Evaluating a Scientific Collaboratory: Results from a Controlled Experiments

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Collaboratory Team

Information Science: Diane Sonnenwald, Kelly Maglaughlin, Bin Li

Computer Science: Mary Whitton, Russ Taylor, Kevin Jeffay, Don Smith

Physics: Rich Superfine, Martin Guthold

Chemistry: Dorothy Erie, Tom Kunkel, Sam Wilson

Gene Therapy: Douglas McCarty, Jude Samulski

Student Research Assistants: 5 distributed across IS, CS, Physics

Research Motivation

National Institutes of Health (NIH) Policy Issue

To provide access to specialized scientific instruments, should NIH:

(1) continue funding scientists' travel

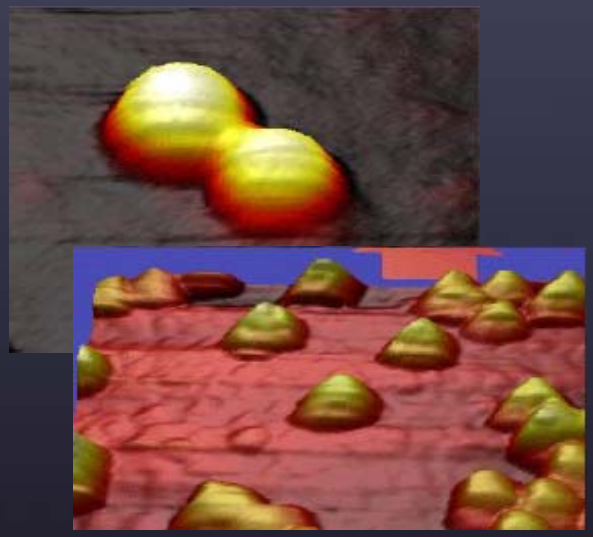
- or -

(2) fund the development of collaboratories

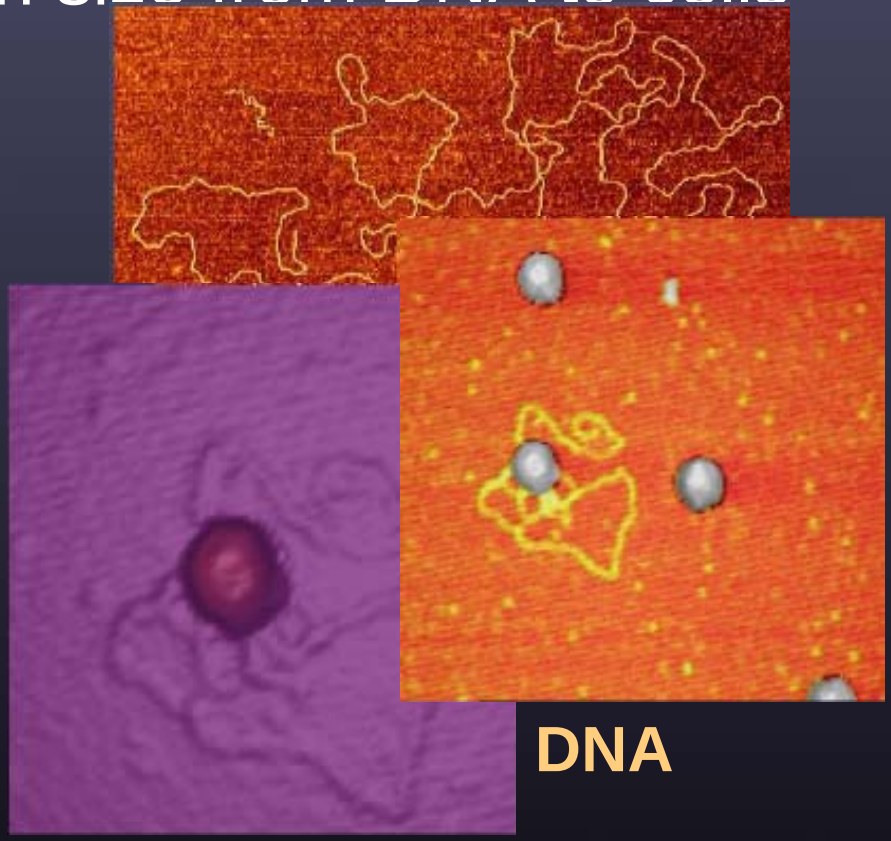
What impact might collaboratories have on the scientific process & outcomes?

Research context: nanoManipulator (nM)

Enables scientists to interact directly with physical samples, ranging in size from DNA to cells



Adenovirus



DNA

(Taylor & Superfine, 1999; Guthold, et al., 1999)

Single-user nanoManipulator

Display Control Software

3D Display of Sample

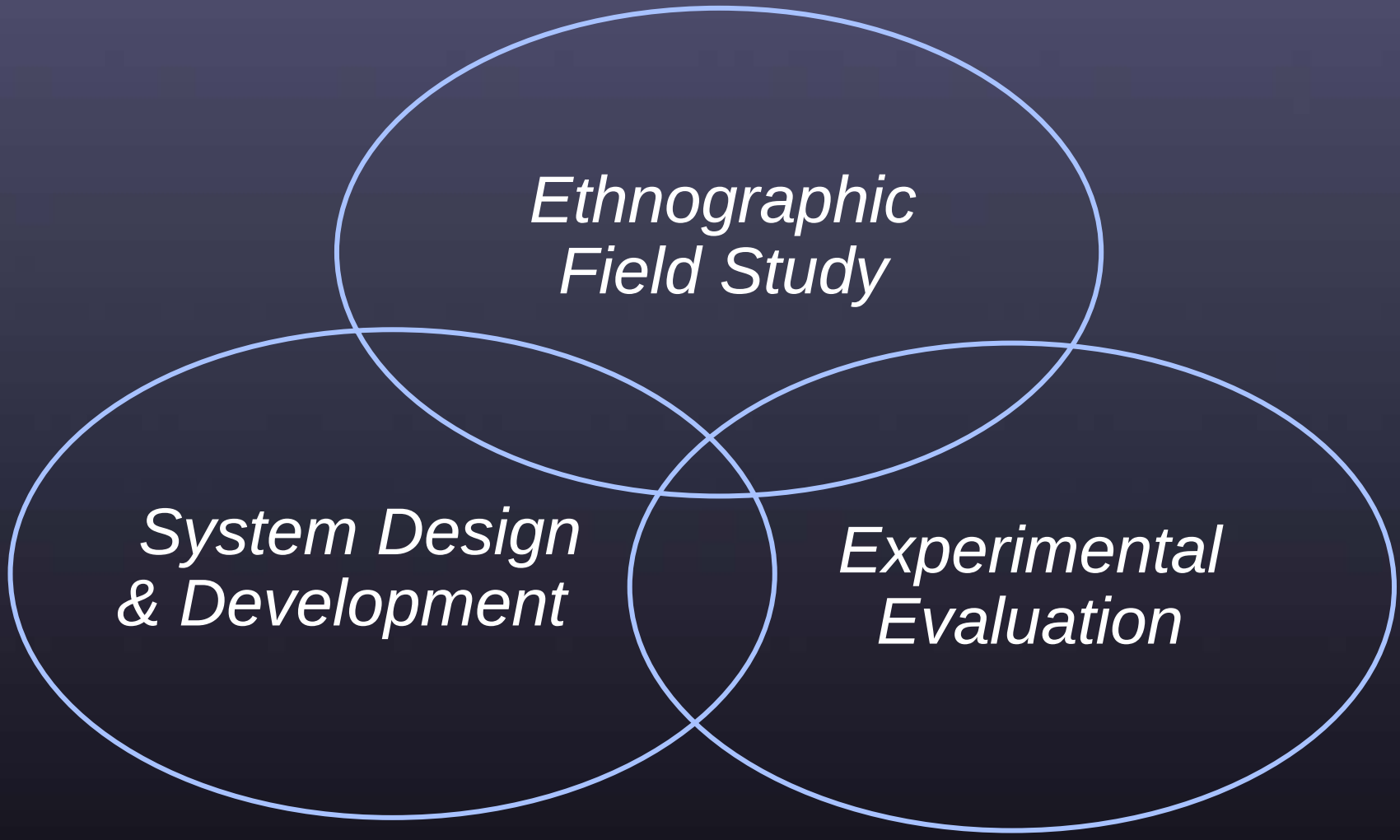
Atomic Force Microscope (AFM) Controls & Analysis Tools

Data Analysis Software

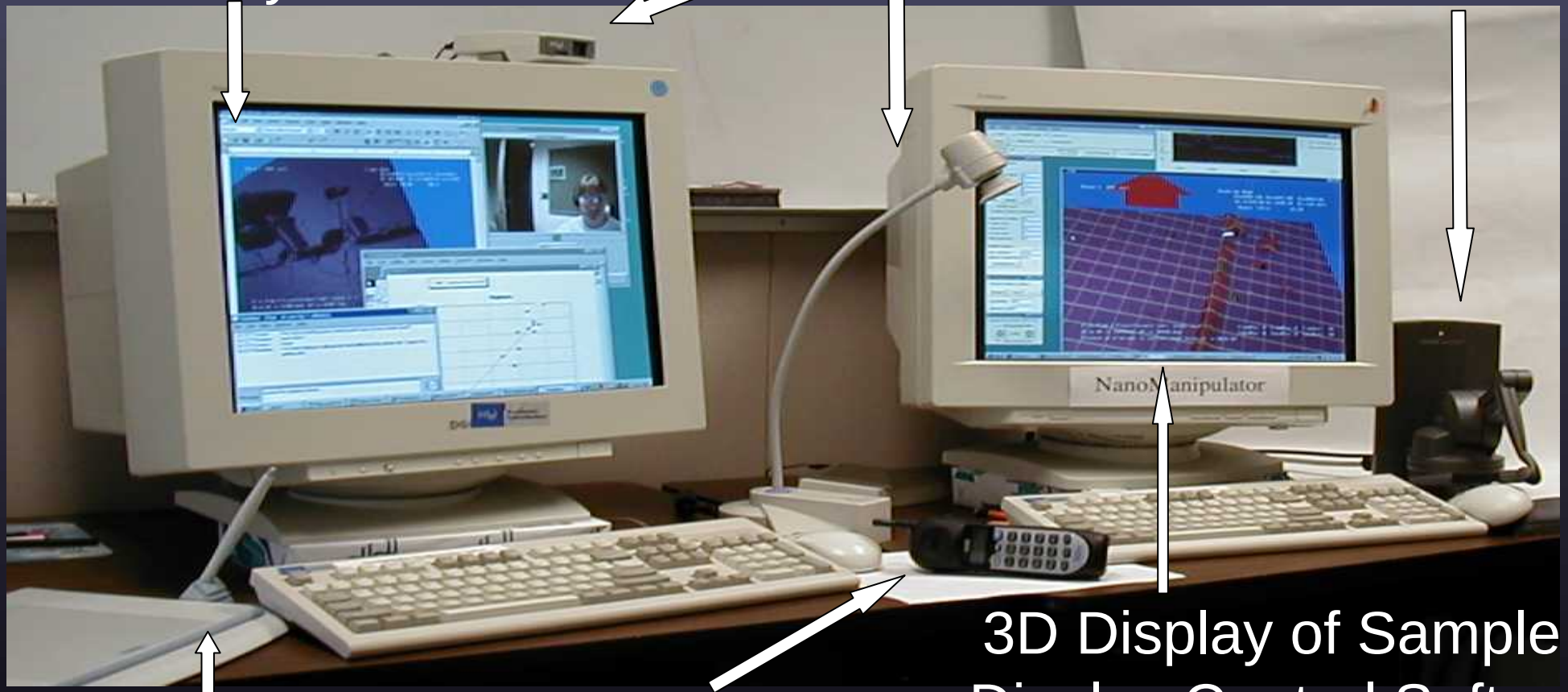
Haptic Feedback Device

Video Display from AFM Camera

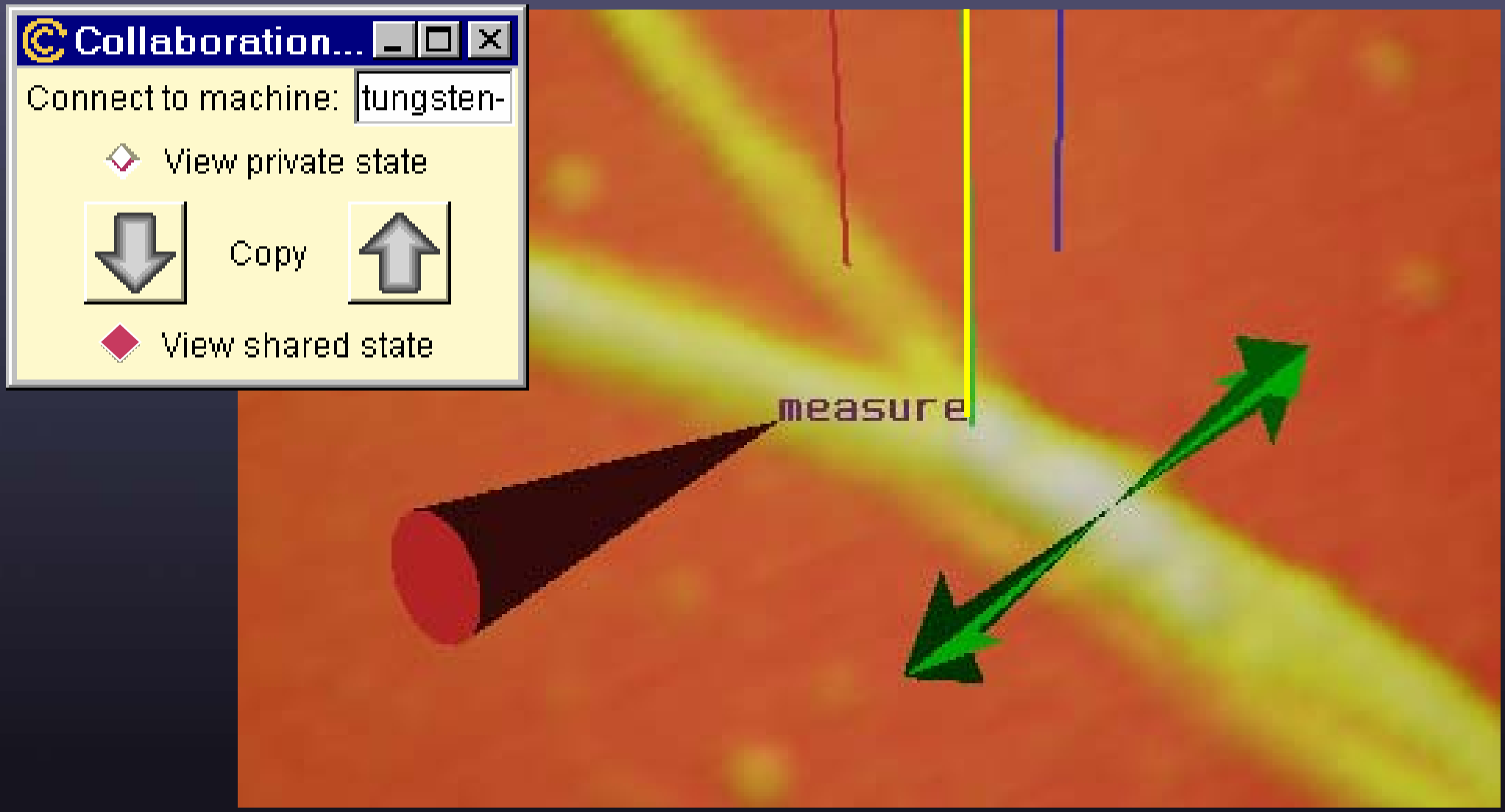
Research Approach



Collaborative nM System



Collaborative nM



Issues in Evaluation

- Need to integrate:
  - Purpose of evaluation
  - Context of scientific use and typical tasks
  - Resources available
- Additional challenges for collaboratories
  - Geographic distribution of participants
  - Rhythm of science
  - Number of participants willing & needing to use new, specialized system

Experimental Evaluation

Repeated Measures Design

FtF – Remote Collaboration	*Realistic scientific tasks*	*Multiple Measures*

Scientific task performance,
Participants' perceptions &
attitudes regarding innovation adoption

Remote < FtF

Study Participants

- 40 upper-level undergraduate science students working in pairs
- 19 males, 21 females
- Majors: 23 biology, 6 physics, 5 chemistry, 4 biochemistry, 1 biomaterial science, 1 biomedical materials
- 36 Caucasian, 2 African-American, 2 Indian
- Self-reported GPA

A+/A	**10**	**A-/B+**	**15**	**B/B-**	**13**	**C**	**2**

Experiment Format

(1) Intro to experiment, instrument & science

(2) Two lab sessions or “Research Experiences”
- Hands-on self-guided tutorial, assistance available
- Scientific research tasks using system
- Participants asked to create lab report (collect data & answer questions)
- up to 5 hours in length

	Lab -1	Lab -2
FtF	Pairs 1-10	Pairs 11-20
Remote	Pairs 11-20	Pairs 1-10

Remote Setting

Face-to-face Setting

Face Validity

Post-survey responses (1-5 scale)	**AVG**	**FtF**	**Remote**
I believe this lab is similar to work scientists do	3.66	3.77	3.55
Concentrated fully on activity	4.31	4.25	4.36
Time given to perform tasks	4.41	4.52	4.30
I was provided ample training	4.50	4.45	4.55

"Everything was like for real"

"I thought it was not too long, not too short… didn't make me feel unsure of what I was doing."

Data Collection

Introduction session

Surveys:

- Demographic data
- Technical skills
- Learning & work styles

Each “Research experience”

- Group lab report:
  Scientific task performance
- Video tape:
  Overhead view
  Side-angle view
  Both monitors
- Audio-tape
- Observer notes
- Post-survey: Innovation adoption
- Post-interview: Participants’ perceptions

Innovation Adoption: Post-questionnaire

Rogers' Attributes of Innovation Adoption (1995)

Relative advantage

Compatibility

Trialability

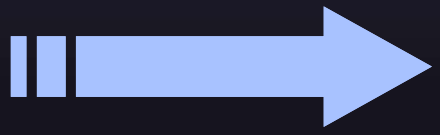
Observability

Complexity

- Validated & used in a variety of domains, including information systems (e.g., Moore & Benbasat, 1991)
- Theoretical framework helps to insure instrument validity (Anatasi, 1986)

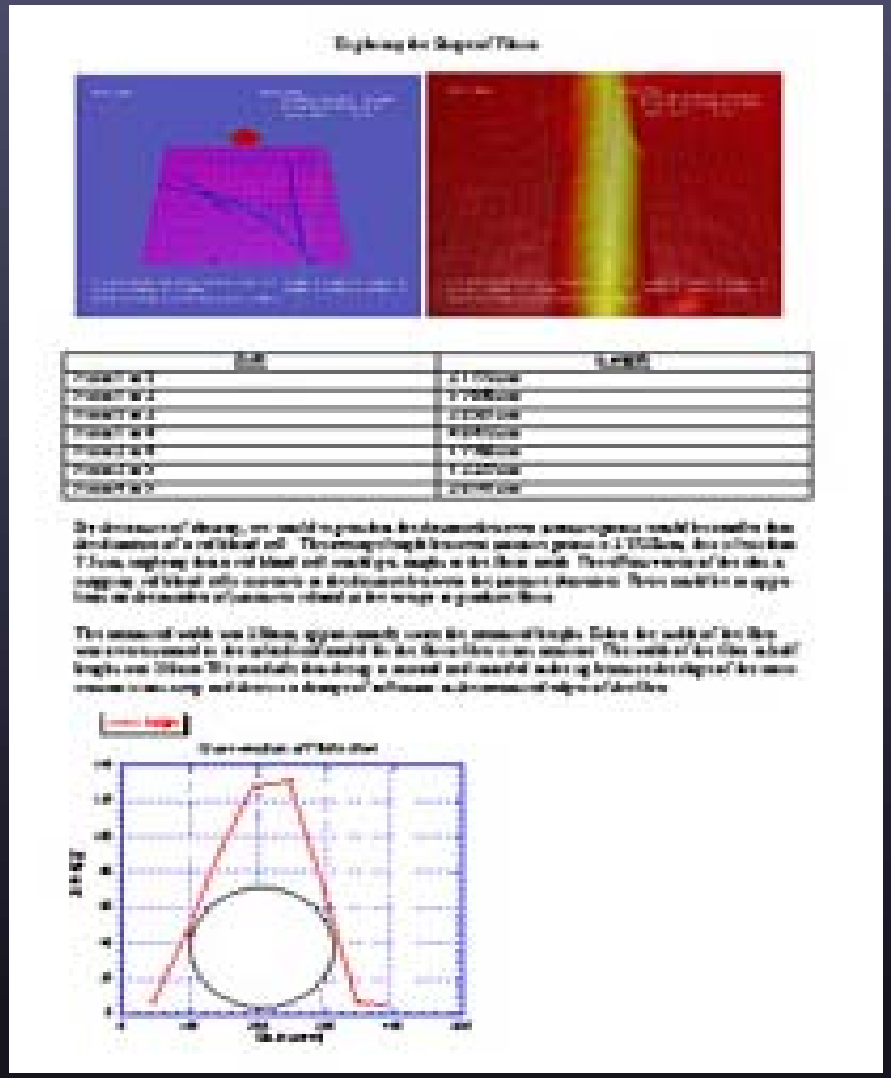
Post-Questionnaire Data Analysis

- Averages for each 5-point scale: 3.42 to 4.33
- Multivariate analysis of variance (MANOVA)
- No significant statistical difference between FtF and remote conditions for any scale
- Relative advantage significantly higher after second research experience ($p < .01$)
- Two alternative conclusions:
  - A poorly constructed instrument
  - Equally effective system for given task



Data triangulation

Performance Measure: Group Lab Reports



- Based on scientist's lab work
- Data images, data values, graphs, annotations, explanations
- Blind grading by three instructors
- Intercoder reliability

Performance Measure: Group Lab Reports

Condition	Mean Lab Scores Collaborated FtF 1st	Collaborated Remote1st
FtF	.70 (lab1)	.86 (lab2)
Remote	.75 (lab2)	.70 (lab1)

- MANOVA analysis of differences between scores
- No significant difference between FtF & Remote (df=1, F=2.670, *p*=.12)
- Collaborating remotely first yielded higher subsequent performance (df=1, F=9.66, *p*=.006)

Participants' Perceptions: Interviews

- Conducted 1-1 with each study participant after each experiment session
- 80 interviews
- Interview questions
  - Satisfying & dissatisfying aspects (Flanagan, 1954)
  - Specific incidents noted by observer
  - Work patterns
  - Technology impact on their interaction
  - Comparisons between working FtF and remotely

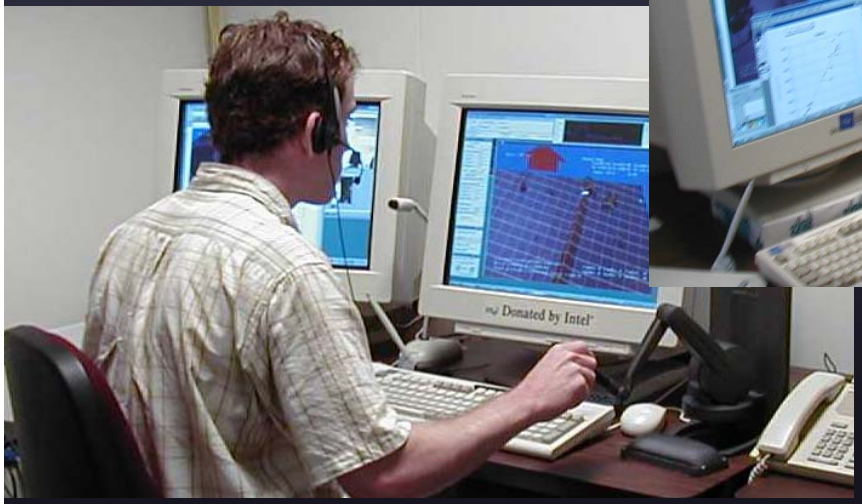
Interview Analysis

Comparing Remote to FtF

Disadvantage	**Advantage/Coping Strategy**
Interaction less personal…….	But doesn't matter for this work
Fewer cues from partner…….	Talk more frequently & descriptively
Harder to interrupt partner……. to ask questions	Easier to explore system & ideas independently
Harder to see everything……. partner is doing	Having exact same view of data visualization is better
Turn-taking in NetMeeting…… is frustrating	Can work simultaneously on data visualization

Limitations

- Students vs. postdocs & faculty as participants
- Repeated measures design vs. Solomon four-group design
- Equivalency of lab sessions assumed
- Not all scientific tasks included, e.g., experiment design
- Sample size



Discussion

- Results illustrate remote collaboration:
  - is acceptable to users
  - yields acceptable outcomes
- Hypotheses that remote < FtF not supported
- No statistically significant differences between FtF & remote lab grades
  - Participants who worked remote first, performed better in subsequent session
- Interview data provides information about advantages & coping strategies
- No statistically significant differences in attitudes towards innovation adoption between FtF & remote

Possible Theoretical Explanation

Structures of the Life World (Schutz & Luckman, 1985)

- Problematic situation

  Can't assume the physical world is the same for both of us

- Motivation to develop a shared reality (intersubjectivity)

- Individuals assume:

  (1) differences will not keep us from achieving our goals (congruence of relevance systems)

  (2) if you were with me, you would experience things the same way (interchangability of standpoints)

Acknowledgement

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For more information see:

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Sonnenwald, D.H., Maglaughlin, K.L., Whitton, M.C. (2004). Designing to support situational awareness across distances: An example from a scientific collaboratory. *Information Processing and Management, 40*(6), 989-1011.

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