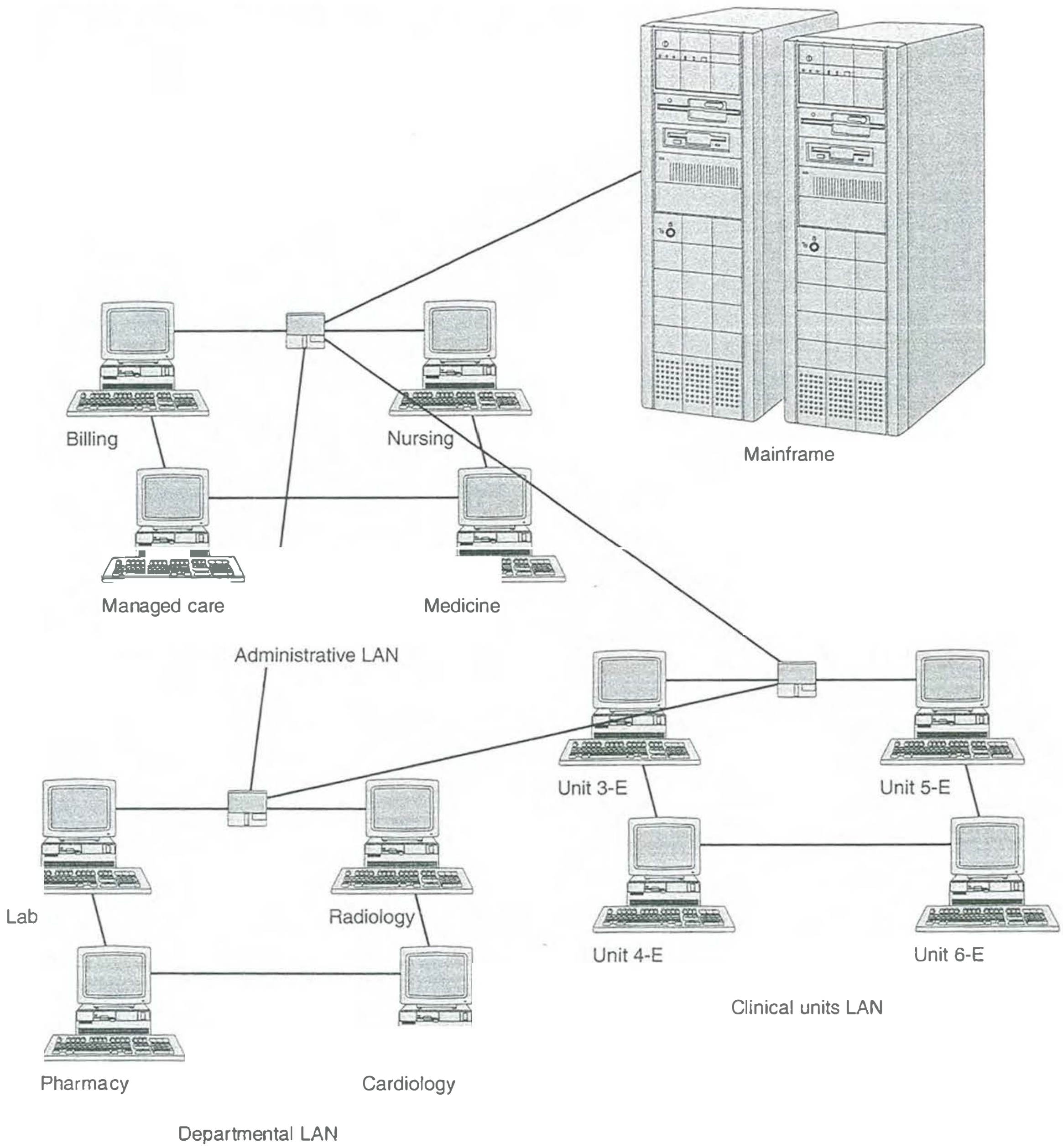
Structure Conceptualization Two different models can be used to conceptualize the structure of a system. These are hierarchical and web. Both models are in operation at the same time. The first model discussed is the hierarchical model. Figure 1-2 demonstrates this model. In this figure each computer is part of a local area network (LAN). The LANs join together to form a wide area network (WAN) that is connected to the mainframe computer. The mainframe is the lead computer, or lead part.

In an analysis of the hierarchical model, the term *system* may refer to any level of the structure. In Figure 1-2 an individual computer may be referred to as a system, or the whole diagram may be considered a system. Three terms are used to indicate the level of reference. These are subsystem, target system, and supersystem. A subsystem is any system within the target system. For example, if the target system is an LAN, each computer is a subsystem. The supersystem is the overall structure in which the target system exists. If the target system is an LAN, then Figure 1-2 represents a supersystem.

The second model for analyzing the structure of a system is the web model. The interrelationships among the different LANs function like a web. Laboratory data may be sent to the pharmacy, and at the same time the clinical unit data collected by nursing, such as weight and height, may be sent to each department needing these data. The web model can also be applied to living systems. Note the processes whereby various body systems interact with each other. In health care informatics much of the work is accomplished in task groups corresponding to body systems. Although someone is in charge of the task group, the relationships and communication among the members of the group flow in a web pattern. As these examples demonstrate, a system includes structural elements from both the web and the hierarchical model.

Structure Characterization Boundary, attributes, and environment are three concepts used to characterize structure. The boundary of a system forms the demarcation between the target system and the environment of the system. Input flows into the system by moving across the boundary, and output flows into the environment across this boundary. Understanding boundary concepts assists in the development of health care information systems. For example, one of the techniques used in developing health care information systems is to divide the health care delivery system into modules or subsystems. This process helps to establish the boundaries of a project. In Figure 1-2 each LAN is a target system. Each computer in the diagram represents a subsystem that can be automated. For example, a health care institution may be planning for a new pharmacy information system. The new pharmacy system becomes the target system. However, the pharmacy system interacts with other subsystems within the total system. As the task group goes about the work of selecting the new pharmacy system, it will need to identify the functional specifications needed to automate the pharmacy and the functional specifications needed for the pharmacy system to interact with the other systems in the environment. Clearly specifying the target system and the other systems in the environment will assist in defining the scope of the project. By defining the scope of the project, it becomes possible to focus on the task at hand while planning for the integration of this computer system with other systems in the institution.

FIGURE 1–2 | Hierarchical Information System Model



When health care information systems are being planned, attributes of the system must be identified. Attributes are the properties of the parts or components of the system. They are the terms used to describe a system. For example, the attributes of a person include hair color, weight, and intelligence quotient (IQ). Computer hardware attributes are usually referred to as specifications. An excellent example of a list of attributes or specifications can be seen in advertisements or the owner's manual for computer hardware. These include such things as the amount of random access memory (RAM), the size of the hard drive, and even the size of the case covering the computer. Another example of a list of attributes can be seen on an intake or patient assessment form for a health care setting. The form lists the attributes of interest. A completed form describes the individual patient's expression of these attributes.

Attributes and the expression of those attributes play a major role in the development of databases. Field names are a list of the attributes of interest for a specific system. The datum in each cell is the individual system's expression of that attribute. A record lists the attributes for each individual system. The record can also be seen as a subsystem of the total database system. A complete discussion of databases can be found in Chapter 3.

Systems and the Change Process

Both living and nonliving systems are constantly in a process of change. Six concepts are helpful in understanding the change process. These are dynamic homeostasis, entropy, negentropy, specialization, reverberation, and equifinality. Dynamic homeostasis refers to the processes used by a system to maintain a steady state or balance. An excellent example is the fluctuations seen in normal body chemistry. Blood levels of normal blood elements begin the drift down or up. Through a feedback loop the body begins to produce more of the decreasing elements and eliminate the excess elements. As the blood level changes, the feedback loop kicks in to reverse the process.

Chapter 10 discusses the life cycle of an information system. One of the stages in this life cycle is maintenance. Maintenance includes a number of activities that function to keep the system operating. Organizations that experience rapid or extensive change experience increased stress because the dynamic homeostasis of the organization is challenged. People working within changing organizations will attempt to maintain a steady state. The result can be seen as resistance to change. An informatics example is the introduction of automation or the introduction of a new computer system that stresses the dynamic homeostasis of the organization. Managing change and thereby decreasing the stress experienced by individual users, as well as the stress experienced by the organization as a whole, is a major piece of the work accomplished by the health care informatics specialist.

Entropy is the tendency of all systems to break down into their simplest parts. As they break down, the systems becomes increasingly disorganized or random. In data transmission, entropy measures the loss of information when a signal is transmitted. Entropy is demonstrated in the tendency of all systems to wear out. It is the tendency of all living systems to reach the point of death. Even with maintenance, a health care information system will reach a point where it must be replaced.

Negentropy is the opposite of entropy. This is the tendency of living systems to grow and become more complex. This is demonstrated in the growth and development of an infant, as well as in the increased size and complexity of today's health care system. With the increased growth and complexity of the health care system there has been an increase in the size and complexity of health care information systems.

As systems grow and become more complex, they divide into subsystems and then subsubsystems. This is the process of differentiation and specialization. Note how the human body begins as a single cell and then differentiates into different body systems, each with specialized purposes, structures, and functions. This same process occurs with health care delivery systems, as well as with health care information systems. As this process occurs, a lead part emerges. The lead part is at the top of the hierarchy. Lead parts play primary roles in organizing and maintaining vertical and horizontal data/information flow. Changes to the lead part can have a major impact across the total system. For example, if the chief information officer leaves the organization, the impact is much more significant than if a beginning-level systems analyst moves to another organization. If the mainframe in Figure 1-2 were to stop functioning, the impact would be much more significant than if an individual computer on one of the LANs were to stop functioning. Understanding the role of the lead part can be key to developing the security and disaster plan for a health care information system.

Change within any part of the system will be reflected across the total system. This is referred to as reverberation. Reverberation is reflected in the intended and unintended consequences of system change. When planning for a new health care information system, the team will attempt to identify the intended consequences or expected benefits to be achieved. Although it is often impossible to identify a comprehensive list of unintended consequences, it is important for the team to consider the reality of unintended consequences. The potential for unintended consequences should be discussed during the planning stage; however, these consequences will be more evident during the testing stage that precedes implementation, or "go live." Often, unintended consequences are not considered until after go live, when they become obvious. For example, eMail may be successfully introduced to improve communication in an organization. However an unintended consequence can be an increased workload resulting from irrelevant eMail messages.

Equifinality refers to the ability of open systems to reach the same end state by starting at different initial states and by using different means. For example, several hospitals may be implementing new hospital information systems. The staff in the various hospitals may or may not be experienced in using this type of software. The hospitals may select from several different approaches for training the staff. Some may use clinical staff and develop superusers. Others may hire outside consultants to do all the training. Others may use information technology or staff development personnel to do the training. No matter what the initial knowledge level of the personnel or the training approach used, each of these hospitals has the potential to effectively train staff and experience a successful implementation. In other words, there is no one correct way to manage many of the challenges inherent in health care informatics.

All systems change and in the process interact with the environment. This interaction is shown in Figure 1-1. Input into the system consists of energy, information, and matter. This input is then processed and results in output. Understanding this process as it applies to informatics involves an understanding of information theories.

INFORMATION THEORIES

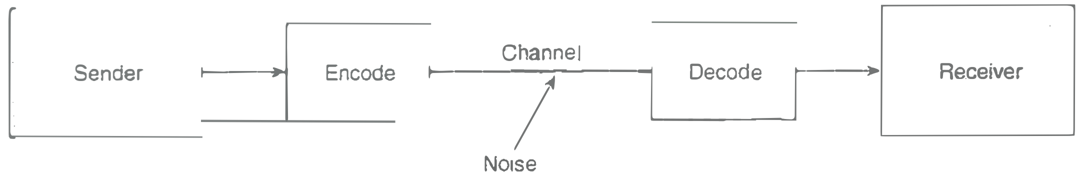
The term *information* has several different meanings (Information, 2000). An example of this can be seen in Box 1-1. Just as the term *information* has more than one meaning, the term *information theory* refers to more than one theory. This chapter examines two theoretical models of information theories: Shannon and Weaver's information-communication model and Blum's model.

Shannon and Weaver's Information-Communication Model

Information theory as a formal theory was born in 1948 with the publication by Claude Shannon of the landmark paper "A Mathematical Theory of Communication" (Shannon, 1948).

The concepts in this model are presented in Figure 1-3. The sender is the originator of the

FIGURE 1–3 Information-Communication Model



Box 1–1 Definitions of *Information*

in·for·ma·tion
noun
Pronunciation: "in-f&r-'mA-sh&n

1. The communication or reception of knowledge or intelligence
2. a. Knowledge obtained from investigation, study, or instruction
   b. The attribute inherent in and communicated by one of two or more alternative sequences or arrangements of something (as nucleotides in DNA or binary digits in a computer program) that produce specific effects
   c. (1) A signal or character (as in a communication system or computer) representing data (2) Something (as a message, experimental data, or a picture) which justifies change in a construct (as a plan or theory) that represents physical or mental experience or another construct
   d. A quantitative measure of the content of information; specifically: a numerical quantity that measures the uncertainty in the outcome of an experiment to be performed
3. The act of informing against a person
4. A formal accusation of a crime made by a prosecuting officer as distinguished from an indictment presented by a grand jury

From Information. In *Merriam-Webster online: Merriam-Webster's collegiate dictionary.* (2000). Retrieved October 8, 2000, from the World Wide Web: http://www.m-w.com/dictionary.htm.

message. The encoder converts the content of the message to a code. The code can be letters, words, music, symbols, or a computer code. For example, the modem on a computer acts as an encoder when it converts a file from a digital form to an analog form so that it can be sent over telephone lines that carry analog sound waves. The telephone line is the channel. A channel carries the message. Examples of channels include sound waves, telephone lines, and paper. Each channel has its own physical limitations in terms of the size of the message that can be carried. Noise is anything that is not part of the message but occupies space on the channel and is transmitted with the message. Some examples of noise include static on a telephone line and back ground sounds in a room. The decoder converts the message to a format that can be understood by the receiver. When one is listening to a phone call, the telephone is a decoder. It converts the analog signal back into sound waves, which are understood as words by the person listening. The person listening to the words is the receiver.

Shannon, one of the authors of the Shannon and Weaver information-communication theory, was a telephone engineer. He was not concerned with the semantic meaning of the message but rather with the technical problems involved in signal transmission across a communication channel or telephone line. He used the concept of entropy to explain and measure the amount of information in a message. The amount of information in a message is measured by the extent that the message decreases entropy. The unit of measurement is a bit. A bit is represented by a *0* (zero) or a *1* (one). The two sides of a coin can be used to explain this concept. If a coin is thrown into the air, it may land on either of two possible sides: heads up or tails up. This can be coded as 1 for heads up and 0 for tails up. Using this approach, the message concerning which side is up is transmitted with 1 bit. If there were four possible states, additional bits would be needed to transmit the message. For example, if the message could be north, south, east, or west, it might be coded 00 for north, 11 for south, 01 for east, or 10 for west. Computer codes are built on this concept. For example, how many bits are needed to code the letters of the alphabet? What other symbols are used in communication and must be included when developing a code?

Warren Weaver, from the Sloan-Kettering Institute for Cancer Research, provided the interpretation for understanding the semantic meaning of a message (Shannon & Weaver, 1949). He used Shannon's work to explain the interpersonal aspects of communication. For example, if the speaker is a physician who uses medical terms that are not known to the receiver (the patient), there will be a communication problem caused by the method used to encode the message. However, if the patient cannot hear well, he or she may not hear all of the words in the message. In this case the communication problem is caused by the patient's ear, which is having difficulty converting the sound waves into neurological impulses that the brain can decode.

The communication-information model provides an excellent framework for analyzing the effectiveness and efficiency of information transfer and communication. For example, a physician may use a computerized order entry system to enter orders. Several questions illustrate the information transfer process. Is the order entry screen designed to capture and code all of the key elements for each order? Are all aspects of the message coded in a way that can be transmitted and decoded by the receiving computer? Does the message that is received by the receiving department include all of the key elements in the message sent? Does the screen design at the receiver's end make it possible for the message to be decoded or understood by the receiver?

These questions demonstrate three levels of communication that can be used in analyzing communication problems (Hersh, 1996). The first level of communication is the technical level. Do the system's hardware and software function effectively and efficiently? The second level of communication is the semantic level. Does the message convey meaning? Does the receiver understand the message that was sent by the sender? The third level of communication is the effectiveness level. Does the message produce the intended result at the receiver's end? For example, did the physician order one medication but the patient received a different medication with a similar spelling? Some of these questions require a more in-depth look at how health care information is produced, transferred, and used. Bruce Blum's definition provides a framework for this more in-depth analysis.

Blum's Model

Bruce L. Blum developed a definition of information from an analysis of the accomplishments in medical computing. In his analysis Blum identified three types of health care computing applications. He grouped applications according to the objects that they processed: data, information, or knowledge. He defined data as uninterpreted elements, such as a person's name, weight, or age. Information was defined as a collection of data that has been processed and then displayed as information. An example is the patient's medical record. Knowledge results when data and information are identified and the relationships between the data and information are formalized. A knowledge base is more than the sum of the data and information pieces in that knowledge base. A knowledge base includes the interrelationships between the data and information. A textbook can be seen as containing knowledge (Blum, 1986).

In their classic article "The Study of Nursing Informatics," Graves and Corcoran (1989) used the concepts of data, information, and knowledge to explain the study of nursing informatics. Graves and Corcoran identified four types of knowledge: empirical, ethical, personal, and aesthetic. Nelson and Joos (1989) extended this data to include wisdom. Figure 1-4 demonstrates the relationships among these four concepts. Wisdom is defined as the appropriate use of knowledge in managing or solving human problems. It is knowing when and how to use knowledge to manage a patient need or problem. Wisdom requires a combination of values, experience, and the four types of knowledge. In Figure 1-4, the concepts of data, information, knowledge. and wisdom overlap. This is demonstrated by the overlapping circles, as well as the overlapping activities included in the circles. As one moves along the continuum, increasing interaction and interrelationships within and between the circles produce increased complexity of the elements within each circle. For example, the concept of wisdom is much more complex than the concept of data.

Using the concepts of data, information, knowledge, and wisdom, it is possible to classify the different levels of computing or automated systems. An automated information system, such as a pharmacy's information system, takes in

FIGURE 1—4 | The Nelson Data-to-Wisdom Continuum

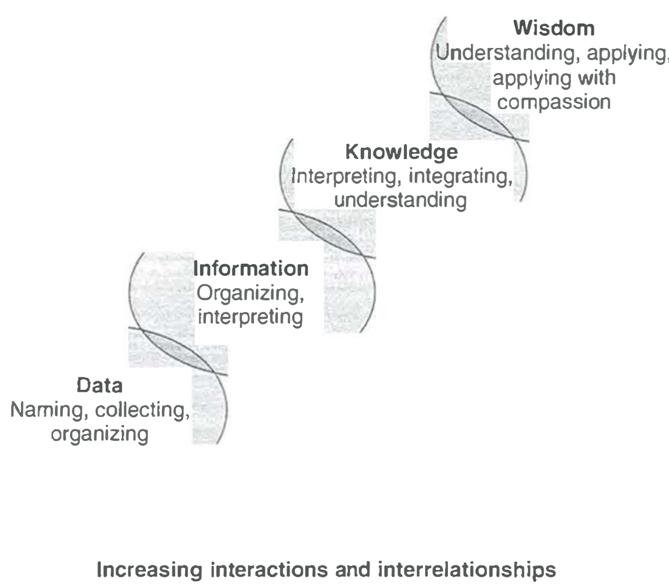
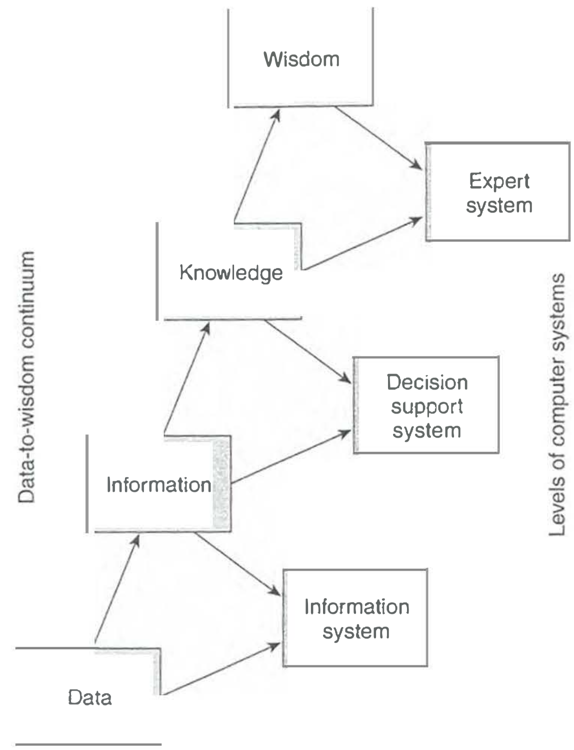


FIGURE 1-5 | Levels and Types of Automated Systems



data information, processes the data/information, and puts out new information. An automated decision support system uses knowledge and a set of rules for using the knowledge to interpret data and information to formulate recommendations. With a decision support system the user decides if the recommendations will be implemented. A decision support system relies on the wisdom of the user. An automated expert system goes one step further. An expert system implements the decision of the computer system without control by the user. The relationships among the concepts of data, information, knowledge, and wisdom, as well as information, decision support, and expert computer systems, are demonstrated in Figure 1-5.

Effective automated systems are dependent on the quality of data, information, and knowledge processed. Table 1-1 lists the attributes: good-quality data, information, and knowledge. These attributes provide a framework for developing evaluation forms that measure the quality of data, information, and knowledge. For example, health care data are presented as either text, numbers, or a combination of text and numbers (alphanumeric). Good-quality health data provide a complete description of the item being presented with accurate measurements. With the use of these attributes, an evaluation form can be developed to judge the quality of a completed patient assessment form or to judge the quality of a health care Web site on the Internet. The same process can be used with the attributes of knowledge. Think about the books or online references that one might access in developing a treatment plan for a patient, or consider a knowledge base

Table 1–1 Attributes of Good Data, Information, and Knowledge

	Attributes
Data	Descriptive Measurable
Information	Quantifiable Verifiable Accessible Free from bias Comprehensive Clear Appropriate Timely Precise Accurate
Knowledge	Accurate Relevant Quality

that is built into a decision support system. What would result if the knowledge were inaccurate or did not relate to the patient's problem, or if suggested approaches were ineffective for treating the patient's problem?

Although this section has focused on computer systems, humans can also be conceptualized as open systems that take in data, information, knowledge, and wisdom. The process is called learning. Learning theory provides a framework for understanding how humans as open systems take in, process, and put out data, information, knowledge, and wisdom.

LEARNING THEORIES

Learning theories attempt to determine how people learn and to identify the factors that influence the learning process. Learning is defined as an increase in knowledge, a change in attitude or values, or the development of new skills. Several learning theories have been developed. Each theory reflects a different paradigm or approach to understanding and explaining the learning process. One example that demonstrates the wide range of learning theories is the Theory Into Practice (TIP) database. TIP is a database containing summaries of 50 major theories of learning and instruction (Kearsley, 2000).

Learning theories are not mutually exclusive. They often overlap and are interrelated. This section focuses on four types of learning theories: behavioral; cognitive, or information processing, theories; adult learning; and learning styles. Learning theories are important to the practice of health care informatics for three reasons. First, health care informatics specialists plan and implement educational programs for teaching health care users to use new applications and systems. Second, learning theory is helpful in designing computer screens and developing computer-related procedures that are effective for health care users. Finally, these theories are helpful in understanding and building decision support systems in health care.

Behavioral Theories

The behavioral approach to learning, which was developed around the turn of the twentieth century, focuses on the smallest units of learning. In this theory the basic unit of learning is conceptualized as the stimulus-response (SR) unit. The stimulus is the input to the system or learner. The response is the output, or behavior exhibited by the learner. Behavioral learning theories provide two key concepts that can be used in informatics to explain learning. These are pairing and reinforcement. Pairing was first demonstrated by ringing a bell when offering food to a dog. The dog would salivate when the food was presented. Over time the sound of the bell alone would result in the dog's salivating (Booth-Butterfield, 1996). Thus the food and the bell were paired. The process of pairing is one approach to understanding computer phobia. New computer learners frequently make mistakes and become frustrated. Over a short period of time the negative experience can be paired with the computer, so that the presence of the computer itself can stimulate anxiety. Such pairing can be avoided if the learners' initial experience is carefully planned to encourage success, thereby minimizing the impact of mistakes.

The concept of reinforcement can also be used to explain computer phobia. Reinforcement may be positive or negative. Positive reinforcement encourages the learner to continue with correct behaviors. An example of positive reinforcement is telling the learner, "You are doing well" or "That is right." Negative reinforcement makes it possible to identify mistakes and correct them. An example of negative reinforcement is telling the learner, "You will need to spend more time working on this procedure" or "No, that is not the correct way to do this procedure; here is what you need to do." Effective learning involves both negative and positive reinforcement. However, if learners experience mostly negative reinforcement when learning to use a computer, they may begin to associate negative reinforcement with the computer in general rather than with the specific mistakes that should be corrected.

The behavioral approach to learning theory explains complex learning processes by breaking down learning into the smallest units. As a result, behavioral theory is referred to as the reductionist approach to learning. Although the behavioral approach demonstrates the relationship between a stimulus and a response, it does not explain the process of learning. This can be seen with systems theory and Figure 1-1. The behavioral approach includes the input to the system and the output from the system but does not deal with the processes within the system. At mid-century a new group of theories concerned with complex learning, such as problem solving or critical thinking, began to evolve. These theories fit with the systems theory approach and included input, processes, output, and feedback. These are the information processing, or cognitive learning, theories.

Information Processing, or Cognitive Learning, Theories

Information processing theories, or cognitive learning theories, divide learning into the following four steps:

1. How the learner takes input into the system
2. How that input is processed
3. What type of learned behaviors are exhibited as output
4. How feedback to the system is used to change or correct behavior

Input of Information

Data are taken into the system through the senses—vision, hearing, smell, taste, touch, and position. Several factors may influence the input process. First, data may be distorted or excluded if there is a sensory organ defect. Second, movement of data across the semipermeable boundary of the system limits how much data can enter at one time. For example, if one is listening to a person who is talking too fast, some of the words will be missed. In addition, the learner will screen out data that are considered irrelevant or meaningless, such as background noise. Data limits are also increased if the learner is under stress. Learners who are anxious about learning to use a computer program will experience higher data limits and thereby less learning.

New information that is presented using several senses at the same time is more likely to be taken in. For example, if a new concept is presented with the use of slides that are being explained by a speaker, the combination of both verbal and visual input makes it more likely that the learner will grasp the concept. As data enter the system, the learner structures and interprets these data, producing meaningful information. Previous learning has a major effect on how the data are structured and interpreted. For example, if a health care provider is comfortable using Windows and is now learning a new software program based on Windows, that learner will be able to quickly structure and interpret the new information using previously developed cognitive structures. If new information cannot be related to previous learning, learners will need to build the interpreting structures as they take in the new information. For example, a person who is reading new information may stop at the end of each sentence to think about the content in that sentence. Learners build interpreting cognitive structures as they import data. Learners who are hearing new information and taking notes at the same time may have difficulty capturing the content that they are trying to record. The more time needed to interpret and structure data, the slower the learners will be able to import data. Assessment of the learners' previous knowledge can help the instructor identify potential problems. Relating new information to previously learned information will help learners develop interpretive structures and in turn learn the information more effectively.

Input Processing

Short-Term Memory New information is interpreted and stored in short-term memory first. Short-term memory consists of the information that is currently being processed by the learner. It is the information that the learner is thinking about at a moment in time. An example is a telephone number that has just been found in a telephone book. The learner will hold the number in memory and actively work to retain the number. This type of memory has several characteristics similar to RAM in a computer. First, short-term memory has a limited capacity, holding about 7, plus or minus 2, bits of information. The size of the bit is determined by how the information is chunked. The number *1952* may be retained as four digits, or if the learner has interpreted this as a year, it may be 1 bit of data. The technique of using organizing structures (such as outlines), giving examples, and explaining how new information relates to previously learned concepts encourages the learner to develop chunks and increases retention.

The second characteristic of short-term memory is that the information is maintained in the temporal order that it was presented. Think of the way a phone number is remembered in order. This is important when presenting new information to a learner. If the information is presented in different temporal orders, it will be more difficult for the learner to retain. For example, an instructor is reviewing a list of commands. At the same time, the learners are given a written handout listing the commands. With computers there may be several approaches that can be used to achieve the same end. If the order that the instructor uses in presenting the commands is different from the order presented in the written materials, the learners can easily become confused. This same confusion occurs if different terminology is used. For example, a phone extension was dictated as "two zero four one." When it was repeated, the speaker said "twenty forty-one." "Twenty forty-one" and "two zero four one" are two ways of saying the same series of digits, but the human mind must do a conversion to create the same mental image of these numbers. The same thing happens when an instructor tells the novice user to "hit the return key," or "hit the enter key."

The third characteristic is that loss of information from short-term memory is inevitable. This occurs by fading or, as new information moves into short-term memory, replacing information in short-term memory. If the replaced information is moved to long-term memory, it can be recalled at a later date. However, when one is learning new information, there may not be time to store the information in long-term memory before it is replaced with more new information. This can often be seen when novice users are learning basic computing skills. First they are presented with a new skill. They understand the skill. They have interpreted the information, and it has meaning. This may be a new command that the learners have completed once or twice by following the directions of the teacher. Next the learners are presented with a second new command or more new information. If the first skill has been interpreted but not stored in long-term memory, the learners may have recognition but not recall. They cannot remember the steps for the first command. However, they will be able to recognize these steps when the instructor repeats them. This process, often seen with novice users learning new systems, is a source of frustration. For example, a novice user has just learned how to do a new procedure such as "cut and paste." The learner is sure he knows how to do this procedure. Next he learns how to change the name of a file after it has been saved. At this point the learner may not be able to recall all of the steps for doing the "cut and paste" procedure. If the instructor now repeats the steps, the learner will recognize each step and be frustrated that that he could not recall the steps on his own. Well-designed handouts and guides play a major role in helping learners deal with this phenomenon.

Long-Term Memory For learning to be maintained over time, the information must be stored in long-term memory. Information is retained in three common formats: episodic order, hierarchical order, or linked. For example, life events are often retained in episodic order. A list of computer commands is also retained in episodic order. Psychomotor episodic learned commands can become automatic. An example of this can be seen in the simple behavior of typing or the more complex behavior of driving a car. Cognitive learning tends to be retained in hierarchical order. For example, penicillin is an antibiotic. An antibiotic is a drug. Finally, information is retained because it is linked or related to other information. For example, the concept of paper is related to a printer. The process by which information is retained in long-term memory can be reinforced by a variety of teaching techniques. Providing students with an outline when presenting cognitive information helps to reinforce the retention of information in hierarchical order. Telling stories or jokes can be used to reinforce links among concepts. Practice exercises that encourage repeated use of computer commands assist with long-term retention of psychomotor episodic learning.

Although long-term memory can retain large amounts of information, two processes can interfere with the storage of information in long-term memory. First, new information or learning may replace old information. For example, health care providers may become very proficient with an automated order-entry system. However, over time they may not remember how to use the manual system for placing orders. This can be a problem if the manual system is the backup plan for computer downtime. Second, previously learned information can interfere with the learning of new information. This can be seen when a new computer system is installed and new procedures are implemented. Experienced users of the old system must remember *not* to use the old procedures that were part of that system. If the instructor for the new system includes clues to remind the experienced users of the change, the process of replacing old learning with new information can be reinforced.

When planning educational programs for health care users, the health care informatics specialist must first plan for intake of the new information via short-term memory and then for transfer of the new information to long-term memory. Several factors assist in moving information from short-term to long-term memory. A list of these factors and examples of each can be seen in Table 1-2. Information that is stored in long-term memory is used in critical thinking, problem solving, decision making, and a number of other mental processes.

Output Behaviors

Learned behaviors are exhibited as output. Three types of output behaviors are usually considered: cognitive, affective, and psychomotor. Cognitive behaviors reflect intellectual skills. They include critical thinking, problem solving, decision making, and a number of other mental processes. These are the skills that are used when designing a procedural manual for users of an automated

Table 1–2 Techniques for Moving Information From Short-Term to Long-Term Memory

Principle	Example
Distribute the learning over time.	It is more effective to schedule four 2-hour classes in 1 week than to schedule one 8-hour class in 1 day.
Plan to retain the information.	Before teaching new content, explain to the learners why the information will be important and when they will need to recall the new information.
Review the materials.	When presenting a list of new ideas, stop after each idea is explained and list each of the ideas that have already been explained.
Overlearn the content.	Once a group of learners has mastered certain concepts, give the group several exercises to reinforce the concepts.
Increase the time spent on task.	This does not mean increase the time scheduled for class; rather, increase the amount of time the learner is actively working on the content to be learned.

health care information system or troubleshooting a computer system that is not transmitting information correctly.

Affective skills relate to values and attitudes. Planning for the learning of appropriate values and attitudes is often overlooked yet can have a major impact on the implementation of an automated health care information system. Automating health care delivery requires change. This can be stressful for health care providers. Often, training programs focus exclusively on how to use the system. There is rarely time to discuss how to integrate the new system into patient care. There is limited discussion of the benefits of change and little support for the development of positive attitudes toward a new system. However, the development of positive values and attitudes can be important to the ongoing maintenance of automated systems in health care. Attitudes play a key role in users' decisions to suggest new and innovative uses for computer systems. Affective knowledge can be key to implementing security systems to protect the confidentiality of patient data. If a high value is placed on the confidentiality of patient data, the development and consistent implementation of security procedures will reflect that value.

Psychomotor skills involve the integration of cognitive and motor skills. These types of skills require time and practice to develop. During the time period when these skills are being developed, productivity is often decreased and users are often frustrated. When new health care information systems are implemented, the institution is usually very interested in measuring the impact of the new system. However, while new users are in the process of developing the psychomotor skills that are part of using the new system, it is ineffective to measure either the impact of the new system or user satisfaction.

Use of Feedback

During implementation, the focus should be on supporting the user's adjustment and troubleshooting problems. Any decision to make significant changes to a new system based on user feedback must be carefully evaluated.

Adult Learning Theories

Adult learning theories focus on the unique learning characteristics of adults. Andragogy is the art and science of helping adults learn (Knowles, 1970). Knowles's model proposes that adults share a number of similar learning characteristics and that these characteristics can be used in planning adult educational programs. Table 1-3 lists a number of these characteristics

Table 1–3 Adult Learning Characteristics and Related Applications

Learning Characteristics	Application
Adults are self-directed	When planning the implementation of a new system review with the users what they think they will need to learn about the new system.
Adults have accumulated a number of life experiences and cognitive structures. These are used to interpret new learning.	When teaching a new system, ask the students to provide examples from their experience and use these to explain how the new system will function
Adults are practical and look for immediate application of learning.	Orientation to a new system should occur no more than 4 weeks before the actual implementation.
Adults are more interested in learning how to solve problems than in retention of facts	When teaching adults about computer application, use real-life examples that can be expected to occur on the clinical unit.
Adult learners expect to be treated with respect and to have their previous learning acknowledged.	When explaining a new system, ask the students what they already know about the new system.

and provides examples of how these characteristics can be used to plan for teaching adult users.

Learning Styles

Since all learners are not alike, they learn in different ways. They vary in how they take in and process information. There are preferential differences in seeing and hearing new information. Some learners process information by reflecting; others process information by acting. Some learners approach reasoning logically; others are intuitive. Some learners learn by analyzing; others learn by visualizing. Learning theories concerning learning styles attempt to explain these differences. Experiential learning theory is one example (Kolb, 1984). The first stage of Kolb's theory involves concrete experience. For example, the learner may learn by viewing a demonstration of a new health care information system.

As learners begin to understand how the system works, they begin to think about how the system would work in their health care setting. This is the second stage, or reflection. In this stage learners reflect or think about the concrete experience. As they continue to think, they begin to form abstract conceptualizations of how the system functions. This is the third stage. Finally, learners are ready to try using the system. This is the fourth stage, when learners use their abstract conceptualization to guide action. In the model these four stages exist on two intersecting continuums. These are as follows:

CE Concrete Experience	**AC** Abstract Conceptualization

and

RO Reflective Observation	⟷	**AE** Active Experimentation

Learners differ in how they use each of these four stages in their individual learning approaches, but all learners ultimately learn by doing. Using this model, Kolb developed a learning assessment tool for identifying individual learning styles. The intersection of the two continua forms four quadrants: diverger, assimilator, converger, and accommodator. These are the four in-

Box 1-2 **Learning Principles for Instructional Design**

- Meaningfulness assists learning.
- Only so much input can be handled at one time.
- Timing of learning is critical.
- Participation and practice support retention.
- Conceptual learning is enhanced with concrete examples.
- Taking in new material through more than one modality can facilitate learning.
- Learning is enhanced when the teaching method includes the cognitive, affective, and psychomotor domains in concert.
- Learning takes place intentionally and unintentionally.
- Individuals learn at different rates and in different ways.
- Learning is contagious.

dividual learning styles in Kolb's model. The learner plots a score along the CE-AC scale, and the RO-AE scale to identify the quadrant that reflects his or her learning style.

A second widely used measure of individual learning styles is the Myers-Briggs Type Indicator (Myers & McCaulley, 1985). This theory identifies four continua:

Thinking ⟷ Feeling
Sensing ⟷ Intuition
Extroverted ⟷ Introverted
Judging ⟷ Perceptive

A series of questions are used to determine where the learner falls on each continuum. For example, a learner may be thinking, sensing, extroverted, and judging (TSEJ). The combination of where the learner falls on each of the four continua is then used to form a composite picture of the learner's preferred learning style.

A health care informatics specialist plans and implements educational programs for a variety of groups within the health care delivery system. These may include physicians, nurses, unlicensed personnel, administrators, and others. These groups vary widely in learning ability, education, motivation, and experience. However, there is also a great deal of variation among the learners within each group. An understanding of learning styles helps to explain these differences and to plan instructional strategies that are effective for individual learners within a group. Each of the four types of learning theories discussed in this chapter provides insights into effective approaches to teaching. Box 1-2 lists some examples of principles that are derived from these theories.

CHANGE THEORIES

Each of the theories presented in this chapter includes an element of change. As pointed out in the discussion of systems theory, all things constantly change. Change theory is the study of change in individuals or social systems, such as organizations. An understanding of change theory makes it possible to effectively plan and implement change in organizations and other social systems. Health care information systems have a major impact on the structure and functions of health care delivery systems. They bring about significant change. The approach used to manage the change process may result in a more effective and efficient health care delivery system, or it may result in increased dissatisfaction and disruption. Health care informatics specialists play a major role in planning for, guiding, and directing these changes. In other words, health care informatics specialists act as change agents.

The change process can be analyzed from two perspectives. The first view is demonstrated by Kurt Lewin's theory, which focuses on how a change agent can guide the change process. This is referred to as planned change. The second view focuses on the process by which people and social systems make changes. Research in this area has demonstrated that people in various cultures follow a similar pattern when incorporating innovation and change. Both views of change provide a framework for understanding how people react to change and for guiding the change process.

Planned Change

The father of change theory is Kurt Lewin. Lewin's theory of planned change divides change into three stages: unfreezing, moving, and refreezing (Schein, 1999). As demonstrated in the discussion of homeostasis, systems expend energy to stay in a steady state of stability. A system will remain stable when the restraining forces preventing change are stronger than the driving forces promoting change. Initiating change begins by increasing the driving forces and limiting the restraining forces, thereby increasing the instability of the system. This is the unfreezing stage. The first stage in the life cycle of an information system involves evaluating the current system and deciding what changes need to be made. The pros and cons for change reflect the driving and restraining forces. If changes are to be made, the restraining forces that maintain a stable system and resist change must be limited. At the same time, the driving forces that encourage change must be increased. For example, pointing out to users the limitations and weaknesses with the current information management system increases the driving forces. Asking for user input early in the process before decisions have been made decreases the restraining forces. Once a decision is made to initiate change, the second stage—moving—begins.

The moving stage is the implementation of the planned change. By definition this is an unstable period for the social system. Anxiety levels are increased. The social system attempts to minimize the impact or degree of change. This resistance to change may occur as missed meetings, failure to attend training classes, and failure to provide staff with information about the new system. If the resistance continues, it can cause the planned change to fail. Health care informatics specialists, as change agents, must anticipate and minimize these resistive efforts. This can be as simple as providing food at meetings or as complex as a planned program of recognition for early adopters. For example, an article in the institution's newsletter describing and praising the pilot units for their leadership will encourage the driving forces for change.

Once the system is in place or the change has been implemented, additional energy is needed to maintain the change. This is the refreezing phase and occurs during the maintenance phase of the information system's life cycle. If managed effectively by the change agent, this phase is characterized by increased stability. In this stage, forces resistant to change are encouraged. Some examples include training programs for new employees, a yearly review of all policies and procedures related to the change, and continued recognition for those who become experts with the new system.

Diffusion of Innovation

Individual Responses to Innovation

The diffusion of innovation theory, developed by Everett Rogers, explains how individuals and communities respond to new ideas, practices, or objects (Rogers, 1995). Diffusion of innovation is the process by which an innovation is communicated through certain channels over time among members of a social system. Innovations may be either accepted or rejected. Health care automation, with new ideas and technology, involves ongoing diffusion of innovation. By understanding the diffusion of innovation process and the factors that influence this process, health care informatics specialists can assist individuals and organizations in maximizing the benefits of automation.

Social systems consist of individuals within organizations. Both the individuals and the organization as a whole vary in how they respond to innovations. The individuals can be classified into five groups based on their responses to change.

These groups are innovators, early adopters, early majority, late majority, and laggards. Innovators are the first 2.5% of individuals within a system to adapt to an innovation. These individuals tend to be more cosmopolitan. They are comfortable with uncertainty and above average in their understanding of complex technical concepts. These are the individuals who test out a new technology; however, they are not usually respected by other members of the social system. They will not be able to sell others on trying the new technology. This is the role of the early adopters.

Early adopters are the next 13.5% of individuals in an organization. Early adopters are more local in focus. They are perceived as discreet in their adoption of new ideas and serve as role models for others in the organization. Change agents should work at identifying these individuals and providing recognition for their efforts. Because of their leadership role within the organization, the support of early adopters is key when introducing new approaches to automation. If the early adopters accept an innovation, the early majority will follow their example. This is the next 34% of individuals in an organization. Members of the early majority are willing to adapt to an innovation but not to lead. However acceptance by the early majority means that the innovation is becoming well integrated into the organization.

The late majority is the next group to accept an innovation. The late majority makes up 34% of individuals in an organization. Most of the uncertainty that is inherent with a new idea must be removed before this group will adopt an innovation. They adopt the innovation not because of their interest in the innovation but rather as a result of peer pressure. The late majority is followed by the last 16% of individuals in an organization. These are the laggards. Laggards focus on the local environment and on the past. They are resistant to change and will change only when there is no other alternative. They are suspicious of change and change agents. Change agents should not spend time encouraging laggards to change but rather should work at establishing policies and procedures that will incorporate the innovation into the required operation of the organization.

Organizational Responses to Innovation

Just as individuals vary in their response to innovations, organizations also vary. There are five internal organizational characteristics that can be used to understand how an organization will respond to an innovation (Trujillo, 2000):

1. Centralization—Organizations that are highly centralized, with power concentrated in the hands of a few individuals, tend to be less accepting of new ideas and therefore less innovative.
2. Complexity—Organizations in which many of the individuals have a high level of knowledge and expertise tend to be more accepting of innovations. However, these types of organizations can have difficulty in reaching a consensus on approaches to implementation.
3. Formalization—Organizations that place a great deal of emphasis on rules and procedures tend to inhibit new ideas and innovation. However, this tendency toward rules and procedures does make it easier to implement an innovation.
4. Interconnectedness—Organizations in which there are strong interpersonal networks linking the individuals within the organization are better prepared to communicate and share innovation. This can be seen, for example, in organizations that use eMail as an integral part of organizational communication.
5. Organizational slack—Organizations with uncommitted resources are better prepared to manage innovation. These resources may be people and/or money.

Although these characteristics help to explain how an organization as a whole will respond to an innovation, they can be analyzed from both an individual and an organizational level. For example, adapting to new software involves a certain degree of complexity. Think about what is involved when an individual must select a new word processing program. Now think about what is involved if an organization decides to select new word processing software as its standard software.

The perceived attributes of the innovation, the nature of organizational communication channels, the innovative-decision process, and the efforts of change agents influence the possibility that an innovation will be adopted and the rate of adoption. There are five attributes that can be used to characterize an innovation:

1. Relative advantage—Is the innovation an improvement over the current approach?
2. Compatibility—Does the innovation fit with existing values, past experiences, and individual needs?
3. Complexity—Is the innovation easy to use and understand?
4. Trialability—Can the innovation be tested or tried before individuals must make a commitment?
5. Observability—Are the results of using the innovation visible to others?

If each of these five questions related to the five innovative attributes can be answered with a "yes," then it is more likely that the innovation will be adopted and that the adoption will occur at a rapid rate. If, on the other hand, an innovation is not gaining acceptance, these characteristics can be used as a framework for evaluating the source of the problem. For example, it may take more time to document a patient assessment with an automated system. As a result, nurses will prefer the manual system because of the relative advantage.

Stages of Acceptance

The decision of individuals and organizations to accept or reject an innovation is not an instantaneous event. The process involves five stages. These stages can be demonstrated when a health care institution considers providing eMail to all professional staff. The first stage of the innovation—the decision stage—is knowledge. In the knowledge stage the individual or organization becomes aware of the existence of the innovation. Mass communication channels are usually most effective at this stage. For example, the institution's newsletter may carry a story about eMail and how staff could use it to support interinstitutional communication with other institutions. If there are no mass communication channels open to the change agent, the knowledge stage may be significantly delayed. Whereas personal-type information moves quickly via informal face-to-face communication channels, cognitive information does not move quickly through these types of channels.

Once individuals become aware of an innovation, they begin to develop opinions or attitudes about the innovation. This is the persuasion stage. During the persuasion stage, interpersonal channels of communication are more important, and early adopters begin to play a key role. In the persuasion stage, attitudes are not fixed but are in the process of being formed. The health care informatics specialist should work closely with the early adopters in developing and communicating positive attitudes to others in the organization.

As these attitudes become more fixed, individuals make decisions to accept or reject the innovation. This is the decision stage. It is at this point that individuals will decide to try the eMail system. For each person this decision can occur at a different point. Early adopters will decide to try the system before the early majority. The individual will test out the system during the implementation stage. In testing out the system, most people begin to discover new features or functions of the system. As they gain a better understanding of how the new eMail system functions, modifications and adjustments are made. For example, eMail is a more informal form of communication. Will individuals be addressed by their first names, or will professional titles be maintained? The health care informatics specialist needs to be sensitive to these modifications. Modifications take on an added significance when formal and informal policies and procedures are developed. The final stage is confirmation. At this point the innovation is no longer an innovation. It has either been rejected or has become the standard procedure. For example, key interinstitutional communication will depend on staff using eMail. Change at this point requires a new innovation.

Using Change Theories

Effective change requires a champion(s) with a clear vision, a culture of trust, an organizational sense of pride, and the intense involvement of the people who must live with the change. The champion must have the institutional resources to support the change process. These resources include leadership skills, personnel (including change agents), money, and time. The change agent uses change theory to understand and manage reactions to change throughout the change process. Reactions to change may be negative, such as resistance, frustration, aggression, surface acceptance, indifference, ignoring, or organized resistance. Or the reaction to change may be positive, such as a sense of pride, supporting and encouraging others, demonstrating how the innovation improves the organization, and overall acceptance. Change agents usually discover both positive and negative reactions during the change process. It is usually more effective to support the positive reactions to change than it is to spend time and effort responding to negative reactions.

CONCLUSION

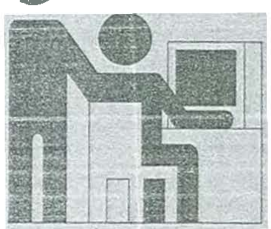
Health care is an information-intensive service. Automation and the use of technology provide an effective and efficient means to manage the large volumes of data and information with knowledge and wisdom. However, the move from a manual to an automated world is changing every aspect of health care. This degree of change brings excitement, anxiety, resistance, and pride. Health care informatics specialists function at the very core of this change. They play a major role in implementing, managing, and leading health care organizations as they move forward with automation. To play this role, they work directly with the clinical, administrative, and technical personnel in the organization. For health care informatics specialists to provide effective leadership, they must understand the institutions, the people, and the processes within the organizations. The theories presented in this chapter provide a framework for supporting and managing the enormous degree of change experienced by the health care system and the people within the health care system.

Web Connection

Theories and models are used to explain ways of viewing the world. Concepts come together in relationships to form theories and models. As noted in this chapter, the basis of all of the theories used in health care informatics is system theory. It is suitable then that we use a preeminent system—the World Wide Web—to continue with our learning. Using the World Wide Web as a portal to data and information can facilitate the development of our knowledge. In the Web Connection for this chapter, activities will be offered to reinforce theories, models, concepts, and relationships that are described and illustrated in the chapter. These activities will allow you to make and reinforce the connections that are introduced in the chapter. You will explore the ways in which the concepts of "data," "information," "knowledge," "wisdom," and "change" are used today.

discussion questions

1. List and explain how theoretical knowledge can be used to plan future approaches, as well as to solve current problems, related to informatics.
2. Examine the following icon. Use this icon to explain systems theory (include characteristics of systems and how change impacts systems).
3. Use Shannon and Weaver's model of information to describe communication in a health care informatics class.



4. Use Blum's model of information to explain how computers are now used and may be used in the future to support health care delivery.
5. Define the concepts of data, information, knowledge, and wisdom. Explain the relationships among these concepts.
6. This chapter includes four types of learning theories. Use each of the types of learning theories to explain how people learn when learning about computers in health care.
7. The response of individuals to innovations has been classified into five groups. List and describe the five groups.
8. List and explain the five internal organizational characteristics that can be used to predict how an organization will respond to a change in automation. Use these five characteristics to predict how the American health care delivery system will respond to health care computing innovations in the next 5 years.

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