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Health Informatics: Moving from a Discipline to a Science

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Abstract. This paper examines the historical definitions of Health (Biomedical) Informatics. It is clear that a majority of the definitions refer to Health Informatics as a discipline. Rather it can be argued that the maturation of Health Informatics is beginning to culminate in a distinct science. This progress need to be reflected in academic programs as well as our conferences and publications.

Keywords. Health Informatics, Biomedical Informatics, Science, Discipline, Definition

Introduction

A Discipline refers to the systematic instruction given to a student. In referring to Health Informatics, we are then referring to an organized body of knowledge which is presented in a systematic way. Indeed, the way Health Informatics developed this was a proper description. Originally Health Informatics was seen as the application of computer science in medicine. A more current view holds that that Health Informatics is a science which describes the knowledge modeled in healthcare. Science is the ordered body of knowledge which is used in a discipline. We will now present the organizing structure of the body of Knowledge that is Health Informatics and show how the science informs the discipline. The formation of the science can provide a way of organizing the discipline and inform educational programs and guide us in the future.

1. Discipline

There has been considerable discussion about the discipline of Health Informatics. Shortliffe [1] and others have described Health Informatics, or if you prefer Biomedical Informatics as a discipline. A discipline is at its core nothing more than a set of ordered ‘stuff’. (Please excuse the technical term.) A formal definition of a discipline:

> An academic discipline refers to a body of knowledge that is being given to - or has been received by - a disciple. The term may then denotes a 'sphere of knowledge' that an individual has chosen to specialize in. In an institute of higher learning, the term 'discipline' is often a synonym of 'faculty'. [2]

This discipline approach to Health Informatics is certainly an appropriate and proper model for the beginning of a new science. During the past ten years or more, we have seen Health (Biomedical) Informatics morph and merge as we have seen elements added to, removed from and reorganized within the discipline of Health Informatics. One need only look at the title of papers found in the International Nursing Informatics and MedInfo Conferences.

This paper will argue that we have indeed begun to focus on the science of Biomedical Informatics. While it is related to our previous understanding of the discipline of Health Informatics, the science of Biomedical Informatics covers a larger scope of information and knowledge as well as a greater scope of scientific models to organize and describe the 'stuff' of the science.

2. Science

Again let us start with the definition of science:

> Science (from the Latin scientia, meaning "knowledge" or "knowing") is the effort to discover, and increase human understanding of how the physical world works. Using controlled methods, scientists collect data in the form of observations, records of observable physical evidence of natural phenomena, and analyze this information to construct theoretical explanations of how things work. Knowledge in science is gained through research. The methods of scientific research include the generation of hypotheses about how natural phenomena work, and experimentation that tests these hypotheses under controlled conditions. [3]

The core of science is knowledge. That includes knowledge of various types: declarative, procedural, and semiotic. We can also talk about knowledge as being formal, complete, informal, situational and constrained by other components. While this is a area of epistemological debate, the fine points of that discussion are beyond the scope of this presentation. What is consistent from the time of Plato on is that there is an association between 'knowledge' and 'truth'. In the commonsense view of this discussion the truth of knowledge is assumed to be its 1:1 correspondence with things in the 'natural' or 'real world'.

If we are to see Biomedical Informatics as a science, how does this move us beyond the notion of a discipline? What new elements are added? How are the elements organized? And what is the 'truth' that will be addressed?

3. Assumptions

3.1 Data, Information and Knowledge

In a recent presentation Dr. Todd Johnson [4] discussed the core of informatics as being focused on data, information and knowledge. I believe that it would be fair to summarize his points as:

> Data: that which is different
>
> Information: relationships among data
>
> Knowledge: information in context.

Generally the three concepts: Data, Information and Knowledge are seen as related and not necessarily distinct, but organized by levels or degrees of abstraction. Using a classic approach, Data is the atomic unit pointing to a single unique datum. This is consistent with Johnson's approach of seeing it as something that is separated from the background. The term DATA has a unique problem in English in that it can be used as either a collective noun; hence the term DATA can be used to demote a collection of data elements.

Information is at least two data elements in a relation. Hence, there are three components needed to create the simplest element of information: datum1, datum2 and the relationship. One could argue whether this rises to the level of 'information' as it is used in the common vernacular but the definition is precise. Knowledge has as at least two pieces of information in relation. The result of course is that there must be at least 7 components to create a unit of knowledge 4 data elements and 3 relationships.

3.2 Praxis and the Nature of a Science

Health Informatics is at its core a Practice Field. Looking back at Coiera [5] and others we can argue the exact core of the practice. However, Coiera's argument that the core is communication seems persuasive. Knowledge and Information that cannot be communicated are of questionable value. Under Coiera's paradigm there are many forms of communication, with several different purposes. Clearly we can see communication between and among clinicians; there are communications between and among patients or clients; there will be communication between clinicians and patients

Like all modern communication, some communication is person to person, some is person to person mediated by technology and other communication may be person to self and person to self, mediated by technology. The communication can occur for a number of different purposes and be structured by the use of a variety of strategies see Te'eni. [6,7]

This is the inherent 'praxis' of Health Informatics. Praxis is the process by which theory is enacted or practiced. Aristotle held that there were three basic activities of man: theoria, poiesis and praxis. There corresponded to these kinds of activity three types of knowledge: theoretical, to which the end goal was truth; poietical, to which the end goal was production; and practical, to which the end goal was action. [8]

3.3 Role of Theory

Rosemary Ellis [9] categorized three types of theory for a practice discipline: Theory IN, Theory OF and Theory FOR. Ellis' insight is that while theory ids critical to practice disciplines, has a more complex set of roles than it does in non-practice disciplines. In more traditional disciplines theory focus on two main roles: to describe and to predict. The ability to describe and predict demonstrates the core of the hypothesis driven model that is western science.

Ellis points out that theory serves several purposes. 'Theory FOR' is theory that is not included in the science but which is appropriated for use into the science. In the area of Health Informatics we appropriate Theory from several different sciences including: Biology, Bio-chemistry, Medicine, Nursing, Mathematics, Computer Science, Information Science and others. As such Informaticians do not do pure science in these areas but rather appropriate theories, technologies and models from these science to enlighten aspects of the work being done in Health Informatics.

More important will be the development of Theory IN and Theory OF Health Informatics. The Theory IN will be the development of the Theory that is the core of Health Informatics. This will constitute the theory that both describes and predicts the core science elements that are emerging in the domain of the Health Informatics science. The Theory OF Health Informatics will constitute the meta-theoretical components that describe the organized knowledge of the domain of Health Informatics.

Ellis's description of the 3 THEORIES allows the organization of the complex relationships that evolve in the world of praxis and how the elements of praxis in a domain constitute more than a discipline and move toward the structure of a science.

4. Biomedical Informatics as a Science

As we have noted above the issues of defining a science have to do with the development of theory and the organized nature of structured research which are used to test the developed theory. We know from the philosophy of science that the two major purposes of theory are to describe and to explain. [10] Hempel and Oppenheim's Deductive-Nomological (D-N) model of explanation says that a scientific explanation succeeds by subsuming a phenomenon under a general law. A scientific method depends on objective observation in defining the subject under investigation, gaining information about its behavior and in performing experiments. However, most observations are theory-laden – that is, they depend in part on an underlying theory that is used to frame the observations.

Thomas Kuhn [11] denied that it is ever possible to isolate the hypothesis being tested from the influence of the theory in which the observations are grounded. He argued that observations always rely on a specific paradigm, and that it is not possible to evaluate competing paradigms independently. By "paradigm" he meant, essentially, a logically consistent "portrait" of the world, one that involves no logical contradictions and that is consistent with observations that are made from the point of view of this paradigm. More than one such logically consistent construct can paint a usable likeness of the world, but there is no common ground from which to pit two against each other, theory against theory. Neither is a standard by which the other can be judged. Instead, the question is which "portrait" is judged by some set of people to promise the most in terms of scientific "puzzle solving".

For Kuhn, the choice of paradigm was sustained by, but not ultimately determined by, logical processes. The individual's choice between paradigms involves setting two or more "portraits" against the world and deciding which likeness is most promising. In the case of a general acceptance of one paradigm or another, Kuhn believed that it represented the consensus of the community of scientists. Acceptance or rejection of some paradigm is, he argued, a social process as much as a logical process. Kuhn's position, however, is not one of relativism. According to Kuhn, a paradigm shift will occur when a significant number of observational anomalies in the old paradigm have made the new paradigm more useful. That is, the choice of a new paradigm is based on observations, even though those observations are made against the background of the old paradigm. A new paradigm is chosen because it does a better job of solving scientific problems than the old one.

Together these arguments point to the critical interaction of theory with the development and definition of a science. The question before us is whether Biomedical Informatics has yet risen to the level that it can be defined as a science. To answer this question let's begin with a definition of Biomedical Informatics and Ellis' notion of the three types of theory related to a science.

Health or Biomedical Informatics is here defined as 'Knowledge Modeling for Health Science'. This includes a broad notion of health.

In 1948, the World Health Assembly defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." [12] This definition is still widely referenced, but is often supplemented by other World Health Organization (WHO) reports such as the Ottawa Charter for Health Promotion which in 1986 stated that health is "a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities." [13]

While the WHO and Ottawa definitions are classic, they do not incorporate the social context in which the determinates of health exist. Hence as we look at health science, we are looking not only at the determinates of health for individuals and populations but also the social context in which the determinates of health exist. Hence we know the social, financial and political contexts affect not only the determinates of health but also the context in which the decisions about health care, the context of health care delivery and the 'value decisions' which affect the valuation of health and health elements occur.

The role of Health or Biomedical Informatics is to understand the knowledge models that are embedded in health and the context of health are made explicit for a purpose. Now we see Health or Biomedical Informatics as the Knowledge Modeling of:

1. Health
2. Health Context
3. Purpose of the Model.

Increasingly we look at these models from the aspect of computational knowledge modeling. That is, our focus is the creation or embedding of systems that can be used for an increased understanding of the nature of health, embedded in its context for a purpose.

5. The Science of Biomedical Informatics

The Science of Biomedical Informatics will include Theory IN, OF and FOR. The area of Theory FOR Biomedical Informatics is the most clear since we have been 'borrowing theory for a long time. As such we can see that theories from Biochemist, Biology, Cognitive Science, Epidemiology, Health Promotion, Medicine, Nursing and Sanitation among other science have been adapted into aspects of Biomedical Informatics

Theory IN Biomedical Informatics includes highly modified Theory Zhang [14] has heavily modified Human Computer Interaction Theory to fit the high-demand-timesensitive nature of healthcare. We are seeing the development of newer knowledge models which allow the embedding of context as part of the knowledge such as *archetypes*. [15]

The Theory OF Biomedical Informatics will be the last to develop. This process has been described by Schon. [16]

Examples of these models include Decision Support Systems (DSSs) and Electronic Health Records. We can argue that these systems in their current implementations focus as information support systems, but do not rise to the level of Knowledge based systems because they do not include contextual information needed for the ability of the user to interpret information without information or knowledge external to the system. The result is that these systems are more of information systems that augment or assist decisions. These systems would not meet the test of being computational knowledge systems.

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