Models and Model Building in Nursing

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NURSING EDUCATION HAS historically focused on knowledge related to practice skills. However, in recent years increasing emphasis in the classroom has been placed on research and theory. Nursing has moved from an applied art borrowing theories from the behavioral and physical sciences to explain its practice to a profession actively involved in the delineation and development of nursing theory. Few topics are receiving more attention in the nursing literature than the need for a refined and clearly articulated theoretical base.

Nursing educators and practitioners generally agree that nursing theory, practice, and research are intimately interdependent. Theory can only be derived from research in nursing practice. Chinn and Jacobs maintain that "the development of theory is the most crucial task facing nursing today."[1(p1)] If nursing is to gain power and prestige within the health care system it is increasingly important that

0161-9268/81/0033-0031$2.00

practitioners have theoretical bases for their practice.

As one way of moving toward the development of a theoretical base for practice Chinn and Jacobs[1] have set forth a four-stage set of operations for a theory development system: (1) concept examination and analysis, (2) formulation and validation of relational statements, (3) theory construction, and (4) the practical application of theory. While there is no argument with their position that nurses must become increasingly involved in the development of theory, the mastery of each step in this four-stage process needs careful attention. Chinn and Jacobs emphasize that concept examination and analysis is probably the most important, yet most frequently overlooked, operation in the theory development system.

A model is a device to facilitate the examination and analysis of concepts. Unfortunately not enough attention has been devoted (either in the classroom or in the literature) to the development of models. Students seem intimidated by the prospect of developing and using models in either practice or research. The purpose of this article is to define and classify models, outline the model building process, and discuss the advantages and disadvantages of models. The position taken here is that a basic understanding of both models and their development is a first step in the process toward theory development.

WHAT ARE MODELS?

Most people tend to view a model as any structure which purports to replicate, reproduce, or represent something else. While this notion of a model is consistent with the scientific view of a model, it ignores the use to which the model is put. Hence a key distinction between the common view of a model and the scientific view is in the use to which the model is put.

In the scientific sense a model may be used to define or describe something, to assist with analysis of a system, to specify relationships and processes, or to present a situation in symbolic terms that may be manipulated to derive predictions. There seems to be only one common characteristic of the various usages of scientific models. According to Kaplan, "we may say that any system A is a model of system B if the study of A is useful for the understanding of B without regard to any direct or indirect causal connection between A and B."[2(p263)]

In various branches of science, engineering, and industry models are used to solve both simple and complex problems by concentrating on some portion or some key features instead of on every detail of real life. This approximation or abstraction of reality, which may be constructed in various forms, represents the scientist's idea of a model. As Hazzard[3] points out, no one segment of the human universe is

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so simple and easy to understand that it can be grasped and controlled without the use of abstraction. Consequently, models do not, and cannot, represent every aspect of reality because of the innumerable and changing characteristics of the real world to be represented. Because models use abstraction, attention is focused only on the details of reality that are perceived to have the greatest relevance to the situation. This feature is an intrinsic part of the scientific model.

RELATIONSHIP BETWEEN MODELS AND THEORIES

The term *model* has often been used as a synonym for theory. While many authors use these terms interchangeably, the substitution of one term for the other has led to their misuse. As Rudner notes, the term *model,* like the term *theory,* shows a "melancholic lack of uniformity in the vocabulary of scientists and others who talk about science."[4(p23)]

The position taken here is that all theories are models, because all theories purport to represent some aspect of real world phenomena. However, the converse is not true; all models are not theories because many models will not have all the requisites of theoretical construction. To qualify as a theory, the phenomena under consideration must be precise and limited, and the concepts need to be clearly defined.[5] Theory also includes the capability for prediction and control regarding the relational statements set forth about the phenomena which constitute the theory.[1] Hence, according to Rudner, "A theory is a systematically related set of statements, including some lawlike generalizations, that is empirically testable. The purpose of theory is to increase scientific understanding through a systematized structure capable of both explaining and predicting phenomena."[4(p10)]

While a model describes the structure of events or systems, a theory moves beyond description to the level of prediction by stating relationships among components. Models provide useful mechanisms for depicting the relationships which exist among the variables of the theory. The construction of a model allows theorists to graphically illustrate and explain relationships. In this context model building is viewed as an early step in the more time-consuming and complex process of theory development.

Although certain characteristics distinguish models and theory from one another, they also share certain common qualities. Both vary in their degree of abstractness, and both are isomorphic systems. Isomorphism refers to the similarity between a thing and model of it.[6(p580)] For a model to be maximally useful, it must accurately depict the object which it purports to represent. Isomorphism requires a one-to-one correspondence between the model or theory and reality. While models are an important tool for theory construction, not all models are designed for this purpose. Therefore to more fully understand the nature of models, they need to be classified.

CLASSIFICATION OF MODELS

Any model can be classified and described in different ways. However, the

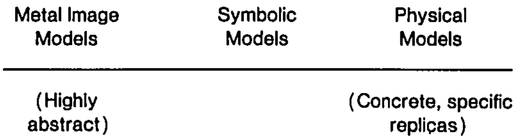

Fig 1. Models classified according to level of abstraction.

task of categorizing models is complicated by the lack of a uniform terminology. A comprehensive review of the literature revealed a considerable variety of terms used to distinguish among various types of models. When several terms are used to describe the same type of model, confusion rather than clarification results. In the classification schema which follows, the basic types of models are identified and, where possible, synonymous terms are noted.

Classification according to level of abstraction

Models are frequently described according to their level of abstraction, which essentially refers to their composition or manner of presentation. When models are classified according to their level of abstraction, they can be arranged along a continuum with *mental models* at one polar end and *physical models* at the other. In this context mental models represent the highest degree of abstraction. In contrast, physical models are specific, concrete replicas of their real-life counterparts. Symbolic models are positioned between pure mental models and physical models. Thus by starting with mental models and moving toward physical models, all models can be positioned on a continuum in which the manner of presentation becomes less abstract (Figs 1 and 2).

Mental models

Mental models, sometimes called images or implicit models, are the pictures of the world held in the mind. Mental models consist of thought patterns composed of words and concepts arranged to constitute a meaningful image of reality. These thought patterns can be

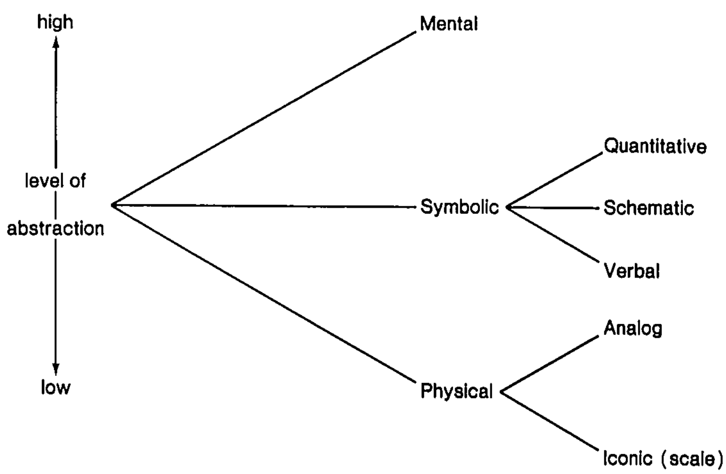

Fig 2. Classification of models according to level of abstraction and including subcategories.

formulated into language, which ultimately allows people to communicate and describe abstractions to others.

A mental model is a simplification of the situation it portrays, consisting of a few incomplete and abstract concepts which are considered integral to forming a meaningful image of reality. It is fortunate that mental models reduce the full scope of the situations which they portray. This enhances their usefulness by not overwhelming the individual with the complexities of reality. The real value of mental models comes from their not corresponding precisely to the complexity of the phenomenon under scrutiny. Instead the model focuses on the details of reality which have the perceived greatest relevance to the situation.

Physical models

Not all phenomena can be understood by the use of mental models. Consequently highly abstract models may become explicit in the form of physical models.

Iconic models. One type of physical model is the iconic model. An iconic model looks like what it is supposed to represent; it is a physical representation of some real-life object, either in a somewhat idealized form or on a different scale. Some iconic models are exact replicas of the entities they are designed to represent, whereas others deviate from reality in the number of properties represented. Iconic models are sometimes referred to as scale models. While not all iconic models involve a change in size, many are designed to be either smaller or larger than the entity being depicted.

Iconic models are frequently used by engineers and designers. For example, they are used in the design of ocean liners, bridges, water supply systems, and various products, ranging from automobiles to stage scenery. Aeronautical engineers use miniature models of airplanes to represent full-sized planes in wind tunnel tests. Iconic models are also used by nurses as replicas of various body organs, such as the heart, kidney, or brain, used for instructional purposes.

Analog model. When a model ceases to look like its real-life counterpart, thus becoming more abstract, while simultaneously retaining physical properties, it is referred to as an analog model. In contrast to iconic models, in analog models properties are transformed. One property is used to represent another. There is a substitution of components or processes to provide a parallel with what is being modeled.

A topographic map in which the property color is substituted for height above sea level is one common example of an analog model. Another example is a graph, such as an electrocardiogram (ECG), in which a unit distance along a line is used to represent a unit of time or speed. The ECG is realistic in behavior, reflecting what is occurring in the heart, but it does not have characteristic features of any aspect of the processes producing the data displayed.

Symbolic model

When a model no longer has a recognizable physical form and takes on a higher level of abstraction it becomes a symbolic model. In this type of model, phenomena are represented figuratively by using a set of connected symbols, objects, or concepts.[7] Symbolic models can be either verbal, schematic, or quantitative.

Verbal model. A *verbal* model is any worded statement indicating the important aspects of a phenomenon. It is either written or spoken in a language that is familiar to those who seek to understand the model.

An important characteristic of this type of symbolic model is that it is easily constructed and communicated. For example, in medicine effective verbal models that describe the transmission of disease have been useful in the eradication of many epidemic diseases. Similarly, Harvey's model of the circulatory system and the various models of the reaction of the human body to invading organisms have influenced the development of the modern treatment of diseases.

Schematic model. Another type of symbolic model is the schematic model, which represents a useful next step in the process of symbolizing a verbal model. Many diagrams, graphs, drawings, pictures, and similar schemata are schematic models. This type of model is more abstract than the analog model mentioned earlier. It is generally descriptive, but it cannot be easily tested for representativeness and may lack precision. However, schematic models often provide an effective way to communicate with nonexperts and can bring together ideas that will be used in formulating other types of models.

One common example of a schematic model is the communications map of an organization, such as a hospital, which uses arrows to show how messages and other means of communication are transmitted. The map does not show anyone talking to anyone else and yet one can easily determine from the map which persons communicate with each other.

Quantitative model. A final type of symbolic model is the quantitative model, which uses mathematical symbols to represent a phenomenon or certain aspects of a phenomenon. Such a model possesses many useful and desirable characteristics. Quantitative models are concise and add the potential for certain kinds of precision. Moreover, they are not easily misconstrued. Mathematical symbols are easier to see and manipulate than words because tools of logic and mathematics may be used with quantitative models. Finally, quantitative models are easier to test and replicate than other types of models.

There are various types of quantitative models, some of which are relatively simple while others are extremely complex. One example of a quantitative model is the health belief model, developed by Becker,[8] which has been expressed in the form of several equations as well as being depicted verbally and schematically.

CLASSIFICATION ACCORDING TO PURPOSE

Not only can models be distinguished from one another in terms of their level of abstraction, but one model can be contrasted with another by considering its purpose. The intent of the model brings into focus a variety of factors which have been used to distinguish various types of models. By using a series of bipolar adjectives, models can be categorized according to their purpose (Table 1). More specifically, models can be classified as being physi-

Table 1. Classification of models according to purpose

Category	Subcategory	Purpose
Physical		Represent structure
vs		
Behavioral		Depict performance
or		
Static		Portray phenomenon at a given point in time
vs		
Dynamic		Show time as an independent variable
or		
Micro		Focus on individual units and detailed linkages between variables
vs		
Macro		Use varying levels of aggregation and gross relationships between variables
or		
Partial		Limited to a few variables, developed in detail
vs		
Comprehensive		Identify many variables, developed in detail or linked with gross relationships
or		
Descriptive		Describe things as they are or as they act
	Communicative	Describe structural arrangement
	Explanatory	Describe causal relationships
	Predictive	Forecast future behavior or events
vs		
Decision		Find problem solutions
	Optimization	Find best solution
	Heuristic	Find a satisfactory solution

cal or behavioral, static or dynamic, macro or micro, comprehensive or partial, and descriptive or decision.

Physical versus behavioral models. When models are classified as being either physical or behavioral, the distinction is based on whether the purpose is to replicate the structure of a phenomenon or to duplicate its performance. For example, one purpose of using a model skeleton in an anatomy class is to show the structural relationship of the various bones in the skeletal system. In contrast, the purpose of two faculty simulating a nurse-patient encounter in the classroom is to demonstrate a behavioral phenomenon and illustrate to students a variety of intervention strategies.

Static versus dynamic models. A similar distinction can be made to differentiate between static and dynamic models. The purpose of a static model is to portray a phenomenon or group of phenomena at a given point. Static models do not readily portray change, although by using several or even a series of static models, change can be depicted. In contrast, dynamic models have time as an independent variable and emphasize the process by which change occurs.[9] For example, the life cycle concept is a dynamic model of human growth and development. In contrast, an organizational chart illustrates a static model. A set of photographs of a child at different ages represents a series of static models that could be viewed as a comparative dynamic model.

Micro versus macro models. Because models can be built at various levels of detail and complexity, another way of distinguishing among them is based on whether they are macro or micro. Models may be more or less aggregated in terms of the variables on which they build. The micro model is the least aggregated. Its purpose is to focus on individual units as well as to postulate detailed linkages between dependent and independent variables.[10(p618-619)] In contrast, the variables in macro or aggregated models may be of different kinds. Sometimes macro models use aggregated variables which are measured at the individual level, whereas other macro models use variables which have no counterparts at the individual level. While the micro model focuses on detailed linkages between variables, the purpose of macro models is to postulate two or more variables and link them with a gross set of relationships without explaining the specific mechanisms operating within each variable.[10(p618)]

An example of a macro model would be a description of the behavior of various population groups with regard to health care service utilization. In contrast, a micro model would focus on the health care service utilization behavior of an individual rather than an entire group.

Comprehensive versus partial models. Closely associated with macro and micro models are comprehensive and partial models. While these terms are occasionally used interchangeably, there appears to be a substantive difference between them. More specifically, comprehensive models attempt to identify and relate most or all of the variables involved in a phenomenon. These variables are then linked with a gross set of relationships, as is the case with macro models, or the variables are linked with more detailed relationships, as is the case with micro models.

Whereas comprehensive models attempt to identify most of the variables, partial models are limited to a few variables, but these variables are developed in detail. For example, a comprehensive model might examine individual health service utilization behavior by considering all possible variables such as demographic characteristics, and sociopsychological variables. In contrast, a partial model would be limited to the examination of selected variables such as attitudes toward health care services. Once again this examination might take place in either a micro or a macro context.

Descriptive versus decision models. Another way of classifying models, according to their purpose, is based on the distinction between descriptive and decision models. This distinction is frequently noted in the literature. However, terms such as *positive, systems, behavioral, empirical* and *concrete* have been used to refer to descriptive models. Similarly, terms such as *analytical, normative, goals, optimization, theoretical,* and *hypothetical* are often used to refer to decision models.

The general purpose of descriptive models is to describe things either as they are or as they work. Descriptive models can be broken down into three subgroups: communicative, explanatory, and predictive models. A communicative model describes the structural arrangement of the various elements or components in a system. An explanatory model describes the causal relationships among the elements in a system. The purpose of a predictive model is to assert or describe the causal relationships among the elements in a system before the events take place. Hence descriptive models either communicate, explain, or predict some phenomenon.[10(p618-619)] Freudian psychology and Maslow's hierarchy of human needs are examples of descriptive models.

In contrast to descriptive models, decision models propose how things should be. Decision models can be grouped into two categories: optimization models and heuristic models. Optimization models may have computational routines for finding the best solution to a stated problem. Examples of optimization models are differential calculus, mathematical programming, statistical decision theory, and game theory. Heuristic models are designed to evaluate alternative outcomes associated with different decisions and to find the best decision when optimization routines are not available or cost effective. Some heuristic models are referred to as rule-of-thumb approaches.[10(p620)]

In the preceding classification, models are categorized according to their purpose, in terms of a series of bipolar adjectives. By using one or more sets of bipolar adjectives (Table 1), any model can be described in terms of its purpose. If both classification schemes, level of abstraction and purpose, are combined, a relatively comprehensive means of classifying models is developed.

MODEL BUILDING

Model building allows for complex, real-world problems to be depicted visually, verbally, or quantitatively to assess relations among events, things, or properties. Some of these relational statements made possible by models are of a cause-and-effect nature.

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Most real-world problems are complex and have an array of variables which affect their outcome. As a first step in systematically solving any problem, an individual should be able to describe, explain, or predict the pertinent part of reality through the use of abstractions such as thought processes, language, or pictures. Thoughts about any specific problem or situation are merely abstractions from reality. The abstractions which are made about a segment of reality are influenced by past experiences, perception, and the parameters of the current situation.

Thoughts or abstractions about a real situation may seem like three-dimensional moving pictures of the part of the real world that was perceived. The pictorial abstraction of reality frequently represents only a part of the total situation. Just as a photograph cannot capture the total range of hidden thoughts and beliefs, perceptions of reality are limited. Often the most critical and influential part of any mental image is that part which does not correspond to the concrete physical aspects of the situation. Model building and the process of abstraction allows part of reality to be represented at a given time by depicting complex events in a form which deletes extraneous factors and only portrays essential components of the situation.

Because model builders are concerned with phenomena which occur in the real world, the model builder must clearly describe the system which is to be analyzed. To describe the system that the model hopes to replicate, the model builder must clearly state the assumptions and values implicit in the model as well as in the society which comprises the environment for the model. For example, in a communications model, likely assumptions would include honest, straightforward interaction among participants, and the ability to hear as well as to understand the spoken or written word. Certain mechanisms for interchange would be implicit, including face-to-face contact, telephone, or the written mode of communication.

The model builder needs to maintain an awareness of the degree of congruence between the model and society at large or at least that segment of society which is in close influential proximity. For example, a model for open communications among all levels of an agency's hierarchy would be doomed to failure if the agency value was: "never talk to other departments or they will steal your ideas."

Next the model builder must be able to "observe and analyze a system of real events in order to isolate the determining variables that are operating in the system."[11(p8)] The major components of the model must be clearly defined and must also be identified as separate, observable units that can be related to one another.

To clearly and logically discuss the units of any given model the ultimate goal or outcome of the model must be described. Each variable or subset should be described in clear, easily understood terms which others can recognize and interpret. Next the actors in the model need to be noted as well as their expected roles and activities. For example, in a nursing situation the caregiver and recipient comprise the actors in the model; their roles, goals, and expected outcomes must be enumerated.

The next step is for the model builder to describe the goals and actual process of the steps taken or activities selected. The activities should relate to the problem statement, the expected outcome, and the characteristics of the actors. The choice of activities includes ongoing awareness both of the model's structure and its functioning because any alteration in one part of the model is likely to affect all other parts. The last skill for the model builder is clearly stating a set of defined concepts and statements which describe them as well as a set of statements which discuss the relationship between the concepts and constituent parts of the model.

Lippitt[12] elaborates on this last step when he purports that any model builder must describe thoroughly and accurately the situation, problem, or system by identifying the essential variables, components, or subsystems and then ask the following questions about each variable:

1. Relevance: Is each variable relevant and necessary for a clear assessment and understanding of the situation?
2. Relationships: How are the variables related to one another, to the total situation, and to characteristics external to the situation being scrutinized?
3. Relative importance: What is the weight of each variable according to

the magnitude of its significance to the total situation?

4. Outside constraints: What boundaries exist for the situation? What forces can exert an influence?
5. Internal constraints: What limits exist within the situation under consideration?

ADVANTAGES AND DISADVANTAGES OF MODELS

Positive and negative results can ensue from the use of models for depicting aspects of a practice-oriented profession such as nursing. The following advantages of models are set forth by Lippitt[12] and have transferability to nursing practice. First, models allow experimentation without risk. By using model building techniques a wide range of alternative interventions for any given problem can be addressed without actually altering the status quo. Such an approach takes a "what if" orientation. The model builder might initially set forth the current situation and then experiment with a variety of variables by considering: "What would be most likely to happen if I did ______?" The range of human reactions and responses to any change in the status quo cannot always be accurately predicted, but some ideas can be gleaned by considering the responses of the persons involved to previous change events.

A second advantage of using models, especially as a preliminary stage in the change process, is that models are good predictors of system behavior and performance. Models are more accurate as describers than as predictors. Any attempt at prediction must consider the wide range of human variables which could easily influence the outcome of the process.

A further advantage of model development for nursing practice is that models promote a higher level of understanding of the system than may have been previously held. To construct a model of a real world situation, careful attention must be paid to looking at each element as well as the relationships between them. By providing a careful assessment of the situation under consideration the model-building process promotes heightened awareness of the relative significance of each component. For example, if any change in A would most likely affect B, C, and then D, then A is central to the situation or problem being considered. Moreover, model building may often indicate where missing data exist. If a situation is being graphically depicted and there suddenly appears a gap in information, then the process has been useful.

The disadvantages inherent in model development may include a tendency to overgeneralize in an attempt to fit all the information available into a preestablished set of categories. The model builder may be tempted for the sake of simplicity and convenience to make the situation fit the model rather than trying to fit the model to the situation. Models have no truth in and of themselves; their accuracy lies in how well they describe reality. The lack of readily available evaluative tools also may be a disadvantage in model building. Once the model is built there may not be a clear-cut way to evaluate its effectiveness.

SUMMARY

There is considerable value in the nursing profession furthering its understanding of models. Nursing models are currently widely applied by both practitioners and academicians. The use of analogies, constructs, verbal descriptions of systems, idealizations, and graphic representations is widespread. As nurses become increasingly skillful at developing practice approaches based on sound theoretical information, the usefulness of models will increase.

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