Research Design – Asking the Right Question

QEM Network Professional Development Workshop: Fundamentals of Research in STEM Education October 26-27, 2007

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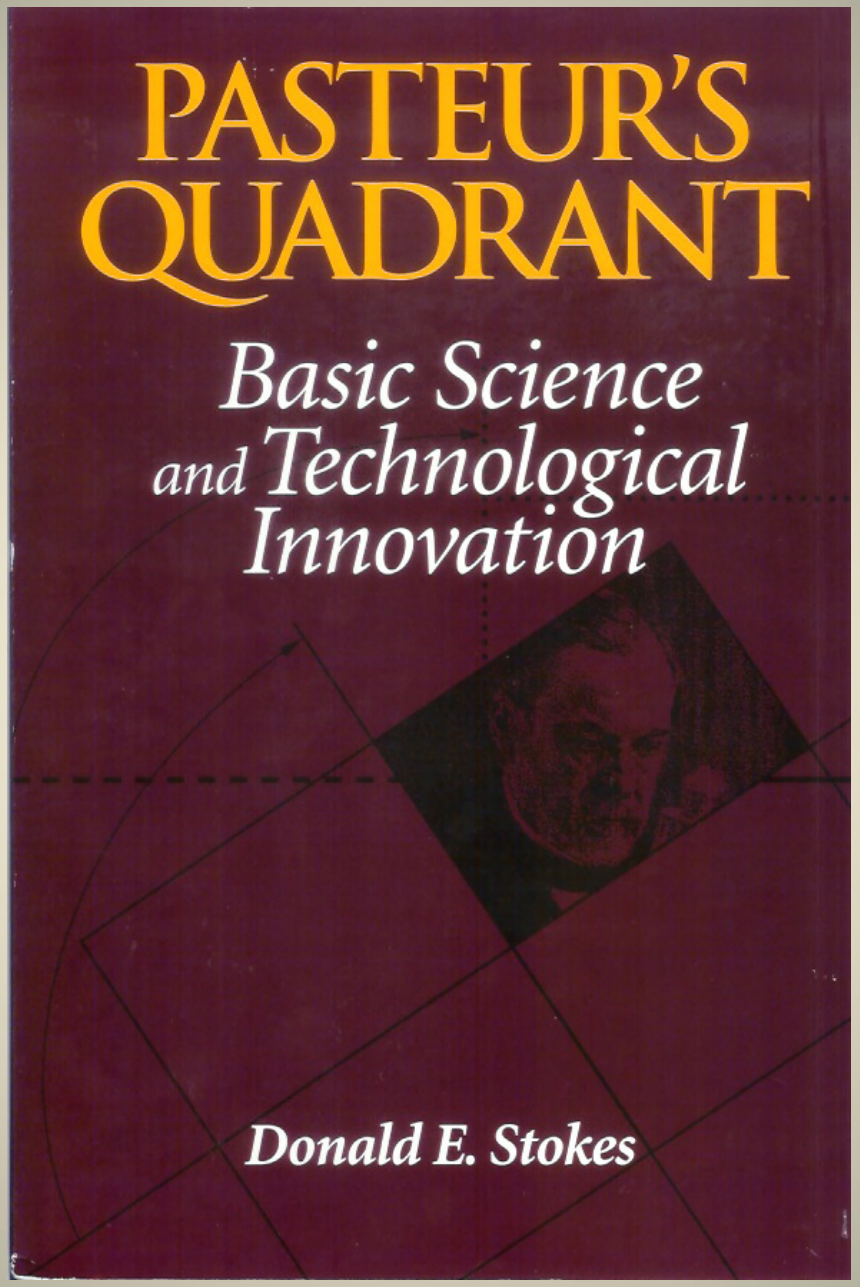
PASTEUR'S QUADRANT
Basic Science and Technological Innovation
Donald E. Stokes

Pasteur's Quadrant (Stokes, 1997 p. 73)

Research is inspired by:

Consideration of use?

Quest for fundamental understanding?	No	Yes
Yes	Bohr	Pasteur
No	*Most Educational Research	Edison

* Burkhardt and Schoenfield (2003)

Peterson's Guide to the Birds of North America


SCIENTIFIC RESEARCH IN
EDUCATION
NATIONAL RESEARCH COUNCIL

Scientific Research in Education

- Scientific Principle 1:
  - Pose Significant Questions That Can Be Investigated Empirically
- Scientific Principle 2
  - Link Research to Relevant Theory
- Scientific Principle 3
  - Use Methods That Permit Direct Investigation of the Question

Pose Significant Questions That Can Be Investigated Empirically

- “Questions are posed in an effort to fill a gap in existing knowledge or to seek new knowledge, to pursue the identification of the cause or causes of some phenomena, to describe phenomena, to solve a practical problem, or to formally test a hypothesis”
- “The significance of a question can be established with reference to prior research and relevant theory, as well as to its relationship with important claims pertaining to policy or practice” (p.55)

An Example of a Significant Question

- Does reducing class size improve students' achievement?
  - The State of Tennessee study (Krueger and Whitmore, 2001)
    - Previous studies had been reviewed in meta-analysis
    - Small positive effect noted
    - Very high potential to make a difference in schools and education policy

Investigated Empirically

- “Put simply, the term “empirical” means based on experience through the senses, which in turn is covered by the generic term observation.” (p.58)
  - The Tennessee question could be investigated empirically (with enough money, time, and appropriate methods)
  - A question such as “Should all students be required to say the pledge of allegiance?” can’t be subjected to empirical investigation.

The Real World of “Significant Questions”

- The funding is likely to have an impact on what is considered “significant”
  - National funding will more likely want to see a question that can have national “impact”
    - Will the results of this study generalize to the nation?
    - It’s the National Science Foundation – Not the Texas Science Foundation.
  - Regional or Local funding will be less concerned about the generalization issue.

Real World – Investigated Empirically

- While the Quantitative and Qualitative dichotomy is artificial – it is becoming more difficult to obtain funding for studies that follow only a few teachers/students in depth via ethnographic and/or observational methods
  - Personal View: The problem of not being able to generalize makes it difficult to make the case that the question is “significant”

Link Research to Relative Theory

- “Scientific theories are, in essence, conceptual models that explain some phenomenon.” (p.59)
  - Education does not have as strong of theories as the physical or even social sciences but…
    - Especially in the cognitive sciences the theory base is getting substantially stronger and more useful for education.

“How Students Learn” NRC, 2005 (Chapter 1)

- Three principles every teacher/researcher needs to know
- #1 Prior Understandings
  - Students come to school with many alternative conceptions
  - New understandings are constructed on a foundation of existing understanding and experiences.

“How Students Learn” (cont.)

- #2 Learning Facts and Concepts
  - Factual knowledge must be placed in a conceptual framework to be well understood.
  - Concepts are given meaning by multiple representations rich in factual details.
- #3 Self-Monitoring (Metacognition)
  - Asking students to “think about their thinking”
    - “What is the evidence for this claim?”

Use Methods That Permit Direct Investigation of the Question

- "The simple truth is that the method used to conduct scientific research must fit the question posed, and the investigator must competently implement the method" (p.62)
- The "Catch-22"
  - "Measurement reliability and validity is particularly challenging in the social sciences and education."
  - "Sometimes the tool used to take the measurement seriously under-represents the

Scientific Research in Education

- Scientific Principle 4
  - Provide a Coherent and Explicit Chain of Reasoning
- Scientific Principle 5
  - Replicate and Generalize Across Studies
- Scientific Principle 6
  - Disclose Research to Encourage Professional Scrutiny and Critique

Provide Coherent, Explicit Chain of Reasoning

- "All rigorous research – quantitative and qualitative – embodies the same underlying logic of inference. This inferential reasoning is supported by clear statements about how the research conclusions were reached;
  - What assumptions were made?
  - How was evidence judged to be relevant?
  - How were alternative explanations considered or discarded?
  - How were the links between data and the

Replicate and Generalize Across Studies

- “In the social sciences and education, many generalizations are limited to particular times and particular places. This is because the social world undergoes rapid and often significant change…” (p.71)
  - California’s implementation of the Tennessee study

Disclose Research to Encourage Professional Scrutiny and Critique

- "…for many reasons the education research community has not been nearly as critical of itself as is the case in other fields of scientific inquiry"
  - An interesting set of "academic arguments" between Kirschner, et al. (2006) and Hemlo-Silver, et al. (2007) on the subject of "inquiry".

References

Burkhardt, H. & Schoenfield, A. (2003). Improving educational research: Toward a more useful, more influential, and better-funded enterprise. *Educational Researcher*, 32 (9), pp 3-14.

Donovan, M. & Bransford, J. (2005, Eds.), *How Students Learn: History, Mathematics, and Science in the Classroom*. Washington, D.C.: National Academy Press.

Kirschner, P., Sweller, J., & Clark, R. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, Vol. 41, No. 2: pages 75-86

Krueger, A.B. and Whitmore, D.M. (2001). The effect of attending a small class in the early grades on college-test taking and middle school test results: Evidence from Project STAR. *Economic Journal*, 111, 1-28

Hmelo-Silver, C., Duncan, R., & Chinn, C. (2007). Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist***,** Vol. 42, No. 2, Pages 99-107

National Research Council. (2002). *Scientific Research in education*. Committee on Scientific Principles for Education Research. Shavelson, R.J., and Towne, L., Editors. Center for Education. Division of Behavioral and Social Sciences and Education. Washington, D.C. National Academy Press.

Stokes, D. (1997). *Pasteur's quadrant: Basic science and technical innovation*.