CS 498 KA
Experimental HCI & Interactive Technologies

Concepts, Values, and Methods for Technical Human–Computer Interaction Research

Scott E. Hudson and Jennifer Mankoff

Science versus Engineering:
Invention as the Basis of Technical HCI Work

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Technical HCI focuses on the technology and improvement aspects of this task—it seeks to use technology to solve human problems and improve the world.

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To accomplish this, the fundamental activity of technical HCI is one of invention —*we seek to use technology to expand what can be done or to find how best to do things* that can already be done.

The ability to create new things, to mold technology (and the world), and to enhance what people (or technology) can do drives our fascination with technical work; hence, the core value at the heart of technical HCI is invention."

Science versus Engineering:
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"Activities of invention at their core seek to bring useful new things into the world. This nearly always requires knowing facts about the world and may entail pursuit of new discoveries if the necessary facts are not known or not known well enough.

But the heart of invention is *changing how the world works through innovation and creation*.

In contrast, activities of discovery at their core seek to develop new understandings of the world. To the extent that inventions play a role in these activities, they are in the service of discovery."

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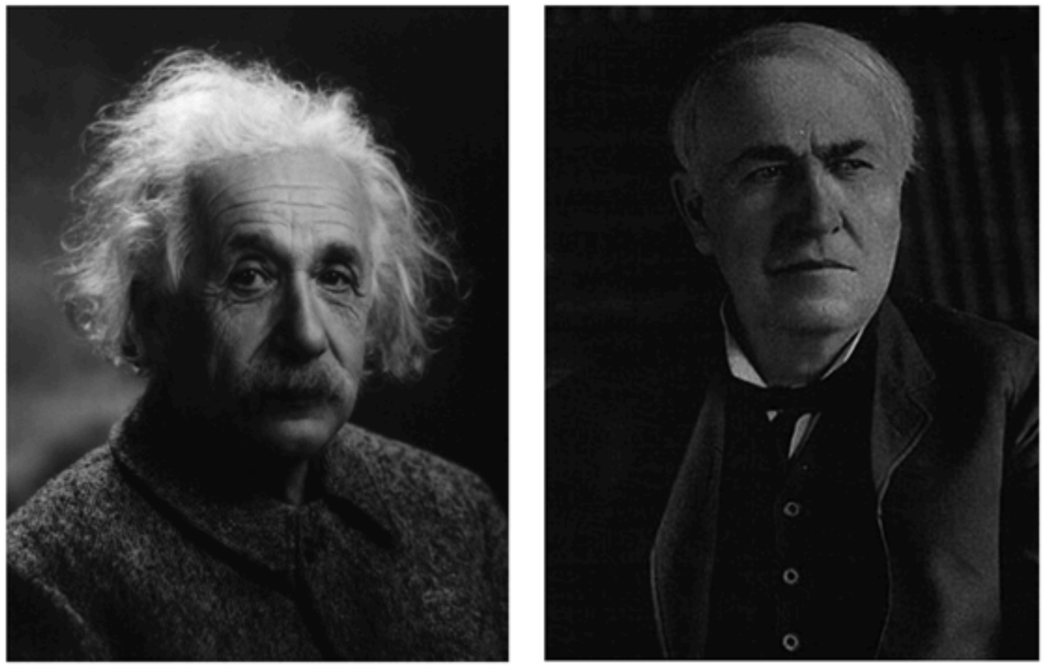

Albert Einstein (1879-1955) Thomas Edison (1847-1931)

But is the story really this simple?

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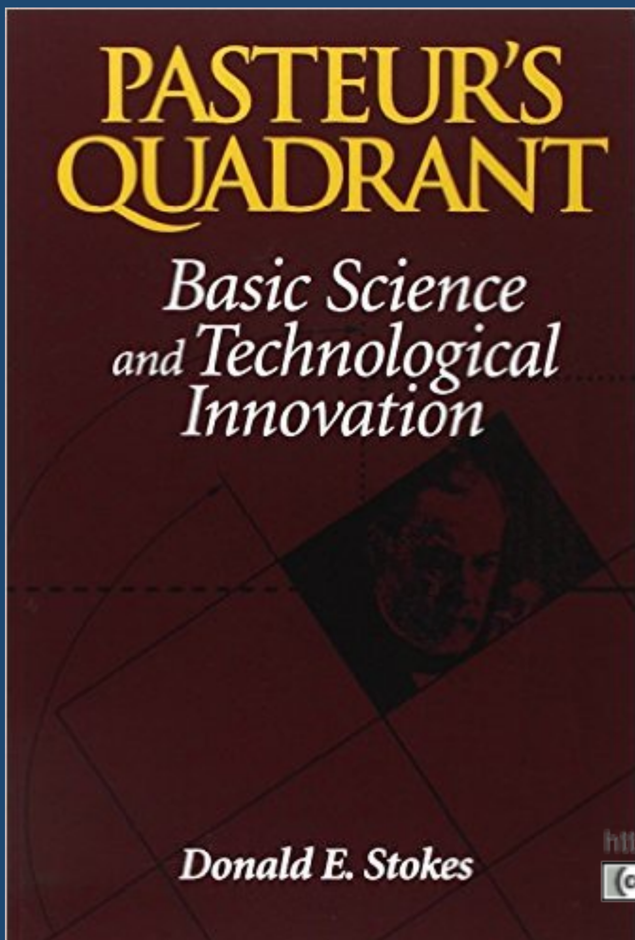

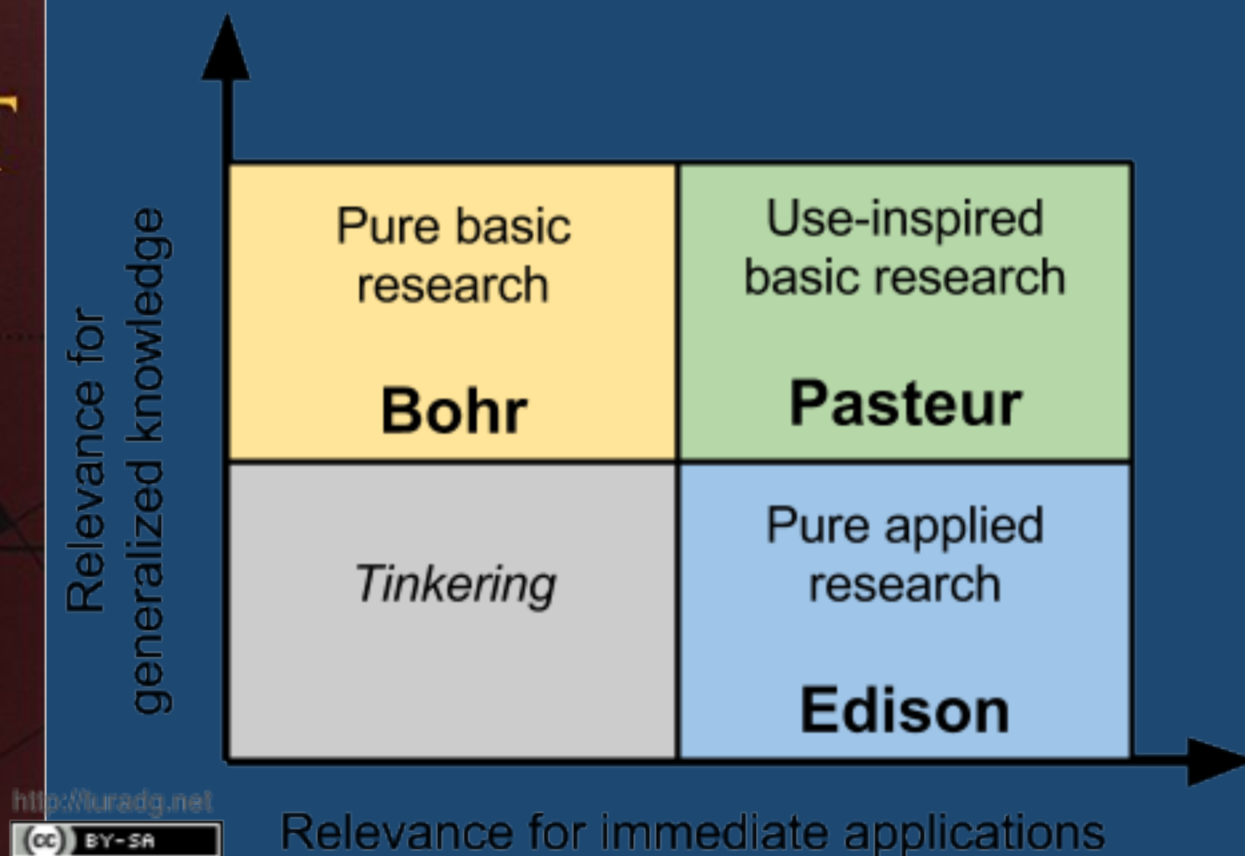

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Information Processing: The Language and Analytical Tools for Cognitive Psychology in the Information Age

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Science versus Engineering: Invention as the Basis of Technical HCI Work

The information age can be dated to the work of Norbert Wiener and Claude Shannon in the 1940s. Their work on cybernetics and information theory, and many subsequent developments, had a profound influence on reshaping the field of psychology from what it was prior to the 1950s. Contemporaneously, advances also occurred in experimental design and inferential statistical testing stemming from the work of Ronald Fisher, Jerzy Neyman, and Egon Pearson. These interdisciplinary advances from outside of psychology provided the conceptual and methodological tools for what is often called the cognitive revolution but is more accurately described as the information-processing revolution. Cybernetics set the stage with the idea that everything ranging from neurophysiological mechanisms to societal activities can be modeled as structured control systems with feedforward and feedback loops. Information theory offered a way to quantify entropy and information, and promoted theorizing in terms of information flow. Statistical theory provided means for making scientific inferences from the results of controlled experiments and for conceptualizing human decision making. With those three pillars, a cognitive psychology adapted to the information age evolved. The growth of technology in the information age has resulted in human lives being increasingly interweaved with the cyber environment, making cognitive psychology an essential part of interdisciplinary research on such interweaving. Continued engagement in interdisciplinary research at the forefront of technology development provides a chance for psychologists not only to refine their theories but also to play a major role in the advent of a new age of science.

Information is information, not matter or energy

Wiener (1952, p. 132)

Science versus Engineering:
Invention as the Basis of Technical HCI Work

Now, back to Hudson and Mankoff

Science versus Engineering: Differences in How the Fields Move Forward

“Activities of discovery can have a variety of aims, including generating rich, empirically based descriptions, and creating new theoretical understandings. Once articulated, theories typically form framing truths that establish a context for the work. The work of discovery often proceeds by elaborating and refining these framing truths to progress towards improved understandings.

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For example, both Newtonian and Einsteinian notions of gravity explain everyday objects falling to earth, and even the motion of planets, quite well. Only when we consider finer and more difficult-to-observe phenomena does one clearly improve on the other.

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As another [HCI] example, the speed and accuracy of directed reaching movements are well described in one dimension by Fitts' law (Fitts, 1954). However this theory has various limits (for example, when applied to 2D targets of arbitrary shape)."

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In an HCI context the first graphical interfaces (Sutherland, 1963) were created using existing input and display devices (a light pen, buttons, rotary input knobs, and a random dot CRT) along with new concepts expressed in software to create (among other pioneering advances) the ability of users to manipulate objects displayed graphically by pointing at them.”

Science versus Engineering:

Differences in What Makes a Result Valuable and Trustworthy

“In discovery work, the properties of valuable and trustworthy results are intertwined. Core values in discovery work include increasing understanding (e.g., of new phenomena) or understanding in more powerful ways (e.g., more profoundly or in some cases predictively). But the desire to know and have confidence in results makes the details and reliability of the methods used to reach a result of central importance.

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This can make it hard to generalize to more complex, real-world settings without replicating the study in many different but similar settings to be sure that the underlying theory is robust across changing circumstances."

The Work of Invention in Technical HCI
Types of Contributions

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Enabling research on the other hand is more indirect. It has as a goal not directly addressing an end-user need, but rather to enable others to address a need by making it possible, easier, or less expensive for future inventive work to do so (e.g. the development of better tools).”

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Systems also sometimes bring together a disparate set of capabilities that had not been combined before or combine capabilities in new ways that make them more useful. As an example, every major operating system today includes a subsystem specifically for handling overlapping windows, which provides basic input and output capability on a single set of devices that can be shared by many programs.”

The Work of Invention in Technical HCI

Approaches to Concept Creation

“One of the most frequent outcomes of inventive work in HCI is to devise a new way to bridge between technical capabilities and human needs. A researcher can <u>start from an observed human need</u> and seek to find a technical approach that can make a positive impact on the need.

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A researcher may do discovery-based work [e.g., in aging, decision making, disabilities, memory, vision, hearing, perception, etc. etc.] to better understand these needs (and human properties that impact them) and then seek (mostly existing) technological capabilities that might be used to meet these needs.

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Within this general framework, one can also work from the technology side: a researcher may specialize in one or more areas of useful or promising technology— and then seek to find existing human needs that the technology might have a positive impact on.”

Validation Through Building of Proof-of-Concept Implementations

"When we consider validation of an invented concept there are many criteria with which we might judge it. However, most fundamental is the question of "does it work?"

Experience with invented concepts shows that many ideas that seem excellent at the early point we might call on paper fail in the details that they must confront during implementation.

This difficulty leads to the most fundamental of validation approaches for inventive work: proof-of-concept implementation. Because of the difficulty of uncovering critical details, experienced inventors do not put much credence in an idea until it has been at least partly implemented; in short: you do not believe it until it has been built."

Validation Through Building of Proof-of-Concept Implementations

Types of Proof-of-Concept Implementations

Many proof-of-concept implementations take a form that can best be described as a *demonstration*. To succeed, that demonstration must illustrate the worth of the invention and in many cases motivate why it should be considered a success. Demonstrations fall along a rough scale of completeness or robustness. As used in the HCI research community, the presentation form of a demonstration is an indirect measure of its robustness, ordered below from the least to the most robust:

- Description in prose
- Presentation through photos (or screen dumps) showing the invention working
- Video showing the invention in use
- Live demonstration by the inventors
- Testing of properties with users
- Deployment to others to use independently

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Perhaps the most common evaluation methods we see employed to demonstrate this are usability tests, human and machine performance tests, and what we will call expert judgment and the prima facie case.

Although these are not universally appropriate, they are the most common in the literature."

Secondary Forms of Validation
Usability Tests

"Because of the current and historical importance of usability and related properties as a central factor in the practice of HCI, usability tests of various sorts have been very widely used in HCI work and are the most recognizable of evaluation methods across the field. In fact the authors have frequently heard the assertion among students and other beginning HCI researchers that "you can't get a paper into CHI without a user test!"

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This assertion is <u>demonstrably false</u>. An invention must be validated, but validation can take many forms. Even if a usability test shows that an invention is easy to use, it may not be very impactful. Its ability to be modified, extended, or applied to a different purpose may be much more important than its usability."

Secondary Forms of Validation

Human Performance Tests

“Another very widely used class of evaluation methods involves measuring the performance of typical users on some set of tasks. These tests are most applicable when goals for results revolve around a small set of well-defined tasks.

Work in interaction techniques is one of the few areas where this type of validation is consistently appropriate.”

NOTE: To close approximation, “human performance tests” or “experimentation” is largely the focus of our “ExpHCI” textbook.

Secondary Forms of Validation

Machine Performance Tests

“Tests can also be done to measure the performance of an artifact or an algorithm rather than the person who uses it. These can be very practical in providing information about the technical performance of a result such as expected speed, storage usage, and power consumption. These measures resemble the validation measures commonly used in other domains such as systems research in computer science.”

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Take Away Message: A good HCI researcher should also get their computer science right. If it is too much to expect that both skill sets should reside within one’s personal domains of expertise, then it will be useful to perform research in collaborative teams that include at least member with each required skill set.

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Expert Judgment and the Prima Facie Case

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Take Away Message: As you move forward pay attention to actively cultivating an *aesthetic skill* or *sense of taste* in evaluating research and its products, much in the way that your skills or tastes in appreciating many other creative endeavors (music, visual arts, cookery, wine) have matured.