Making change: understanding software technology transfer

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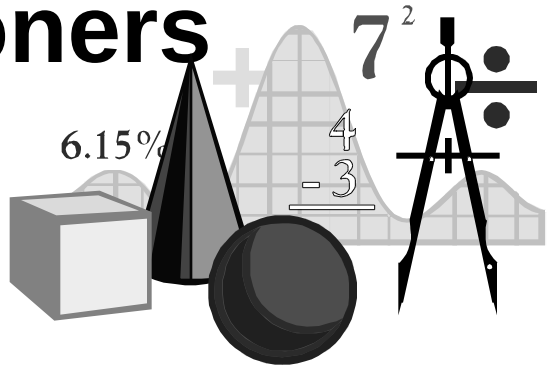
Overview

- Models of technology transfer
- Important variables
- The need to evaluate evidence
- Importance of organizational culture
- Next steps for practitioners and researchers



What do we mean by “technology”?

- ***Method or technique***: formal procedure for producing some result
- ***Tool***: an instrument, language or automated system for accomplishing something in a better way
- ***Procedure***: like a recipe, a combination of tools and techniques that, in concert, produce a product
- ***Paradigm***: an approach or philosophy for building software
- ***Technology***: method, technique, tool, procedure or paradigm

Redwine and Riddle study (1985)

Major technology areas
- KBS
- SWE principles
- formal verification
- compiler construction
- metrics

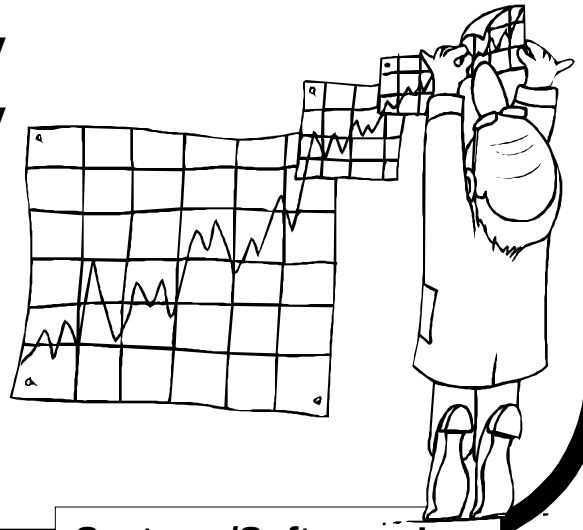
Consolidated technology
- cost models
- automated SW environments
- Smalltalk-80
- SREM
- Unix

Technology concepts
- abstract data types
- structured programming

Methodology technology
- SW creation and evolution methodologies
- SW cost reduction
- SW development and acquisition methods
- US DoD development standard STD-SDS
- US AF regulation 800-14

Redwine-Riddle maturation model

- Basic research
- Concept formulation
- Development and extension
- Enhancement and exploration (internal)
- Enhancement and exploration (external)
- Popularization
  - propagation through 40% of the community
  - propagation through 70% of the community



Adoption rate

- **Time to get from idea to “the point it can be popularized and disseminated to the technical community at large”**
- ***Worst case*: 23 years**
- ***Best case*: 11 years**
- ***Mean*: 17 years**
- **7.5 years from developed technology to wide availability**

Current time pressures

No, Thursday's out. How about never? Is never good for you?

Accelerated adoption

- SEI Capability Maturity Model
- Ada
- Reuse
- Java
- CASE tools
- UK Ministry of Defence use of formal methods

Finding the right audience

- **Potential users NOT = Population of software developers**
- **Zelkowitz study at NASA:**
  - **distinguished technology producer from consumer**
  - **recognized role of the "gatekeeper"**

Models to encourage transfer

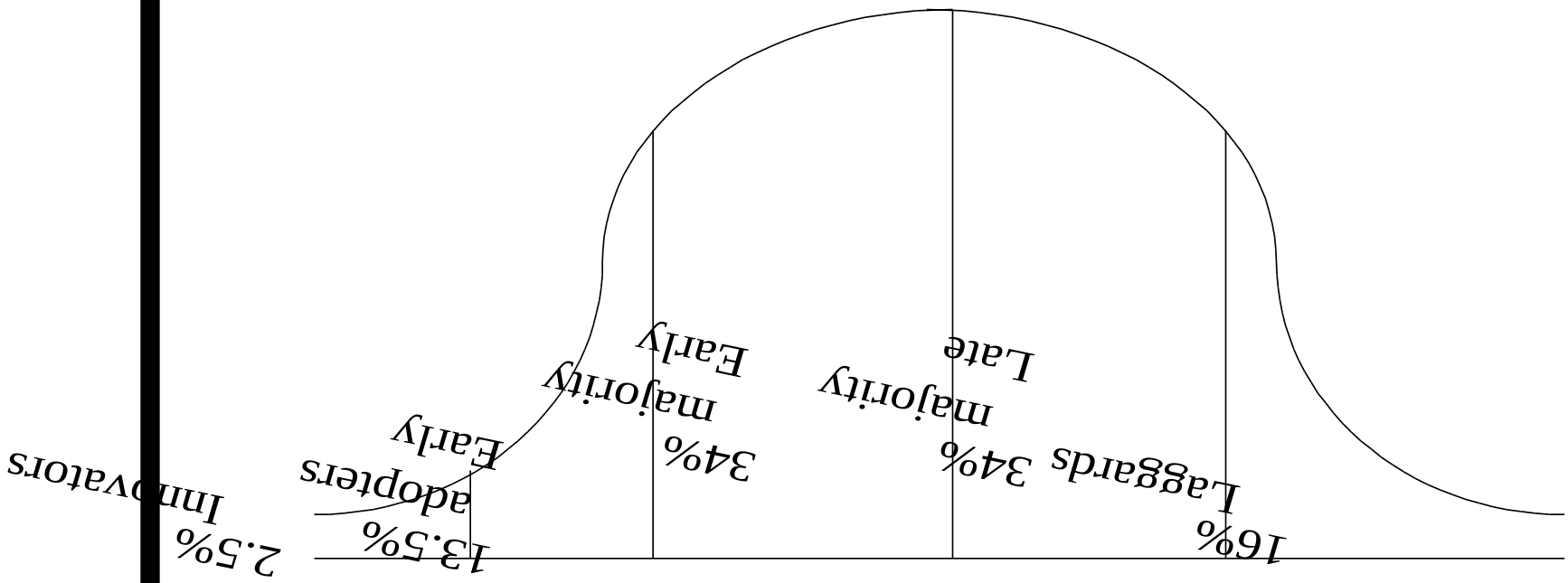
Berniker (1991):

- **People-mover: relies on personal contact between producer and consumer**
- **Communication: report in print is noted by gatekeeper**
- **On the shelf: packaging and ease of use encourage transfer**
- **Vendor: primary software or hardware vendor is gatekeeper**

Zelkowitz:

- **Rule: Outside organization imposes technology**

Rogers: Patterns of adoption



Adopter categories

- **Innovators: "venturesome," driven by doing something daring from outside organizational culture**
- **Early adopters: integrated in organizational culture, respected by peers, want to decrease uncertainty**
- **Early majority adopters: deliberate in their thinking, follow rather than lead**
- **Late majority adopters: skeptical; adopt due to economic or peer pressure**
- **Laggards: adopt only when certain the technology will not fail, or when forced to change**

Relationship between audience and transfer model

Adopter categ	Level of risk	Adoption model
Innovators	Very high	People-mover model
Early adopters	High	Communication model
Early majority	Moderate	On-the-shelf model
Late majority	Low	Vendor model
Laggards	Very low	Rule model

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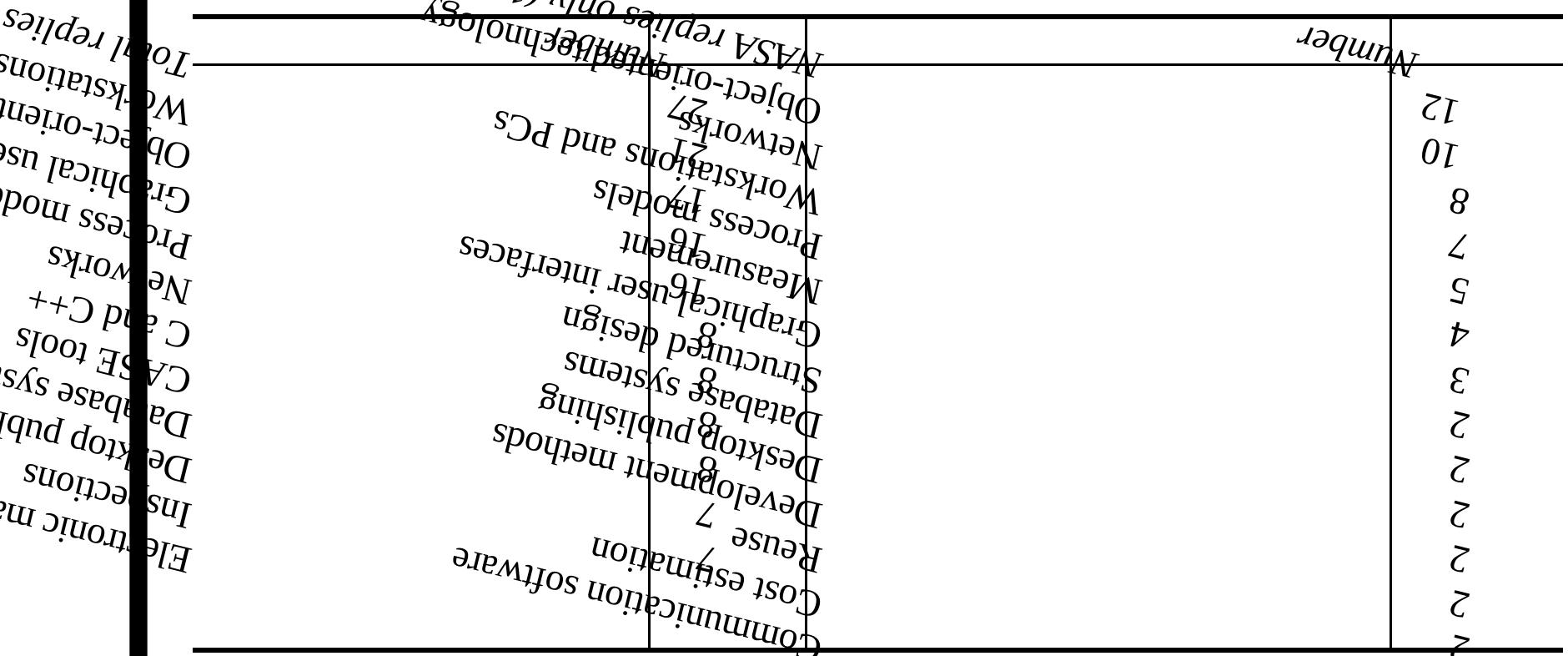
Top transferred technologies



(from Zelkowitz 1995)

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Similar surveys

Yourdon (1998)

- **declining interest in OO**
- **growing interest in Y2K**
- **linear decline in interest in CASE**
- **initial peak but then decline in interest in reuse**

Glass and Howard (1998)

- **Top technologies in practice: 4GLs, feasibility studies, prototyping, code inspections or walkthroughs**
- **Little interest in: CASE, JAD, metrics**

Example: problems with TT at NASA

- No good infusion mechanism for bringing technology to the agency
- Major NASA goal is transfer of products, not increases in quality or productivity
- People-mover model rarely used
- Most successful TT done outside of established NASA TT mechanisms

(Zelkowitz)

Problems industry-wide

- Most software professionals resist change.
- Infusion mechanisms for other TT do not always work well for software technology, perhaps because the focus is more on producing than on transferring a product.
- TT needs more than just understanding the new technology.
- Quantitative data needed for understanding how and why the new technology will fit in or replace existing technologies.
- TT is not free.
- Personal contact is essential for change.
- Timing is critical.

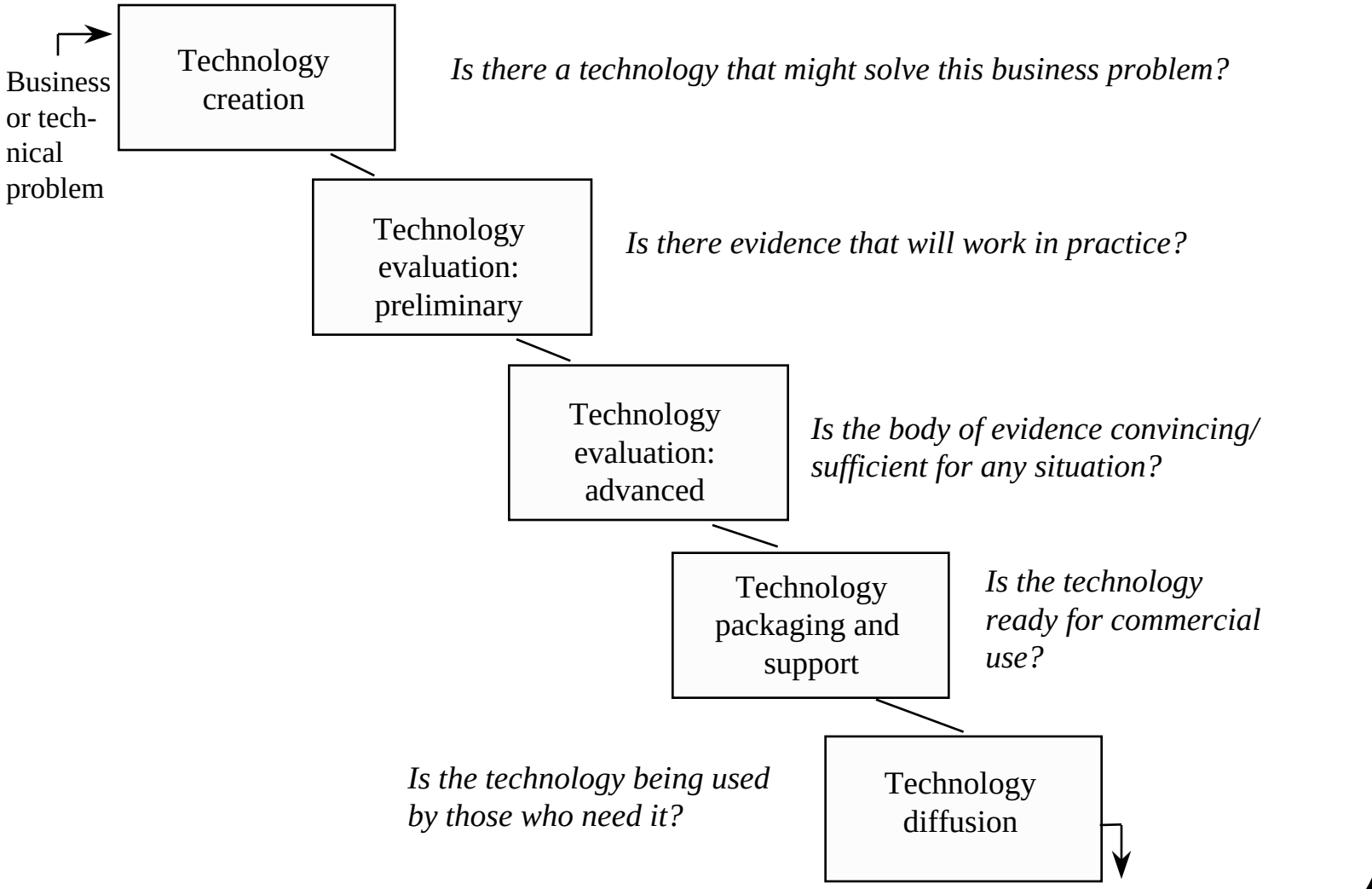
(Zelkowitz)

Promoters and inhibitors

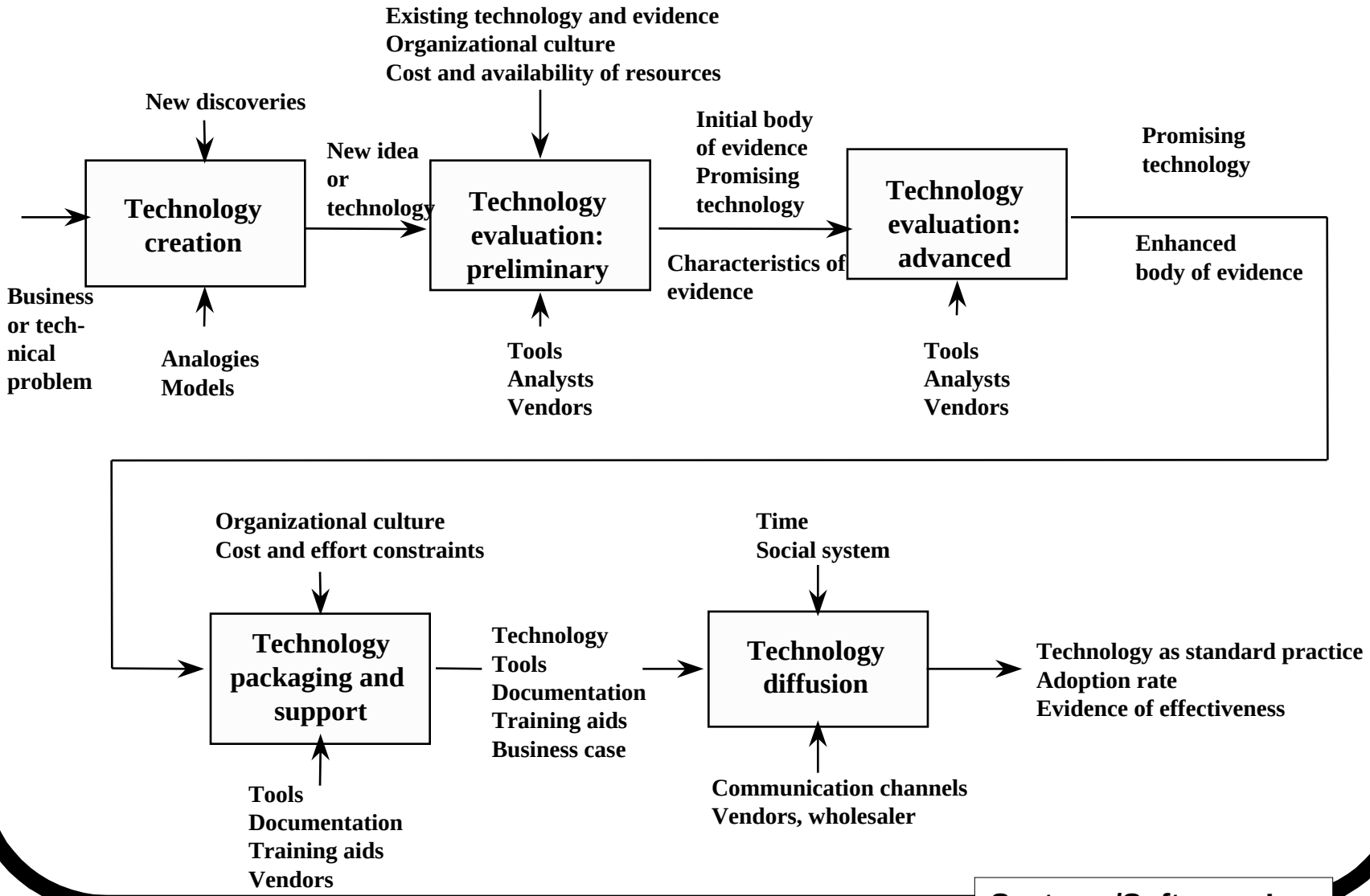
- Need to identify TT promoters and inhibitors.
- Promoter is a person, technique or activity that accelerates technology adoption.
- Inhibitor is a person, technique or activity that interferes with or prevents technology adoption.

- Example: Rai (1995) surveyed IS managers about CASE tools. Perceptions depended on whether the technology was in its infancy, being tried for the first time, or was a mature candidate for adoption. Thus, maturity was a promoter.

Questions to be answered



New model of technology transfer



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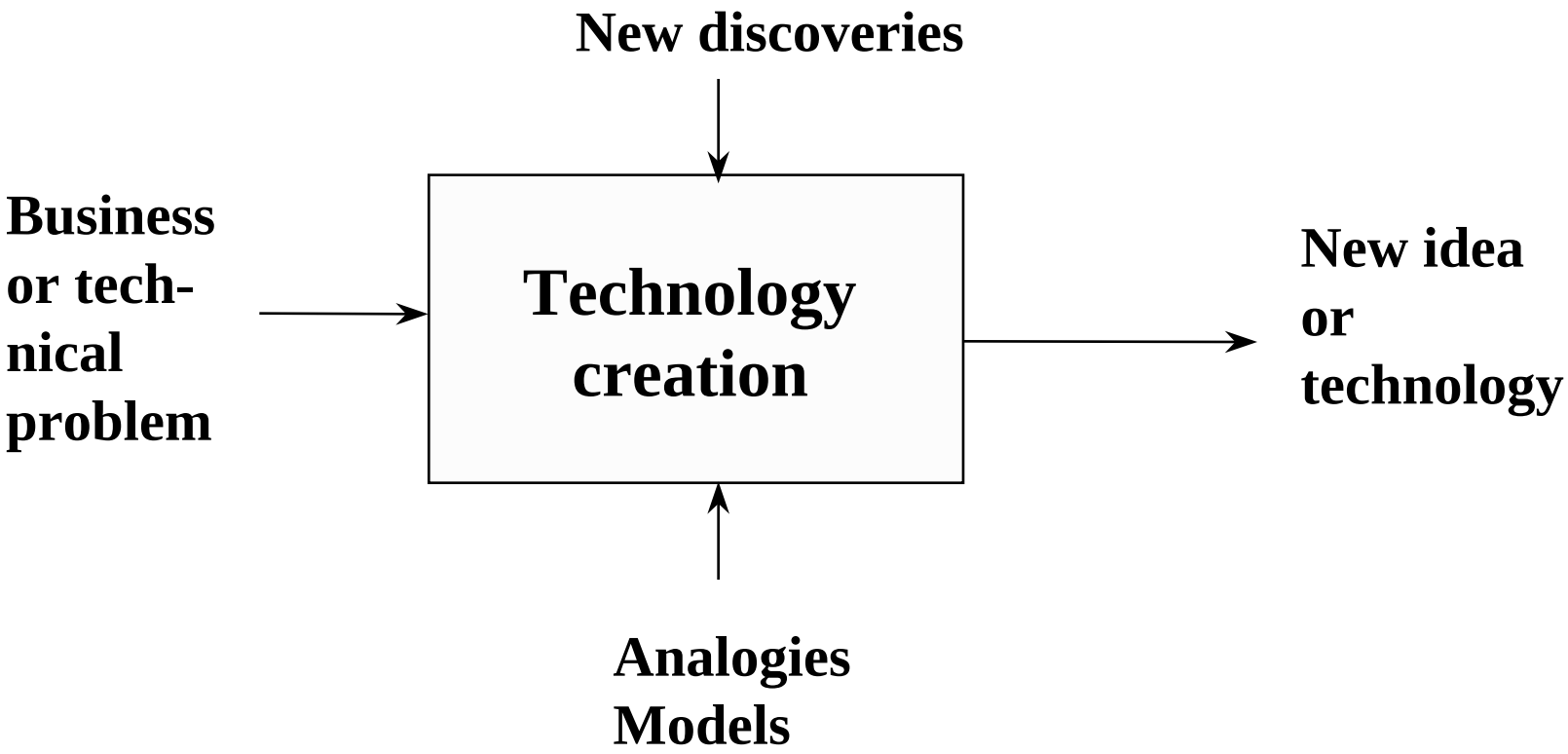
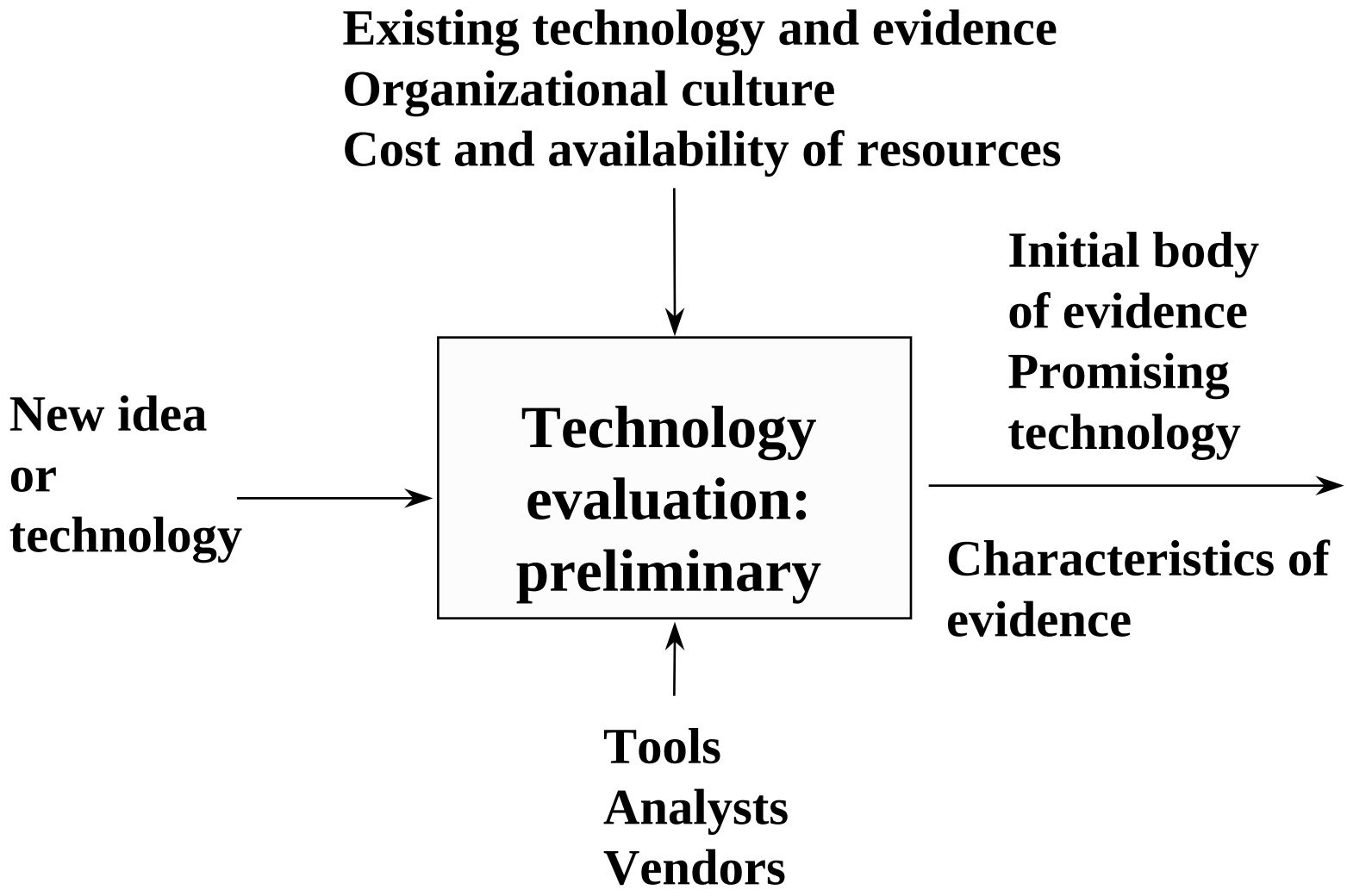
Technology creation



For a new technology:

- What problem does it solve?
- Does it work properly?
- Does it replace/extend/enhance an existing technology?
- Does it fit easily in the existing development or maintenance process, without great disruption to established and effective activities?
- Is it easy to understand?
- Is it easy to learn?
- Is it cost-effective?

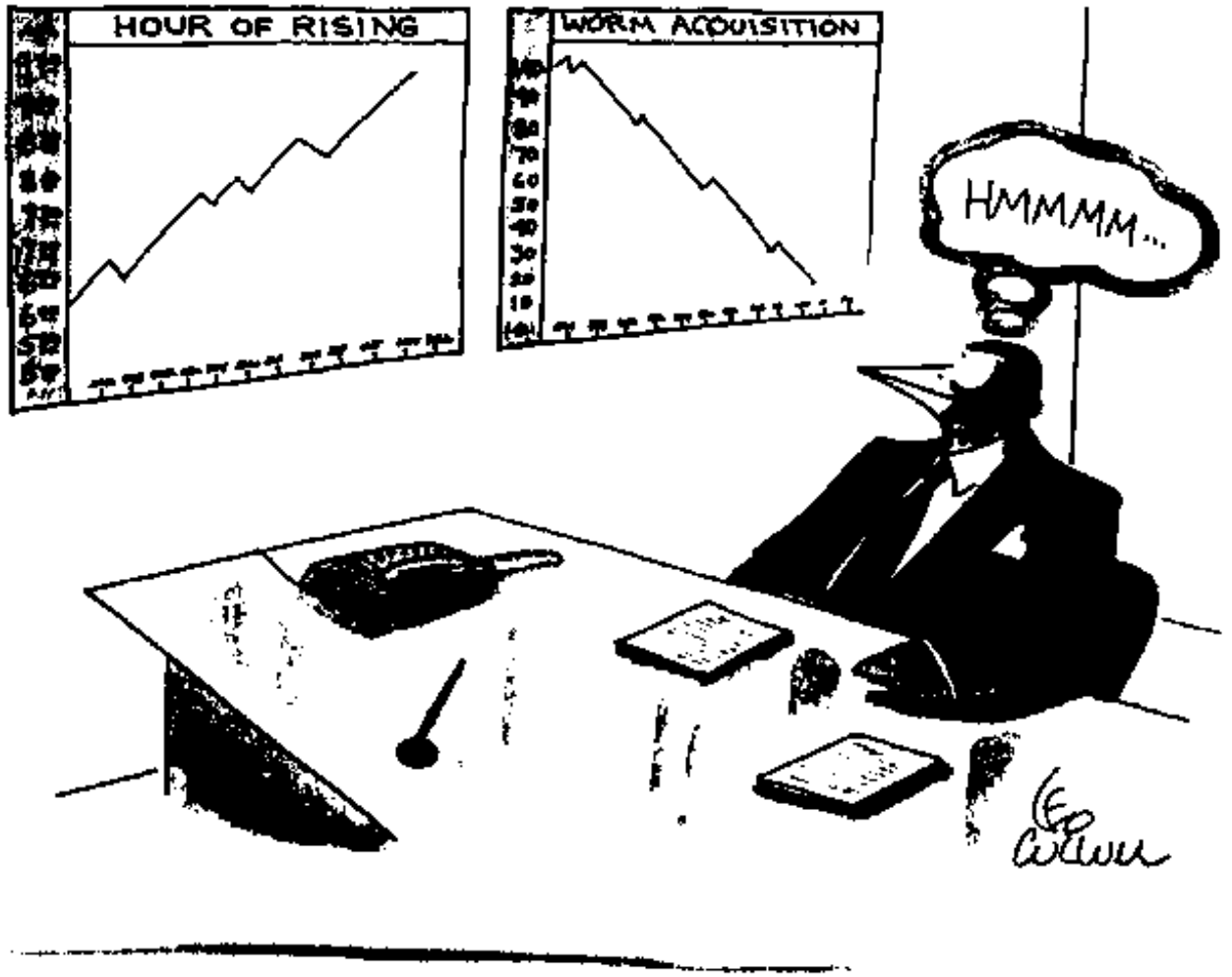
Technology evaluation: preliminary



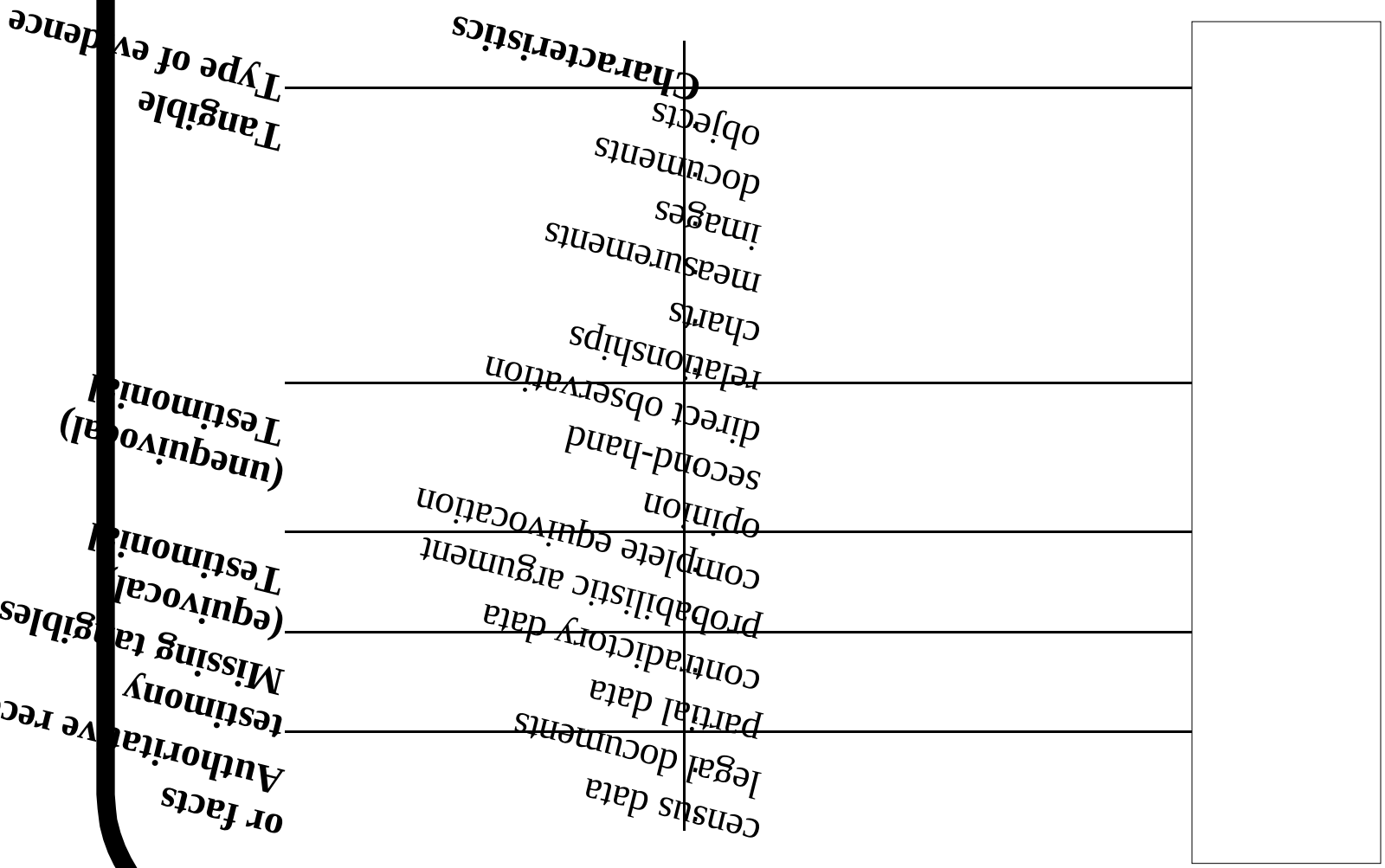
Goal of preliminary evaluation

- **Evaluating the technology relative to the organization's existing technologies and processes**
- **In other words, is there any benefit to using the new technology relative to what we already do?**

Dealing with evidence



Forms of evidence (Schum)



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The nature of the evidence

Zelkowitz, Wallace and Binkley (1998):

Practitioners value methods relevant to their environment:

- **Case studies**
- **Field studies**
- **Replicated controlled experiments**

Researchers valued reproducible validation methods:

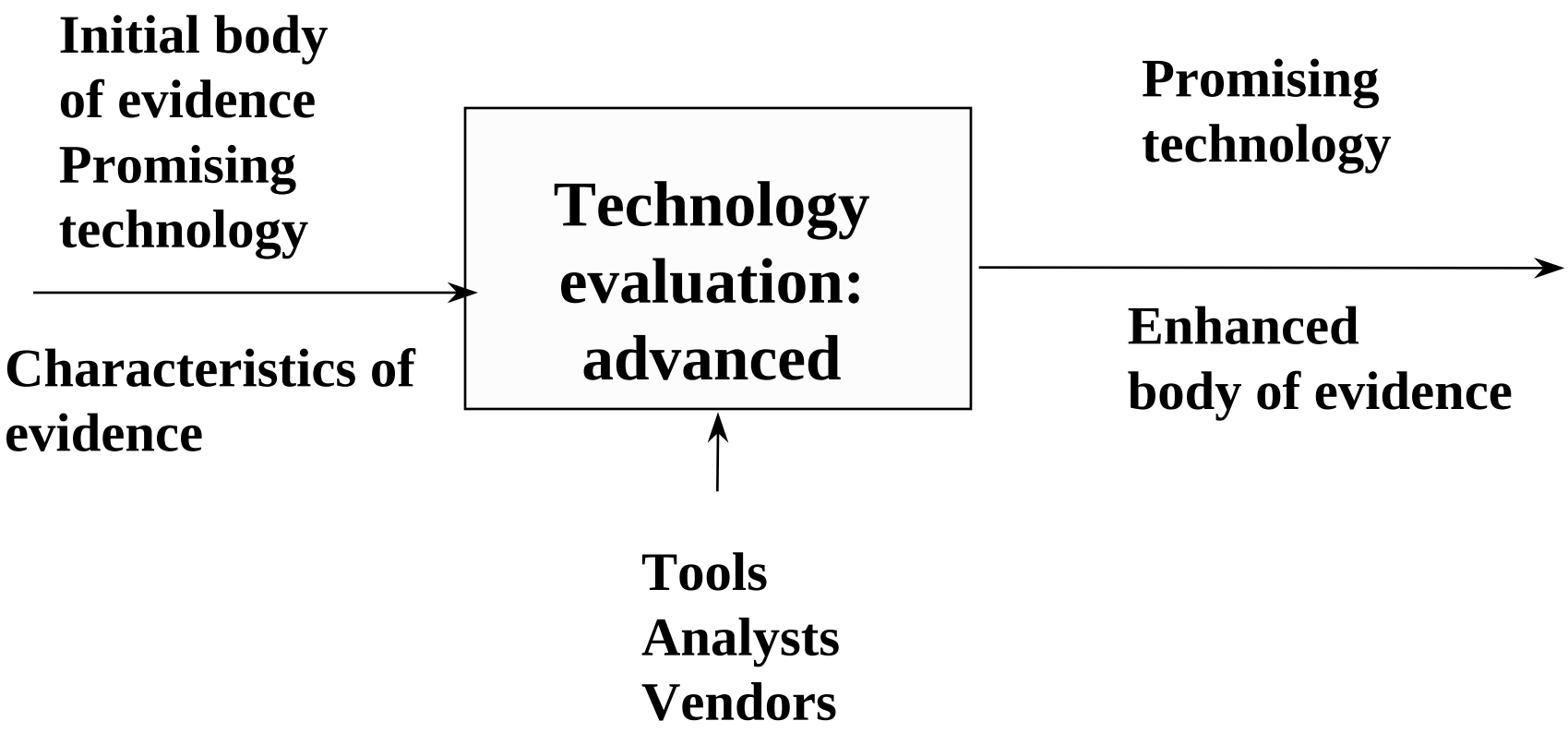
- **Theoretical proof**
- **Static analysis**
- **Simulation**

Questions addressed by evidence

(Rogers)

- **Relative advantage: To what degree is the new technology better than what is already available?**
- **Compatibility: To what degree is it consistent with existing values, past experiences, and the needs of potential adopters?**
- **Complexity: To what degree is it easy to understand and use?**
- **Trialability: Can it be experimented with on a limited basis?**
- **Observability: Are the results of using it visible to others?**

Technology evaluation: advanced



Example body of evidence

4GL vs. COBOL: reports in the literature (Misra and Jalics, Matos and Jalics, Verner and Tate, 1980s)

- **4GL was 29-39% shorter (in source lines) than COBOL**
- **4GL development process was 15% faster to 90% slower**
- **4GL performance was 6 times faster to 174 times slower**

Goals of advanced evaluation

- Is the entire body of evidence compelling?
- Who is providing the evidence, and what is the credibility of the provider?
- Are the judgments of cause and effect absolute or relative?
- How much confidence do we have in the evidence, based on the strength of the evidence?
- What is the process by which the evidence was generated?
- What is the structure of the argument made from the evidence?

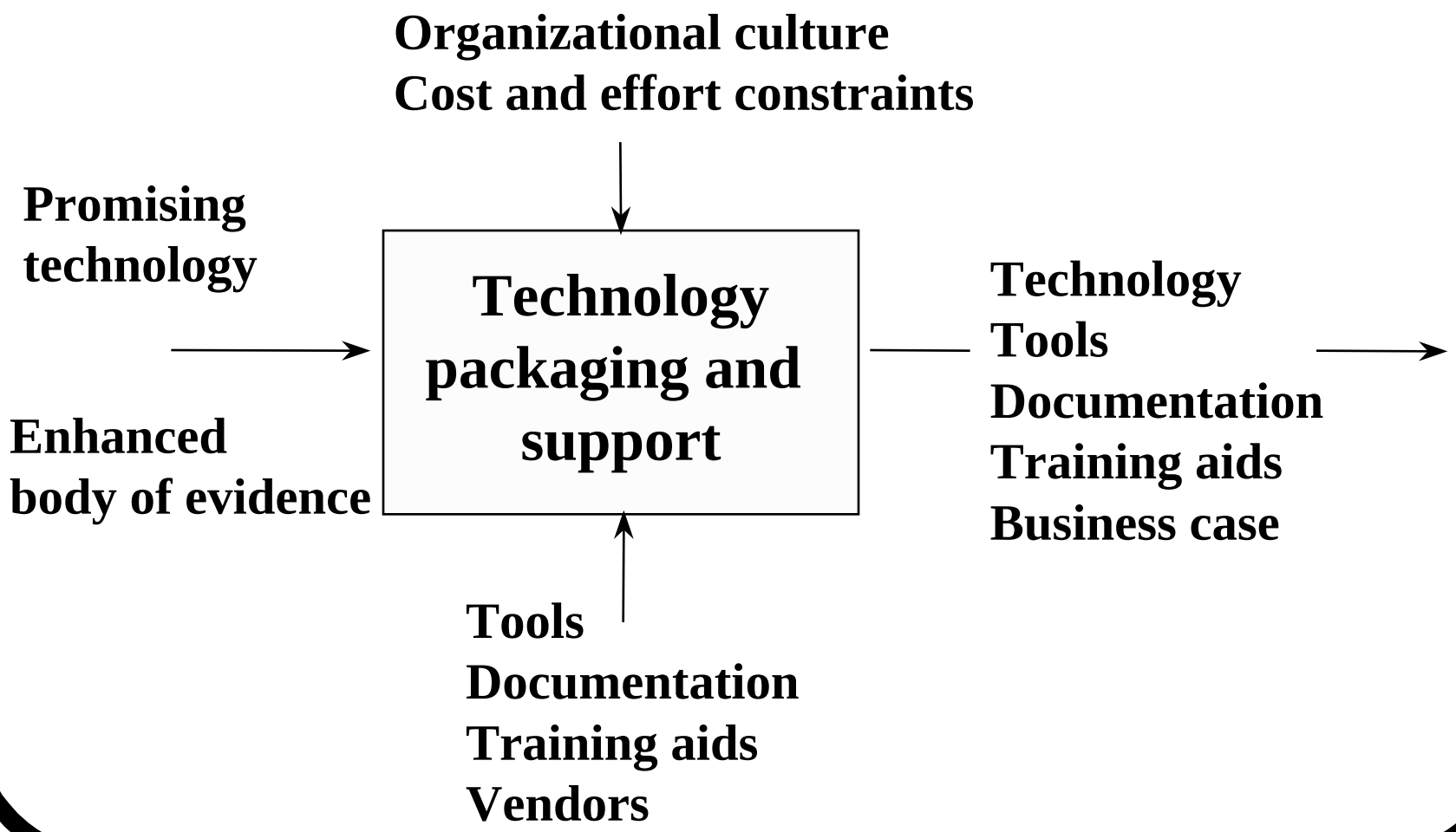
Assessing the argument's evidential force

- Is each piece of evidence relevant to the argument?
- What is each piece of evidence's inferential force?
- What is the evidential threshold? That is, what is the point below which the evidence is irrelevant?
- What is the perspective of the provider of the evidence, and how does the perspective affect the conclusion?
- What is the nature of the evidence? Is it documentary, testimonial, inferential, or some other category of evidence?
- How credible is the evidence?
- How accurate is the evidence?
- How objective were the evidence collection and results?
- How competent are the evidence providers and interpreters?
- How truthful are the evidence providers and interpreters?

	Specific	Less specific	Unspecific
Observational sensitivity	• Sensory defects • General physical condition • Conditions of observation • Quality/duration of observation • Expertise/allocation of attention • Sensory bias	Observational instructions and objectives	• Contradictions • Conflicting evidence • Prior inconsistencies
Objectivity	• Expectancies • Objectivity bias • Memory-related factors	• Stakes, motives, interest • Self-contradiction	
Veracity	• Honesty • Misconduct • Outside influences/corruption • Testimonial bias • Demeanor and bearing • Truth		

Tests of testimonial credibility (Schum)

Technology packaging and support



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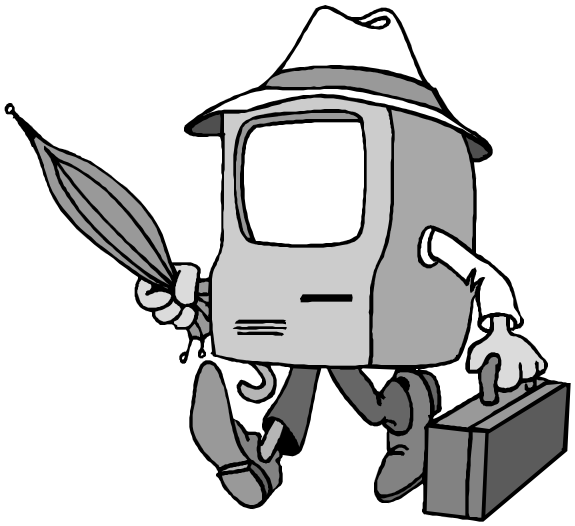
Fichman and Kemerer study

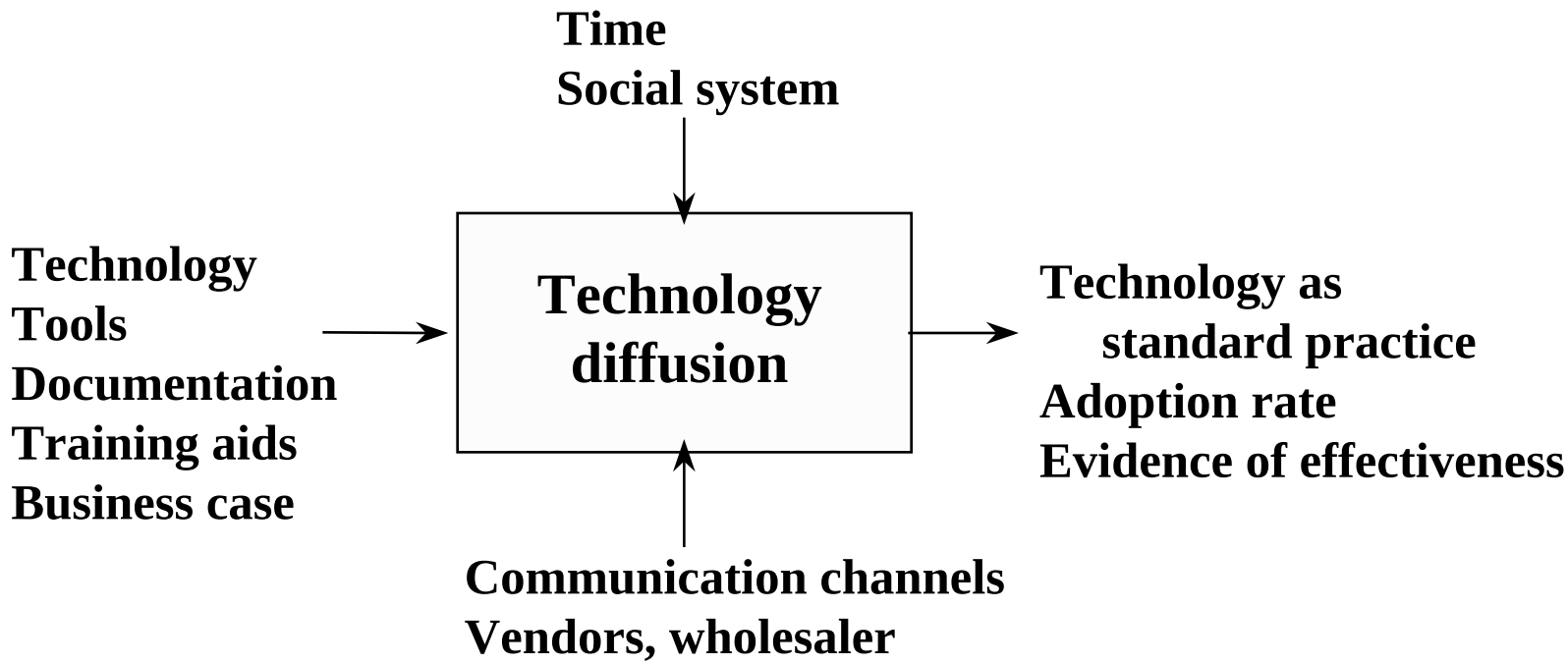
- **Empirical study of 608 IT organizations using OO languages**
- **Packaging and support needed to break "knowledge barriers"**



Questions about packaging and support

- Are there effective tools, documentation and training aids to assist learning and using the technology?
- Is there institutional support?
- Is there interference from existing techniques? That is, if a potential user already knows one technique, does that prevent him or her from learning the new one?
- Has the technique been commercialized and marketed?
- Is the technology used outside the group that developed it?

Technology diffusion



Studies from the literature (1)

- **Premkumar and Potter: IT managers and CASE tool adoption**

They found five variables distinguishing adopters from non-adopters:

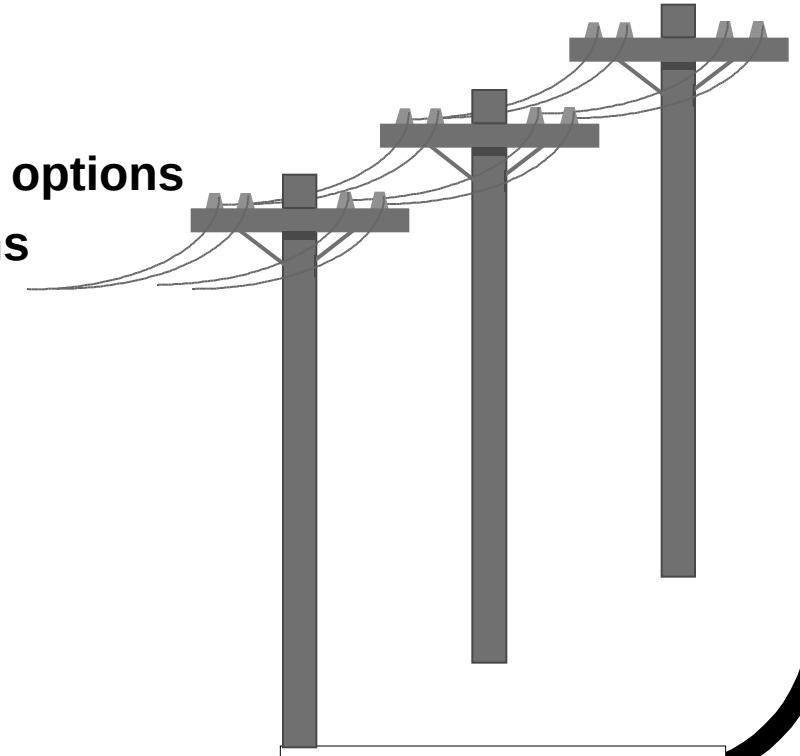
- **existence of a product champion**
- **strong top management support**
- **lower IS expertise**
- **a perception that CASE has an advantage over other technologies**
- **a conviction that CASE is cost-effective**

Studies from the literature (2)

- **Lai and Guynes: Business Week 1000 companies and ISDN**

Most receptive

- **were larger**
- **had more slack resources,**
- **had more technology expansion options**
- **had fewer technology restrictions**



Rogers' suggestions

- Determine if the technology changes as the user adopts and implements it.
- Understand the potential audience, including similarities between those who have already adopted and those who might.
- Understand the diffusion process itself:
  - knowledge
  - persuasion
  - decision
  - implementation
  - confirmation (leading to adoption or rejection)
- Understand the role of the people who are promoters.

What do we know?

- **There is great variety in adoption times, most of which are too long.**
- **It is not clear how to build and assess evidence when we have minimal control of variables.**
- **We know little about how the compelling nature of evidence relates to successful adoption.**
- **Evidence is not enough to ensure adoption.**
- **We can learn much from the literature of other disciplines.**

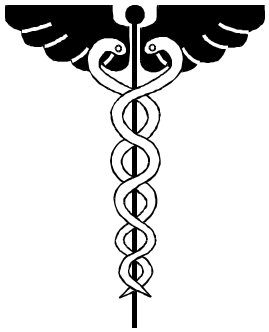
  "DIFFUSION is the process by which an INNOVATION is COMMUNICATED through certain CHANNELS over TIME among the members of a SOCIAL SYSTEM." (Rogers)

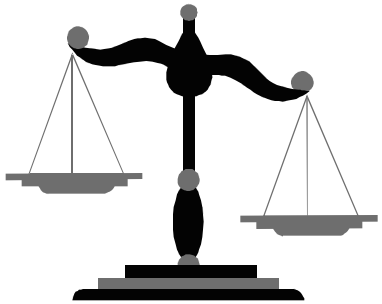
Inhibitors and promoters

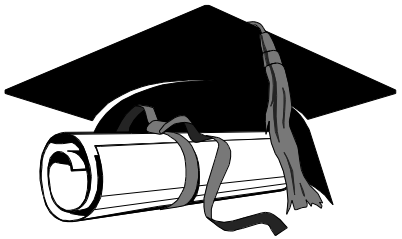
	Inhibitors	Promoters
Technological	Lack of "packaging" No clear relationship to technical problem Difficult to use Difficult to understand	Supporting tools, manuals, classes, help Clear benefit to technical problem Well-understood context for using the technology Easy to use Easy to understand
Organizational	No management support Cognitive dissonance Biases and preconceptions Cross-organizational mandate Not cost-effective Heterophily	Gatekeeper Technology booster Trial within one organization Results (especially improvement) visible to others Perceived advantage Success in similar organizations Compatible with values Compatible with experience Compatible with needs Cost-effective Homophily
Evidential	Conflicting evidence Lack of evidence Unclear meaning of evidence Experiments in toy situations	Consistent evidence Case studies and field studies Credible messenger Relative advantage Cause-and-effect evident

Next steps

- **Collaborative work between practitioners and researchers.**
- **Look for examples of TT; identify key variables.**
- **Develop guidelines for**
  - **planning and organizing evidence**
  - **evaluating bodies of evidence (what is enough?)**
- **Learn from other disciplines and improve our models.**







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