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CONTINUING EDUCATION

An Organizing Framework for Nursing Informatics Research

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Because nursing informatics is a young specialty, perhaps it is not surprising that much of the research done to date has been problem-driven, as opposed to model-driven. Continuing to struggle with definitions, nursing informatics lacks a theoretical base on which to build its science. When models or theories have been used to guide research, they typically have been applied to a single, or to very few, studies. In this paper, I describe and evaluate several of the models that have been described in nursing informatics literature and then propose an organizing model that may be used as an overarching framework to guide research.

KEY WORDS

Conceptual model • Organizing framework • Research • Theory

INTRODUCTION

In 1986, Schwirian observed that there was little theory-driven research in nursing informatics,[1] a situation that persists today. My semistructured review of the 75 most recently published articles, based on a January, 2003 search of CINAHL, Medline, and PsycInfo databases, using "nursing informatics and research" as keywords, found 29 actual nursing informatics research articles, of which only 8 identified a theoretical or conceptual framework. When a model was used to guide research, it was generally borrowed from another discipline (eg, information science, cognitive science, or education) for the purpose of framing the specific problem, as opposed to developing or testing theory.

The lack of theory-driven research may not be surprising because nursing informatics is a young specialty that is just beginning to build a science. The discipline continues to struggle with definitions[2] and has not yet prepared the critical mass of researchers to develop and test theory. In the United States, the list of informatics research priorities defined by the National Institute for Nursing Research (NINR) encourages research on particular problems,[3] but does not (and appropriately so) provide a conceptual framework for that research.

Staggers and Thompson recently documented the evolution of definitions for nursing informatics.[2] Perhaps a similar evolution will be needed for informatics theory. It is generally acknowledged that science advances most efficiently when it is based on theoretical foundations that allow research to be broadly applied. Without theory as a guide, research tends to focus on specific problems rather than on the underlying causative factors.[4] Theory can serve several purposes for nursing informatics[5–7]:

- Ensure that a particular research study falls within the nursing informatics domain.
- Provide an organizing framework for research.
- Provide a common language for researchers.
- Focus researchers' thinking on the work to be done, rather than on the tasks to be accomplished.
- Provide a basis for understanding, explaining, and predicting outcomes of nursing informatics innovations.

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The work described in this article is the product of students and faculty in the systems division at the college who came together in a doctoral seminar and continued to work over 2 years on the models described here.

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Given the present lack of available theories, a nursing informatics researcher has 3 options:

1. Borrow theory from other domains.[8–10] Because nursing informatics is a combination of information science, computer science, and nursing science,[11–13] these theories may describe and systematically explain the phenomena of interest.[14(p6)] However, when these theories overlap or different theories are used to explain the same phenomenon,[15] developing a comprehensive science of nursing informatics is more difficult.
2. Abandon theory altogether. This approach is used when theory is unavailable or when external constraints drive research. Many software evaluations fall into this category.[16,17]
3. Utilize a conceptual model (or conceptual framework).[18] Conceptual models are "sets of general concepts or propositions that provide perspectives on the major concepts of the metaparadigm."[14(p6)] Various conceptual models have been proposed to guide research in nursing informatics. However, few have been used to guide multiple research studies. The lack of an overarching organizing framework has made it difficult to identify concepts that can be used broadly to develop the science of nursing informatics. In this paper, I first evaluate the potential of some of these models to serve as organizing frameworks and then propose an alternative to guide nursing informatics research and theory building.

WHAT MAKES NURSING INFORMATICS DIFFERENT?

Clearly, much nursing informatics content is common to informatics in general, grounded as it is in information theory, computer science, and cognitive science. Graves and Corcoran[19] described some of the challenges of addressing a profession that uses multiple conceptual models, has even more diverse practice variations, and deals with a variety of clients in many settings (hospitals, homes, extended care, etc). Turley proposed a nursing informatics model in which informatics is understood as the interaction between nursing science and informatics (itself the intersection of three sciences: cognitive science, information science and computer science) (Figure 1).[20]

My colleagues and I have observed that *nursing systems theory* differs from *nursing theory* in its explicit inclusion of context as a critical component that must be recognized and addressed.[21,22] The same is true for nursing informatics theory.[19] Context is a multifaceted, layered construct that includes cultural, economic, social, and physical aspects, to mention just a few. Understanding the context in which an application is planned, designed, implemented, or evaluated is crucial to understanding the potential, as well as the actual, outcomes of the application.

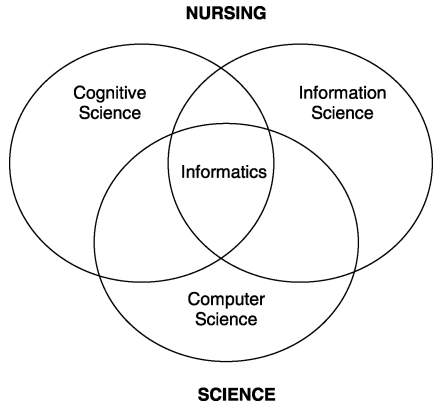

FIGURE 1. Turley's nursing informatics model.[20]

Nursing systems theory is further distinguished from *systems theory* by its inclusion of all four components of nursing's metaparadigm (nursing, health, environment, and patient).[21–23] In theories and models that support *nursing informatics research*, as opposed to *informatics research*, we should expect to find the same four components represented. Although each of the components may not be present in a particular research study, each will be represented in a researcher's program of nursing informatics research, as well as in a comprehensive theory. In the following section, I use these two criteria as a way to evaluate the potential of current models to serve as organizing frameworks for nursing informatics research:

1. Context must be recognized and addressed in the model.
2. All four components of the nursing metaparadigm must be represented in the model.

Description and Evaluation of Current Nursing Informatics Models

Various models have been proposed to describe different aspects of the discipline. None were developed with the intention of their serving as grand theories or organizing frameworks for the discipline. As we search for an overarching framework, it is nevertheless useful to consider the concepts that have been included and the degree to which the models meet the criteria defined in the previous section.

Schwirian was perhaps the first to propose a model to guide nursing informatics research.[1] Her model included interacting components (information, user

context, and technology) and a goal. In a demonstration of its utility, Spranzo applied the model as a framework for studying implementation.[24] Gassert added a fifth element, information processing, to Schwirian's original four elements in a model for defining nursing information systems requirements.[25] Nursing, context, and goal (roughly equivalent to "health") are represented in this model, but patient is not made explicit (Criterion 2).

Graves and Corcoran[19] developed a model for the components of an information system that was intended to reflect the reality of the discipline of nursing. Their model distinguished nursing as a discipline (ie, the body of nursing knowledge with its various conceptual structures and methods for developing knowledge) from nursing as a practice profession (various settings, clients, and methods), and the nursing practitioner (with various cognitive and affective characteristics). This model's strengths lie in the rich characterization of nursing and in its recognition of context as a crucial factor to consider. Although it was developed as a model for designing nursing information systems, it provides a useful foundation for an overarching model for nursing informatics in general.

Graves and Corcoran's 1989 model[11] depicts a continuum in which nurses as "knowledge workers"[12] convert raw data, first into information, and then into knowledge. Graves and Corcoran's model clarified the role of the informatics nurse in transforming data into information and then into knowledge. However, neither context (Criterion 1) nor nursing's metaparadigm (Criterion 2) are included.

Goosen's extension of Graves and Corcoran's framework (Figure 2) includes the processes of collecting, aggregating, representing, and using information[13] and adds the decisions made by nurses and the actions taken based on those decisions.[26] Evaluation includes both patient outcomes and evaluation of the care provided. Two-way arrows indicate the nonlinearity of the model. We begin to see the role of nursing (decision, action, evaluation based on data, information, and knowledge). In addition, the patient is included implicitly in the concept of patient care, although it could be argued that the model is more about nursing than about patients. Health (as outcomes) is represented to some degree in the concept of evaluation. Context (Criterion 1) may be implicit in the transition of data to information, but is not explicitly represented. Finally, Goosen's depiction of categories of information (data, knowledge, information) and categories of control (decision, action, evaluation), as if they were a sequential process, is somewhat problematic because these two categories have a reciprocal relationship much like two sides of a coin (eg, information leads to some action, which changes the information, leading to a different action, etc).

A process model used widely in informatics is the systems development life cycle (SDLC), which commonly includes planning, analysis, design, implementation, maintenance, and sometimes evaluation. To define more clearly the role of nurse informaticist, Thompson, Snyder-Halpern, and Staggers described an expanded SDLC model in which context takes on a more prominent role.[27] The model treats assessment as identifying potential risks in 4 areas, but does not explicitly include descriptions of nurse, patient, or health (Criterion 2).

Effken[28] proposed a hierarchical approach to the analysis of complex, dynamic sociotechnical systems (cognitive work analysis), as viewed through a set of 4 lenses or perspectives, Carper's ways of knowing.[29,30] Each perspective adds richness to the analysis process and presumably contributes to the integrity and usability of the ultimate design. The model emphasizes the environment (context) and the nurse user, but patient and health are not described (Criterion 2). The model may be an informatics model, but, based on my two evaluation criteria, it is not a nursing informatics model.

Staggers and Parks described a framework for nurse-computer interaction research in which nurses and computers interact with information as the common basis for that interaction (Figure 3).[31] The model includes a developmental trajectory, an assumed goal (optimization of outcomes), an interaction in which nurses initiate and respond to information within a particular task domain, and the differentiation of nurse behaviors from nurse characteristics. This model explicitly includes nursing and context, but both patient and health are missing (Criterion 2).

This brief review shows that a number of models have been proposed for various aspects of nursing informatics, but none meets the criteria for an organizing

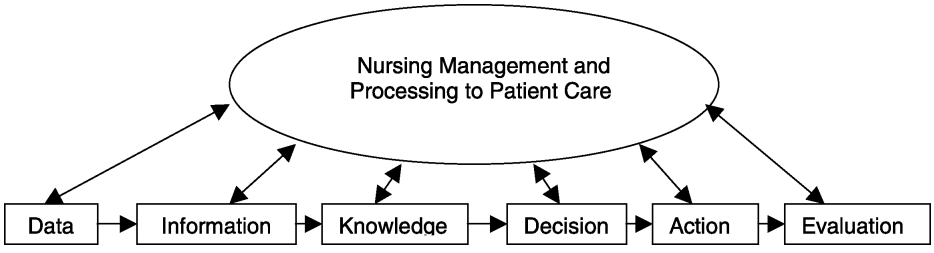

FIGURE 2. Goosen's framework for nursing informatics research.[26]

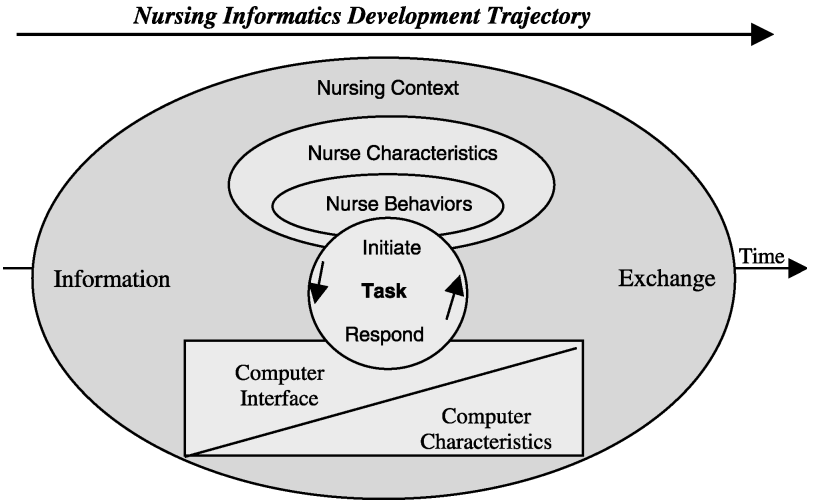

FIGURE 3. Staggers & Parks' nurse-computer interaction framework.[31]

framework to guide the development of nursing informatics theory because none includes all components of the nursing metaparadigm and only infrequently does a model include context. An organizing model is needed that could serve as a framework for the development of nursing informatics as a science. In the following sections, I propose such a model.

An Organizing Model for Nursing Informatics Research

My starting point for an organizing model for nursing informatics is a model for nursing systems research proposed by the Academy of Nursing's Expert Panel on Quality Health Care.[32] The model extends Donabedian's structure-process-outcomes model[33] to show the nonlinear dynamics among 4 components (system, client, intervention, and outcome) in complex systems of care. The model also incorporates nursing's metaparadigm: system (environment), nurse (intervention), patient (client), and health (outcomes), thus differentiating *nursing systems* research from *systems* research. The model is at a very high level of abstraction, thus providing an organizing framework in which middle-range theory and models can be incorporated and also allowing for multiple levels of analysis and specification. At the University of Arizona, faculty and doctoral students in a systems seminar adapted the Academy model as an organizing framework to guide nursing systems research. In the adapted systems research organizing (SRO) model, "system" was changed to "context" because the entire model was viewed as the relevant "system."

Systems are complexes of elements that are perceived as a whole because they continually interact, are interdependent, synergetic, and share a common goal. Each system has subsystems and a suprasystem. System boundaries are moveable, fluid, and penetrable, but the system must always be viewed from a holistic perspective. The researcher sets arbitrary boundaries on the system to be studied, while recognizing that substantial parts of the system must necessarily go unmeasured. The systems approach emphasizes the connections between system components and recognizes that our prior assumptions of temporally ordered cause-effect relationships may not hold.[34–36] Thus, all components are connected and no unidirectional links are assumed unless empirically demonstrated. The SRO model has several strengths for guiding nursing systems research:

- Model constructs are at a high level of abstraction, thus allowing it to have broad applicability across settings, clients, interventions, and outcomes.
- All relationships in the model are mutual, thus making clear the complexity of a dynamic, interacting healthcare system, but probably complicating the analysis process.
- The nursing metaparadigm (patient, nursing, context, and health) is identifiable in the model's 4 constructs (client, intervention, context, and outcome).

Various middle-range theories and conceptual frameworks can be accommodated within the organizing framework.

My colleagues and I have argued elsewhere that if a research program is to be categorized as "nursing systems research" (as opposed to systems or nursing research), it must recognize and incorporate all 4 constructs, although each individual research study may not incorporate all 4.[21,22] I would argue that this is equally true for nursing informatics research programs;

they too must recognize and incorporate all 4 metaparadigm constructs.

Our informatics faculty and doctoral students recently adapted the SRO model as an informatics research organizing model (IRO) (Figure 4).[22] Informatics-related additions included explicitly representing the systems development life cycle and the data-to-knowledge continuum. Evaluation is shown as occurring at each stage of the lifecycle. In the resulting organizing framework, the SDLC is a process model that interacts with all 4 concepts in the SRO model. Thus, the model suggests that planning for a nursing informatics innovation to facilitate a transition from information to knowledge, for example, can only be done effectively if client, context, and characteristics of the intervention are carefully evaluated, as well as the desired outcome. Note that the SDLC is a unidirectional, iterative, cyclical process, with 7 steps.

The data-to-knowledge continuum is represented within 2 constructs. It appears in the client construct as client data and knowledge and in the outcome construct as information and knowledge, indicating that there can be a transition from data to knowledge or from knowledge to information. Decisions and actions are also included within the outcomes construct.

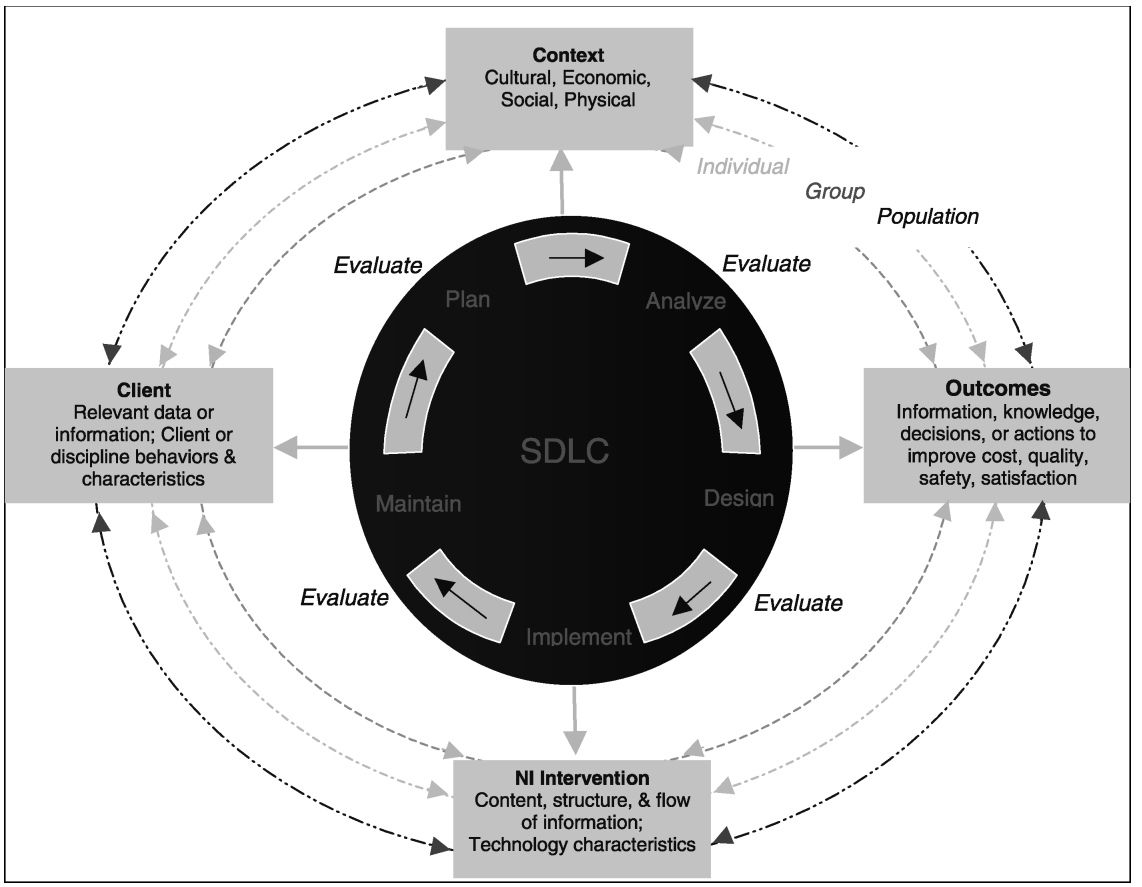

FIGURE 4. The informatics research organizing (IRO) model. The organizing model is composed of 2 component models. The first is the systems development life cycle (SDLC), a process model which is represented by the center ring as 5 distinct phases. Evaluation, sometimes considered the sixth phase, is represented at occurring throughout. The second, shown by the outer ring, represents the 4 constructs of the original systems research organizing (SRO) model. In the IRO model, the client construct is composed of the data and information collected from clients, as well as client behaviors and characteristics. Context is defined as the cultural, economic, and social environment in which the intervention occurs. Outcomes correspond to the information, knowledge, decisions, and actions that emerge from the data to improve cost, quality, safety, and satisfaction outcomes. Nursing informatics intervention corresponds to nursing (in the nursing metaparadigm) and describes the nursing informatics solution in terms of the content, structure, and flow of the information, as well as the technology used. These two circles in the dynamic model (the conceptual model and the process model) are distinct, but each presents an incomplete picture without the other. At any stage in the SDLC, for example, design, analysis, or implementation, the SRO model concepts are considered. Although at first it may seem counterintuitive, the arrow between clients and outcomes also goes both directions. Outcomes here act as a feedback loop. The SRO concepts are connected by 3 different sets of arrows to represent the different levels of analysis at which the model may operate (eg, individual client data to information; or aggregated group information to knowledge). The corresponding multiple lines connecting the client to outcome and context to intervention have been omitted here to simplify the design.

No specific links between the SDLC and the SRO models are shown because the 4 constructs of the SRO model serve as a framework at each step of the SDLC process. When doing design, implementation, or evaluation, each of the 4 constructs in the SRO model should be considered explicitly, for example, when goals are set during the analysis or design phase or when potential risks to goal achievement are assessed.

In the model, context is treated as described earlier; that is, as a complex, multifaceted concept with cultural, economic, social, and physical aspects of the setting. Context is not unbounded, however, but is defined for each study. The nursing informatics (NI) intervention is operationalized as the content, structure, and flow of the information being processed or transformed, as well as the characteristics of the computer technology used.[19,31] Outcomes include targeted information and knowledge measures, as well as cost, quality, satisfaction, and safety outcomes achieved due to the application. Outcomes too may be defined at the individual, group, or organization level. Outcomes are assumed to incorporate goals and that degree to which those goals are achieved.

There are three 2-directional arrows connecting each of the SRO constructs to indicate the various levels of analysis at which nursing informatics may work (in Figure 4, individual, group and population levels are shown explicitly; other levels might include families or communities). Although the levels are drawn as if discrete, cross-level analyses are not uncommon; for example, collecting data at the individual level, which is later aggregated to the group or organization level to measure outcomes. This is inherent in the Graves and Corcoran[11] model. Crossing levels introduces additional methodological issues for the researcher, but a description of those is beyond the scope of this article.

Implications and Applications

The strength of the IRO organizing model is its broad applicability to guide research in any setting with any users or user groups, any kind of computer application, and any kind of outcome. Applications may be designed for individuals, groups, or even populations (eg, Brennan's description of a computer network for families of patients with AIDS).[37] Doyle and Effken[22] described how the IRO model could be used to guide an evaluation of medication barcoding. Because of the dual arrows, the model may actually expand our thinking. The model suggests that outcomes of a nursing informatics innovation might affect client characteristics or behaviors, for example. Although it's unlikely that a particular innovation would affect the age, gender, or prior education of users, it may well change their behavior in a particular setting. As a case in point, poorly designed clinical systems may require that users find "workarounds" that change their subsequent behavior. Thus, the model's arrows provide us with a variety of testable hypotheses.

The IRO model suggests that the SDLC needs to be framed (or constrained, perhaps) by the remainder of the constructs in the model. Are the clients nurses, students, or patients? Experienced or inexperienced computer users? Individuals, families, organizations, or communities? What are the characteristics of the specific application (information structures, information processes, and information technology) by which nursing data are being transformed? What is the relevant physical, social, and economic context of the change? What are the expected outcomes? Diagnostic accuracy? Appropriate treatment? Knowledge? Cost savings?

The IRO model is a meta-framework into which other more focused models and theories can fit. Although the constructs in the model can be operationalized in many ways, nursing informatics research programs and comprehensive theories will include all 4 constructs, regardless of whether the research is focused on planning, design, implementation, or evaluation.

One of the most pressing research issues in nursing informatics is the development of an inclusive nursing taxonomy. If we were to apply the IRO model to this problem, we would find that all 4 constructs are very relevant, when operationalized appropriately. A study might investigate how choosing a particular taxonomy for an information system (nursing informatics intervention) affects clinical outcomes for nurses (clients) with differing expertise in a variety of practice settings (context).

Limitations of the Model

Constructs in the IRO model have been intentionally defined at a high level of abstraction. To be applicable to a particular research study, the constructs must be explicated further and operationalized in much the same way that grand theories are explicated into middle-range theories for application. The astute reader might ask whether the model is too general to be of use as an organizing framework. Only further research will answer this question.

The IRO model presents new challenges in terms of methodologies. Because the model is targeted at complex, dynamic healthcare systems, we have all the methodological issues that researchers dealing with complex dynamical systems face. Scientists are only beginning to develop effective methods to test multiple reciprocal relationships at multiple levels of analysis. Structured equation modeling is one possibility; another is computational modeling.

We may need to turn to other sciences for new methods, for example, dynamical systems research.

CONCLUSION

Because nursing informatics is a young specialty, it is only beginning to build a research base. Much of the research done to date has been problem driven, as opposed to model driven. When models or theories have been used to guide research, they typically have been used in a single, or in a few, studies. To facilitate the development of nursing informatics as a science, an organizing model is needed to help structure research; but we currently lack such a framework. The IRO model may serve to fill that void. The model integrates the University of Arizona College of Nursing adaptation[21] of the Academy's Quality Health Outcomes Model[32] with aspects of previous nursing informatics models. The model is consistent with Staggers and Thompson's proposed definition for nursing informatics,[2] but moves beyond definition by suggesting relationships among core concepts that provide an organizing model in which to develop new theory and derive new methods to test those theories. Our initial model building began as an "academic exercise,"[38] but resulted in a model that can be used as an organizing framework to guide informatics research. Of course the "proof is in the pudding." Our initial experience in applying the model has been positive, but only its application by many nursing informatics researchers in many settings will ultimately establish the model's utility.

Acknowledgements

The model described in this paper is a product of work initiated in the Doctoral Seminar at the College of Nursing. Work on the model has continued for 2 years in discussions and in seminars; various version of the models described are being used by students and faculty as the framework for their research. Faculty who contributed significantly to the model include Joyce Verran, PhD, RN, FAAN; Rita Snyder-Halpern, PhD, RN; and Gerri Lamb, PhD, RN, FAAN. Students who contributed significantly to the model's development include Barbara Brewer, Liz Greenberg, Mary Doyle, Marylyn McEwen, Carol Hatler, Sharon Sweeney-Fee, and Micki Williams.

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CE Test

An Organizing Framework for Nursing Informatics Research

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CE TEST QUESTIONS

GENERAL PURPOSE: To familiarize the nurse informatics researcher with organizing frameworks that are available for nursing informatics research.

LEARNING OBJECTIVES: After reading this article and taking the test below, you will be able to:

1. Describe challenges associated with nursing informatics research.
2. Differentiate between the organizing frameworks used in nursing informatics research.

1. Which of the following statements is true regarding nursing informatics?
a. It is a long-lived specialty.
b. Research in nursing informatics is usually model driven.
c. Definitions have been clearly identified.
d. Few research studies have been guided by theory.

2. Nursing informatics theory
a. excludes economic aspects.
b. is single faceted.
c. includes cultural components.
d. lacks critical components.

3. The nursing paradigm includes
a. environment.
b. illness.
c. medicine.
d. death.

4. Which of the following statements is true regarding the author's evaluation of organizing frameworks for nursing informatics research?
a. Only one nursing meta paradigm may exist.
b. Context in the model must be evident.
c. Organizing framework must be problem driven.
d. One other discipline must be included.

5. Which of the following elements was not stated clearly in Schwirian's proposed model to guide nursing informatics research?
a. nursing
b. health
c. patient
d. environment

6. One strength of Graves and Corcoran's model is its inclusion of
a. nursing context.
b. nursing meta paradigm.
c. the characterization of nursing.
d. definitions needed for nursing informatics.

7. One process that Goosen added to Graves and Corcoran's framework is
a. representing.
b. analyzing.
c. exchanging.
d. initiating.

8. A weakness of Staggers and Parks framework for nurse-computer interaction research is the omission of
a. a developmental trajectory.
b. optimization of outcomes.
c. nursing context.
d. the patient and health.

9. According to the author, no model exists for use in guiding the development of nursing informatics theory in part because existing models
a. do not view nursing informatics as a science.
b. do not include all of the nursing meta paradigms.
c. have no applicability to nursing.
d. lack nursing language.

10. Which of the following statements is true about systems?
a. Boundaries are rigid.
b. Interactions are not possible.
c. Synergy is noted.
d. Common goals are absent.

11. The author's support of the SRO model is based on the fact that
a. it has broad applicability.
b. the analysis process is made simple.
c. prior assumptions of cause-effect relationships hold.
d. all relationships in the model are unidirectional.

12. Which of the following statements is applicable to the IRO organizing model?
a. It can only be used in certain settings.
b. Only one-way arrows are used.
c. It may be applied to large groups.
d. Limited computer application exists.

13. **Which of the following is an example of a nursing informatics intervention within the IRO organizing model?**
    a. flow of information
    b. relevant information
    c. client characteristics
    d. knowledge to improve satisfaction

14. **A possible research study suggested by the author is**
    a. developing a model to be used in informatics research.
    b. comparing the IRO model with Turley's model.
    c. investigating whether an organizing model is needed to conduct nursing informatics research.
    d. exploring the impact of a particular taxonomy on clinical outcomes with different levels of expertise on the part of nurses.

15. **Which of the following statements describes a possible limitation of the IRO model.**
    a. It is defined at a low level of abstraction.
    b. The model may be too general to use.
    c. The model lacks clarity.
    d. The model may not be able to be used in all settings.

CE Enrollment Form

CIN: Computers, Informatics, Nursing, November/December 2003: An Organizing Framework for Nursing Informatics Research

A **Registration Information:**

Last name_____ First name_____MI____

Address_____

City_____State_____Zip_____

Telephone_____Fax_____email_____

Registration Deadline: December 31, 2005

Contact Hours: 3.0

Fee: $19.95

❑ LPN ❑ RN ❑ CNS ❑ NP ❑ CRNA ❑ CNM ❑ other_____

Job Title_____Specialty_____

Type of facility_____

Are you certified? ❑ Yes ❑ No

Certified by_____

State of License (1)_____License #_____

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	A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D
1.	❍	❍	❍	❍	5.	❍	❍	❍	❍	9.	❍	❍	❍	❍	13.	❍	❍	❍	❍
2.	❍	❍	❍	❍	6.	❍	❍	❍	❍	10.	❍	❍	❍	❍	14.	❍	❍	❍	❍
3.	❍	❍	❍	❍	7.	❍	❍	❍	❍	11.	❍	❍	❍	❍	15.	❍	❍	❍	❍
4.	❍	❍	❍	❍	8.	❍	❍	❍	❍	12.	❍	❍	❍	❍					

C **Course Evaluation***

	A	B
1. Did this CE activity's learning objectives relate to its general purpose?	❑ Yes	❑ No
2. Was the journal home study format an effective way to present the material?	❑ Yes	❑ No
3. Was the content relevant to your nursing practice?	❑ Yes	❑ No

4. How long did it take you to complete this CE activity?____ hours____minutes

5. Suggestion for future topics_____

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