ENCYCLOPEDIA OF NURSING RESEARCH

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SPRINGER PUBLISHING COMPANY

SCIENTIFIC DEVELOPMENT

Scientific development is a term defining the process of producing and making available new knowledge through systematically testing theories against empirical reality in order to solve problems. The term *scientific* is used as an attribute of the human knowledge interpreting natural, social, economical, historical, and psychological systems as parts of the empirical world. Scientific knowledge consists in systems of theories able to explain and solve scientific problems. Its essence is testability (Popper, 1969); it requires agreement among individuals about the nature of the problem and the validity of the explanation.

Controversies exist about what scientific knowledge is. For instance, the traditional empirical-ration-alism perspective holds the position that knowledge is scientific only when it has passed certain rigorous standards of method. Thus, only when reality has been defined in a measurable way and tested under sufficiently controlled conditions as an "objective" phenomenon (well protected from the investigators' subjective biases) can the generated knowledge be defined as scientific and therefore valid and reliable. Deductive reasoning facilitates objectivity by encouraging examination of a phenomenon in light of findings from previous research, conceptualizations contributed by other scholars, and testing of more than one prediction. In this perspective, scientific knowledge progresses by a process of formulating bold conjectures and then subjecting them to equally bold criticism and test.

The main criticism against empirical rationalism comes from the phenomenological perspective originated by preeminent philosophers such as Husserl, Heidegger, and Merleau-Ponty. From the phenomenological point of view it does not make sense to objectify our knowledge because reality consists of the meanings one assigns throughout experiences. Therefore, to the phenomenologist there is no reality separated from the interaction of a person as a perceiving, meaning-giving being. Reality cannot be known independently of a person's experience with all its meanings: "My knowledge of the world, even my scientific knowledge, is gained from my own particular point of view, or from some experience of the world without which the symbols of science would be meaningless" (Merleau-Ponty, 1962, p. vii).

Theories of Rationality of the Scientific Development

The development of modern science can be defined from different theoretical perspectives; each one provides a rational framework (or a methodology) for understanding the historical development of human science. Each framework provides a set of rules for the validation of testable theories; those rules also can be used as criteria for demarcation between common and scientific knowledge. At least four different frameworks can be identified, each one characterized by a specific set of rules finalized to accept or reject theories or research programs.

Inductivism dictates that only those propositions describing hard facts or true generalizations of those facts (or very probable generalizations in the neoinductivist version) can be accepted as scientific. Inductivism's basic assumption is that primitive propositions can be directly derived from facts, and it has been widely criticized. An inductivist accepts a scientific proposition when proved true; otherwise it will be rejected. This approach has a very strict scientific rigor: a proposition has to be demonstrated by facts or inductively-deductively derived from propositions proved to be true. However, inductivism does not offer any explanation about directions of the scientific development, nor can it rationally explain the reasons for the main scientific progress of humankind.

Conventionalism defines science development as the building of systems organizing facts into a consistent whole. When inconsistencies arise, a conventionalist changes or modifies the system, assuming that it can be considered true or false by convention. According to this approach, science develops by accumulation on the level of facts and progresses through simplifications or better conventional explanations. For example, Einstein's theory was progressive because it provided a simpler explanation than former theories. For a conventionalist, false assumptions can lead to true conclusions; therefore, false theories may have great predictive power (this is a solid philosophical position, not to be confused with instrumentalism). Under conventionalism any idea can be acceptable and used for scientific inquiry; what cannot be used is not considered nonscientific, as in the inductivist approach.

Falsificationism admits that the basic assumptions about facts can be accepted by agreement, but it does not apply to the theories. According to this approach, a theory is scientific only if it can be tested against a basic assumption or if it can be experimentally falsified. Thus, a theory must be rejected if it conflicts with accepted assumptions. Popper (1969) stated that, in order to be considered scientific, a theory has to predict new facts (new because they are not considered by other rival theories), has to be empirically testable, and not be adjustable with ad hoc hypotheses. In the latter, more conventionalist version of this approach, some inductive principles are accepted. Falsificationists define the development of science as a process of falsifying the dominant theories: behind each important discovery there is a theory proved false. Scientific development is related to the importance of the falsified theories; the more important they are, the more progress that has been made.

Research programs have been proposed by Lakatos (1968) as methods of analysis for scientific development. Research programs are identified as testable results in terms of progressive and regressive "problemshifts." Scientific revolutions consist in substitution of a research program with a more advanced one. According to this approach a positive heuristic has to dictate the choice of problems for research instead of anomalies or incoherences, as in the falsificationism and inductivism methodologies. Therefore, the development of scientific theories is characterized by high degrees of freedom and is not influenced by the dominant paradigms. Thus, a research program progresses because its theoretical development anticipates the empirical one. It is regressing when it can provide only post hoc explanations because the empirical development is predominant over the theoretical one.

Each one of the four frameworks defines scientific development in a specific way. However, each perspective has to be integrated by external empirical theories able to explain the nonrational factors involved in scientific development, such as the social context and the historical period, because they are powerful forces driving or opposing any scientific development.

Scientific Development in Nursing Knowledge

A method of analysis that can define how knowledge evolves is essential for understanding scientific development in general as well as in a disciplinary field. Three approaches can be proposed to understand nursing's scientific development: (a) revolution, (b) evolution, and (c) integration.

Development by Revolution. The concept of revolution was first used by Kant (1781/1991) to explain his idea that from an initial revolution a discipline will find a secure path for its scientific development. Kuhn (1970) introduced the idea that, under particular circumstances, the whole traditional paradigm (all theories, methods, applications, and instruments made available throughout a consistent tradition of research) is subject to change, not just a theory or a research program. Important progress in scientific development is possible through a series of transitions, from crisis or revolutions to normal science, when members of the field accept in a unified way a common, dominant paradigm (later defined as disciplinary matrix). Using a revolutionary perspective, nursing is in a preparadigmatic stage. Because there may not be periods of normal science (even if nursing knowledge is progressing), it is possible that the nursing scientific revolution may never come (Meleis, 1997).

Development by Evolution. In this approach, knowledge progress is a gradual process of change and differentiation toward a higher level of complexity. It is a process of generating new ideas in continuity with the old ones and therefore systematically accumulating knowledge following a well-defined course. Propositions of one theory are used as premises for another; they are tested against the practice, and vice versa. As in the Darwinian process, environment continuously challenges the existent theories, and only the ones that interpret and meet its demands can temporarily survive. Using this approach to nursing, environmental demands for scientific development come from its practice and the scientific community. However, to date in nursing there are no recognizable trends of systematic development by accumulation.

Development by Integration. According to this approach, new ideas and theories are generated simultaneously without following any specific path. Thus, it is more than a process of testing, accepting, and rejecting theories; it is a process of developing agreement or disagreement about phenomena and methodologies that are most congruent with the subject matter of nursing. It follows, from this perspective, that nursing is much affected by external factors; nurses scientists gain insights mostly from the ongoing scientific developments in other fields. Therefore, nursing scientific development proceeds through a process of borrowing and repatterning ideas and theories across disciplines, as well as developing new ideas and differentiating them from the traditional ones; all are competing and coexisting.

From an evolutionist perspective, nursing has not accumulated enough knowledge to deserve the status of discipline; from an integrationist perspective, nursing is a discipline because it is able to provide new questions and answers, including repatterning, inventing, and testing knowledge through research and practice.

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See also

ACTION SCIENCE
EPISTEMOLOGY
MIDDLE-RANGE THEORY
PHENOMENOLOGY
THEORETICAL FRAMEWORK

SCIENTIFIC INTEGRITY

Scientific integrity is concerned with the principles of good science, which aim to promote the generation of knowledge that is both scientifically sound and ethically defensible. The principles are developed and operate within the frameworks of scientific community norms and ethical principles. Most authors conceive the domain of scientific integrity as concerned with the following: data management and access, publication practices, collaboration, mentorship, and conflict of interest. These areas collectively address scientists' duties and obligations toward science and society, fellow scientists, and their students.

Until recently, the rules governing the conduct of good science were implicit and understood among scientists. However, a number of highly publicized cases of scientific misconduct have heightened awareness of the public, legislative bodies, and professional groups. Given the scope of public funds devoted to science, demands for accountability have increased. As a result of these developments, policies and monitoring mechanisms have been created at every level to deal with ethical violations in research. A corollary development has occurred in educational institutions to systematically and formally teach good scientific practice during the training of future scientists. This has required the formalization and codification, by way of guidelines and policies, of canons of good science to guide the practice of science and the teaching of young scientists.

A survey of nursing found that instruction in scientific integrity varied greatly; the majority of schools limited coverage to the area of protection of human subjects, revealing a limited conception of scientific integrity. The norms regarding practices and data management varied greatly, with little consensus. The respondents saw varying roles for professional societies, institutions, and journals, but the need for common standards was frequently articulated (Ketefian & Lenz, 1995; Lenz & Ketefian, 1995).

Realizing the need for formal standards, the Midwest Nursing Research Society developed *Guidelines for Scientific Integrity* (MNRS, 1996). The guidelines are now being promulgated widely

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TAXONOMY

Definition and Related Terms

The word *taxonomy* derives from the Greek *taxis-nomos*, meaning arrangement and rule; together, the two words lead to the idea of giving an order or classifying objects. The term *taxonomy* was first used in 1813 by de Condolle in his *Theorie Elementaire de la Botanique* as a system for classifying plants on the basis of natural relationships.

A distinction between taxonomy and classification was introduced by Sokol (1974), who defined classification as a process through which objects (or phenomena) are ordered into groups or sets based on their relationships. A process of classification produces a classification system. Taxonomy is a methodology that provides rules and principles on how to classify and identify objects, where identification means to assign additional objects to a correct class once a classification system has been established.

Taxonomy can also be defined as a field having as its object of inquiry theories, practical aspects, and rules for classifying organisms. Information for choosing name, description, and classification of a specific organism is derived from different disciplinary fields. For example, classic taxonomy is based on morphology and anatomy. Biochemical taxonomy studies analogies between structures of protein and nucleic acids.

Principles of Classification

Taxonomic theory provides two major principles of classification: (a) the principle of monothetic classification and (b) the principle of polythetic classification (Aydelotte & Peterson, 1991). The monothetic principle dictates that the established classes must differ by at least one property or characteristic that is common to the members of each class, for example, the classification of nursing students in the school of nursing. Undergraduate students are one class, and graduate students are another. Each class has a single property that all share in common (i.e., being a student) and that differentiates it from the other class. Other properties may be similar to those in the other class, such as age, marital status, income, and the like. The polythetic principle groups individuals (or objects) who share a large portion of their properties but do not necessarily agree on any one property (Sokal, 1974). This principle has been used in developing patients' classification systems based on activity. Patients in one class may share certain characteristics, but any one characteristic will not necessarily be observed in all members of the class. Therefore, following this principle, many properties may be necessary to classify objects.

Taxonomy requires, for classification purposes, the arrangement of the objects' properties by use of methods and techniques such as pairing, clustering, ordinating, or use of graphs and trees and other complex formulas to handle similarities and dissimilarities between objects.

Usefulness of a Taxonomy in Nursing

The World Heath Organization's *International Classification of Diseases*, diagnosis related groups, and other case mix groupings are being used to organize information about health care and make decisions for health care delivery and allocation of resources. All these systems are disease-oriented and may not include any nursing contribution.

The usefulness of defining a classification system in nursing depends on many factors, mainly the degree to which definitions systematize the knowledge in the field and lead to a standardized nomenclature and the degree to which simplicity characterizes the system. Aydelotte and Peterson (1991) define some requirements that must be met in order to use a taxonomy:

1. The purposes for the classifications must be clear and widely accepted in the discipline.
2. Procedures and rules for describing and naming properties (defined characteristics of phenomena) have been adopted and implemented.
3. Criteria for classes and subclasses have been identified, these have been defined and their definition and labels convey relationships that are logical and have meaning to the user; and the classes are exhaustive and mutually exclusive.
4. Format or structure of the system has been selected and shows a relationship between classes and subclasses.

Taxonomies in Nursing

In the past decades, nurses have produced several patients' classification systems in order to define nursing care requirements. The main difference between the early systems and the modern ones can be seen in the much higher measurability of the classification criteria and a better definition of the attributes used to define classes.

Hartley and McKibbin (1983) describe five types of classification systems traditionally used in nursing: (a) procedure-based; (b) acuity-based; (c) disease-based; (d) those that combine disease, procedures, and complications; and (e) intensity plus disease-based. For the most part, a nursing classification system will fall within the acuity-based grouping. The differences between the medical and the nursing classification systems relate to the variety of information contributing to the categories and the scope and depth of the information. The selection of categories and principles of division reflects the orientation toward, or perspective on, the phenomena to be classified and the purpose of the classification. The underpinning classification system's conceptual framework must be consistent with the science of nursing in order to define the system as a nursing classification system. Bulechek and McCloskey's taxonomy of nursing practice, the Omaha classification scheme for interventions, the National Council of State Boards study's categories of nurse activities, and the North American Nursing Diagnosis Association's (NANDA) Taxonomy I for Nursing Diagnosis can be considered examples of nursing classification systems based on taxonomic rules.

Future Directions

NANDA's Taxonomy I for Nursing Diagnosis is probably the best known and most widely used taxonomy in nursing since 1973. It is a two-dimensional structure consisting of nine patterns of human responses on one dimension and two levels of abstractions to make them more concrete and clinically useful. NANDA's taxonomy II, currently under development, proposes the addition of multiple axes, which will change the structure from a two-dimensional orientation to a multidimensional structure based on four axes: unit of analysis, age group, wellness, and illness (Fitzpatrick, 1991a).

In 1996 an alpha version of *The International Classification for Nursing Practice* (ICNP) was released by the International Council of Nursing (ICN). The ICNP differs from the existing nursing classifications because it is built according to the rules of classification in which all of the concepts are placed within a framework of hierarchical relationships governed by one single principle of division and by a generic relationship between concepts (ICN, 1996).

Classification of phenomena helps to advance the knowledge base of the nursing field through the discovery of the principles governing what is known. Internationally standardized nursing taxonomies for diagnoses, activities, and outcomes are needed to create a common language in nursing, to develop compatible care systems, and to interface with other care provider information systems. More research is needed to evaluate and validate rules of classification and categories.

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See also
INTERNATIONAL CLASSIFICATION FOR NURSING PRACTICE
NANDA
NURSING INTERVENTIONS CLASSIFICATIONS
NURSING OUTCOMES CLASSIFICATION
OMAHA SYSTEM

TELEHEALTH

Telehealth is a rapidly growing technology for health care delivery that holds the promise of improving access to health for people living in rural and underserved areas as well as improving the resources available to health care practitioners in those areas. Telehealth is an application of telecommunications technology. Historically, the use of telecommunications technology for aiding communications between health care practitioners has been occurring since the days of the telegraph. The 1990s has seen an exponential growth in the available technologies and the interest in their use for health care.

As yet there are no standard terms or definitions for the various aspects of this health care technology. Telecommunications refers to the transmission, emission, or reception of data or information, in the form of signs, signals, writings, images, and sounds or any other form, via wire, radio, visual, or other electromagnetic systems. Telehealth may be defined as the removal of time and distance barriers for the delivery of health care services or related health care activities. Some of the technologies used in telehealth include telephones, computers, interactive video transmissions, direct links to health care instruments, transmission of images (e.g., radiographic images), and teleconferencing by telephone or by video. The rapid development of new communications technologies and the discovery of new uses for existing technologies will continue to expand this list.

Telenursing is a subset of telehealth in which the focus is on nursing practice across the domains of nursing. Similarly, telemedicine is another telehealth subset and includes the domains of medical specialty practice, such as teleradiology, teledermatology, telepsychiatry, and so forth. As the use of telecommunications technologies became more popular and more prevalent during the early 1990s, *telemedicine* was the term most often used. All health care practitioners and activities were subsumed under the telemedicine label. In the health care literature during this time most descriptions of telemedicine projects addressed only physician-to-physician communications. Now *telehealth* is being adopted as it is more inclusive and more appropriate to a health care system focused on wellness, illness prevention, and health maintenance.

Many potential benefits are predicted from telehealth, including increased consumer access to primary care practitioners, health care specialists, and specialized or advanced care facilities; rapid access to client health records and related information; more accurate and faster diagnosis and care; decreased use of emergency rooms as consumers use direct video contact with a health care practitioner (e.g., the managed care "triage nurse"); and monitoring of health status between required in-person visits that will allow early identification of problems and initiation of appropriate interventions. The consistent belief among proponents of telehealth is better health outcomes for individuals and populations and a reduction in health care costs.

Unfortunately, empirical data to support the anticipated benefits of telehealth are lacking, as are methodologically sound evaluation studies. The federal government has recognized this lack and undertaken activities to resolve it. The Institute of Medicine (IOM) was requested to study the issue of evaluating telehealth projects. In its report, *Telemedicine: A guide to assessing telecommunications in health care* (Institute of Medicine, 1996), the IOM states that this technology must be subject to the same evaluation principles that apply to other technologies in health care.

Until recently, studies of telehealth were either pilot projects related to the feasibility of implementing a particular application or the implementation of large-scale projects. Reports on these studies