Viewpoint Paper ■

A "Fundamental Theorem" of Biomedical Informatics

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Abstract This paper proposes, in words and pictures, a "fundamental theorem" to help clarify what informatics is and what it is not. In words, the theorem stipulates that a person working in partnership with an information resource is "better" than that same person unassisted. The theorem is applicable to health care, research, education, and administrative activities. Three corollaries to the theorem illustrate that informatics is more about people than technology; that in order for the theorem to hold, resources must be informative in addition to being correct; and that the theorem can fail to hold for reasons explained by understanding the interaction between the person and the resource.

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As best I can tell, the field of biomedical informatics continues to struggle to define itself. Those in the field refer often to large numbers of people in health care and biomedical research who "don't get it" with regard to informatics. Educational programs with "informatics" in their names are growing in number, but the increasing variation in level and scope of these programs further clouds the issue of what informatics is, and is not.

In hope that it might be helpful in providing greater focus and sense of identity, I offer here a formulation of our field that I have audaciously labeled the "Fundamental Theorem of Informatics." The theorem is based significantly on early ideas from members of our profession that RA Miller recapitulated in two commentaries.[1,2] The first of Miller's essays, in 1990, proclaimed the end of the "Greek Oracle" era in clinical decision support, calling primary attention to how information technology can augment human reasoning as opposed to what the technology itself is capable of doing. The second, in 1996, addressed technology evaluations and proposed that, "The ultimate unit of evaluation should be whether the user plus the system is better than the unaided user with respect to a specified task or problem . . ." The current fundamental theorem expands Dr. Miller's proposition on evaluation into a metaphor for the entire field. The theorem is also consistent with a statement, often attributed to Reed Gardner, that "informatics is only 20% about technology."

The "theorem" is depicted in Figure 1.

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The content of the work is based on the author's experience before joining the federal government, and does not reflect governmental policies or programs.

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I am suggesting that the essence of what we in informatics do, and how we do it, is captured in this simple diagram. The diagram may be read as "A person working in partnership with an information resource is 'better' than that same person unassisted."

What we in informatics do, then, is create and support the information resources that seek to make the inequality true. It is equally a part of our mission to study whether we have made people better, and if we find that we have not, to revise the information resource in hope that a modified version will be more successful.

The metaphoric "person" depicted in the theorem can be a clinician, a scientist, a student, a patient or an administrator. The "person" can also be a team or group, or even an organization. The "information resource" is any mechanism capable of providing information or knowledge or advice to support the person's completion of a task. Information resources are usually, but do not have to be, computer-based. The "plus" in the figure is intended to convey interaction between the person and the resource, the outcome of which is determined by what the information resource is capable of, as well as how the person elects to use it. The "plus" symbol is employed because of its universal recognition, but is not to be read literally in the sense of mathematical addition. The parentheses further connote a bonding between the person and resource, and suggest that the person-resource interaction is shaped by its environment or organizational context.

"Better" and the "greater than" inequality are used loosely by intention, so as not to convey specific requirements for testing the theorem. Whether the inequality holds can be demonstrated in many ways. The alternatives certainly include controlled trials that would compare, using predetermined outcome measures, the work of persons who used an information resource with the work of those who are unassisted. Whether the theorem holds can also be illuminated through the more subjective but very important perceptions of the persons who are the users of the resource.

In keeping with the notion of a fundamental theorem, there are some important corollaries that follow directly from it.

These corollaries offer a somewhat finer depiction of what informatics is and is not, and what informaticians do.

Corollary 1: Informatics is more about people than technology. This corollary can be seen from the "person" appearing twice in the theorem, while the information resource appears only once. This first corollary reminds us that information resources must ultimately be built for the benefit of people. This corollary also shows what informatics is not. As illustrated in Fig 2, creating resources that function as "oracles" and may be seen as competing with people—resources that seek, on their own, to be better than the person unassisted—is not a pursuit of interest in informatics.

Corollary 2: In order for the theorem to hold, the resource must offer something that the person does not already know. This corollary helps explain why the development of effective information resources is often so challenging. What the resource offers to the person must not only be correct, it must also be informative. It must increment his/her knowledge in some significant way. Because the persons who interact with these resources typically bring to any task a high level of personal knowledge about the domain in which they are working, the requirement that the resource be informative sets a very high bar for the theorem to be satisfied.

Figure 1. A "Fundamental Theorem" of informatics.

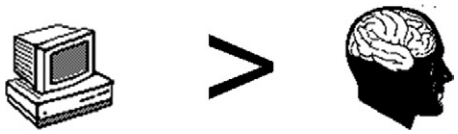

Figure 2. What informatics is not.

Corollary 3: Whether the theorem holds depends on an interaction between person and resource, the results of which cannot be predicted in advance. This final corollary reminds us that what we know about the person alone, and what we know about the resource alone, cannot tell us what will happen when the resource is deployed. The theorem can fail to hold, even though the resource has potential to be helpful, if it is used by the person in ways that do not enable the realization of its potential. This can happen because the resource is poorly designed and thus hard to use well, or because the person does not know enough about the domain to make best use of the resource.

By way of conclusion, the theorem and its three corollaries seek to establish the timbre of informatics rather than its libretto. I hope this formulation will promote understanding through simplicity, by stimulating imagination and further discussion. Sometimes less is more, and a picture is invariably worth a thousand words.

References ■

1. Miller RA, Masarie FE. The demise of the "Greek Oracle" model for medical diagnostic systems. Meth Inform Med 1990;29:1–2.
2. Miller RA. Evaluating evaluations of medical diagnostic systems. J Am Med Inform Assoc 1996;3:429–31.