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“Virtual” Lab or “Virtual Lab”: How Students Engage with Laboratory Simluations

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The Purpose of Laboratory Classes

Some analysis in the literature

- Feisel & Rosa 2005
- Scanlon et al 2002
- Antsaklis et al 1999

Many good reasons

- Why do *you* have laboratory classes?

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There are some downsides:

Expensive to run

Difficult to schedule

Safety issues

Space requirements – need a laboratory

Require physical attendance

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Alternative Modes for Laboratories

Remote Access

- Hardware can be anywhere
- Safety issues are reduced
- Don’t need room around the equipment
- Asynchronous access

Simulation Access

- No hardware at all

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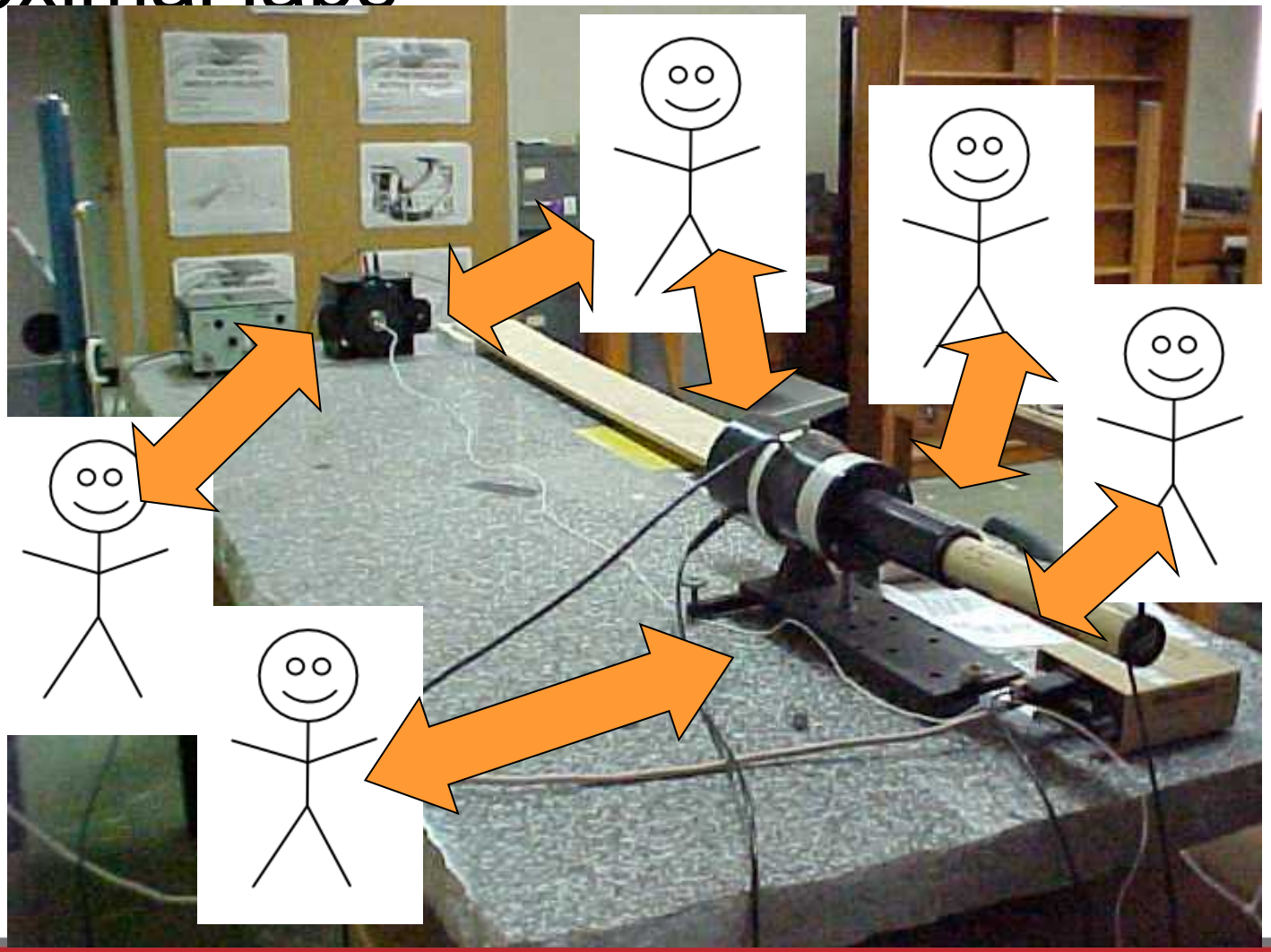
Proximal labs



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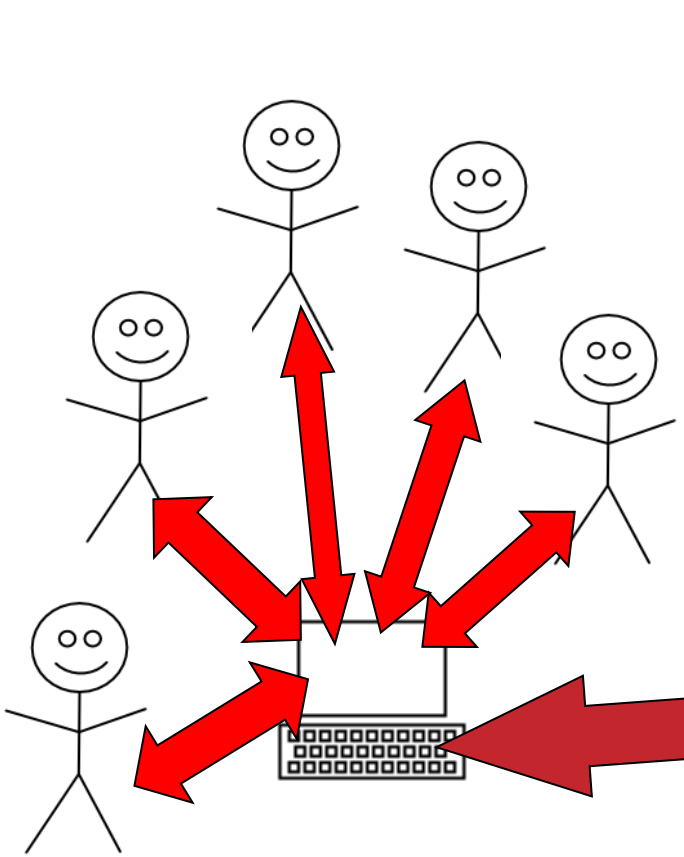
Remote Labs



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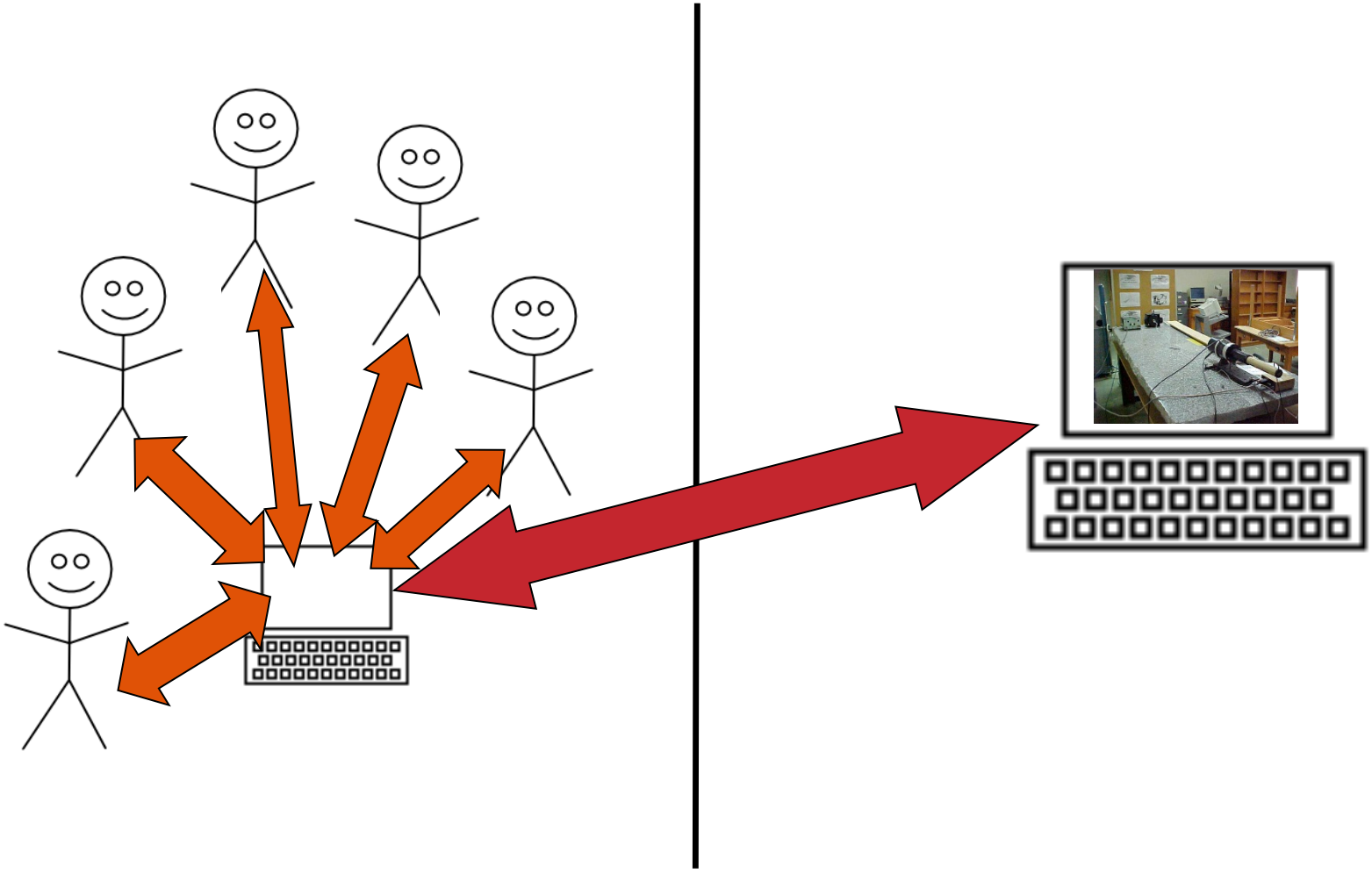
Virtual Labs



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Two Necessary Ingredients:

Separation

- Physical separation in remote labs
- Psychological separation in virtual labs

Technology-Mediated Interface

- Usually some kind of computer GUI

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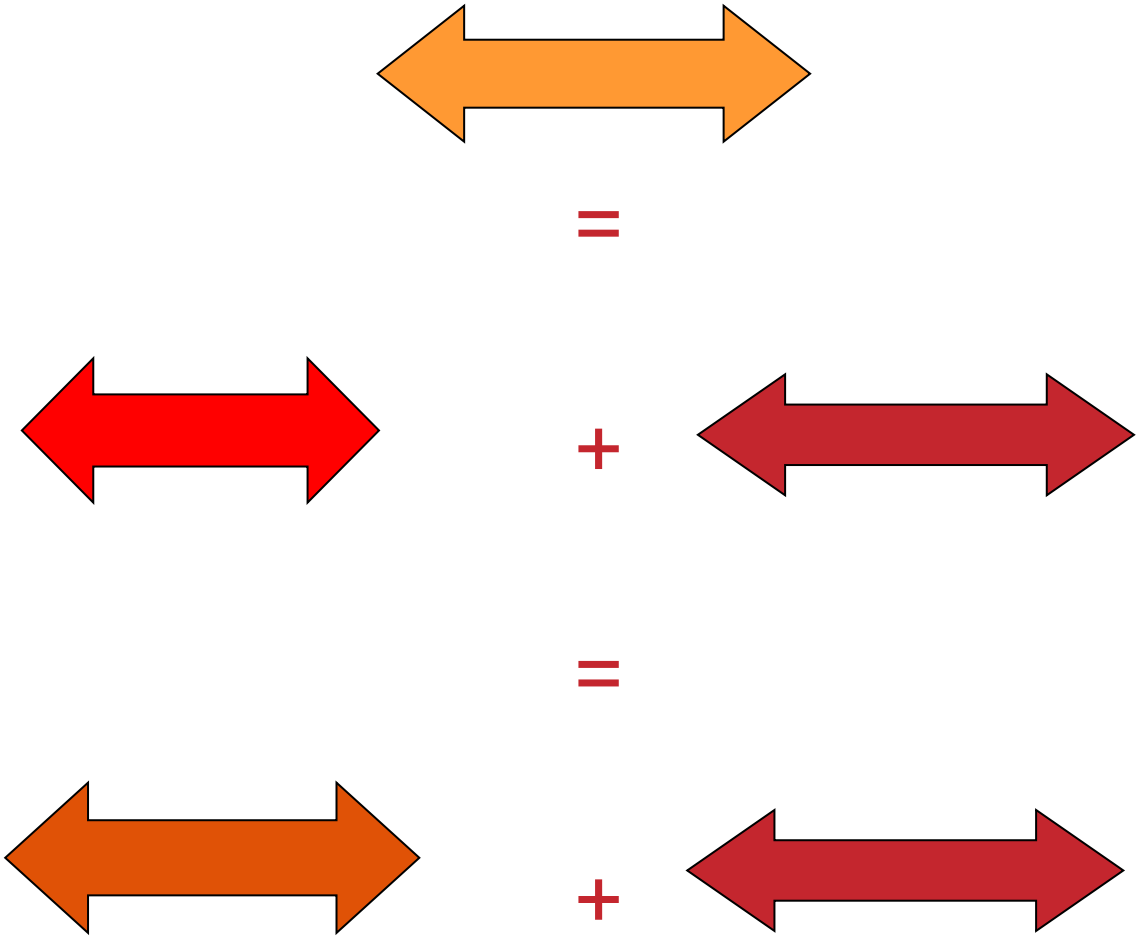
Equivalency?



Literature from elsewhere suggests perhaps no

Distance Education literature says separation causes changes

Technology in Education literature says interfaces cause changes

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Establishment Reality
vs
Maintenance Reality

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Look around and choose two people

One you already know well

One you've never met before today

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Look around and choose two people

One you know well

One you've never met before today

Write down the first question you would ask upon starting a conversation with them at lunchtime

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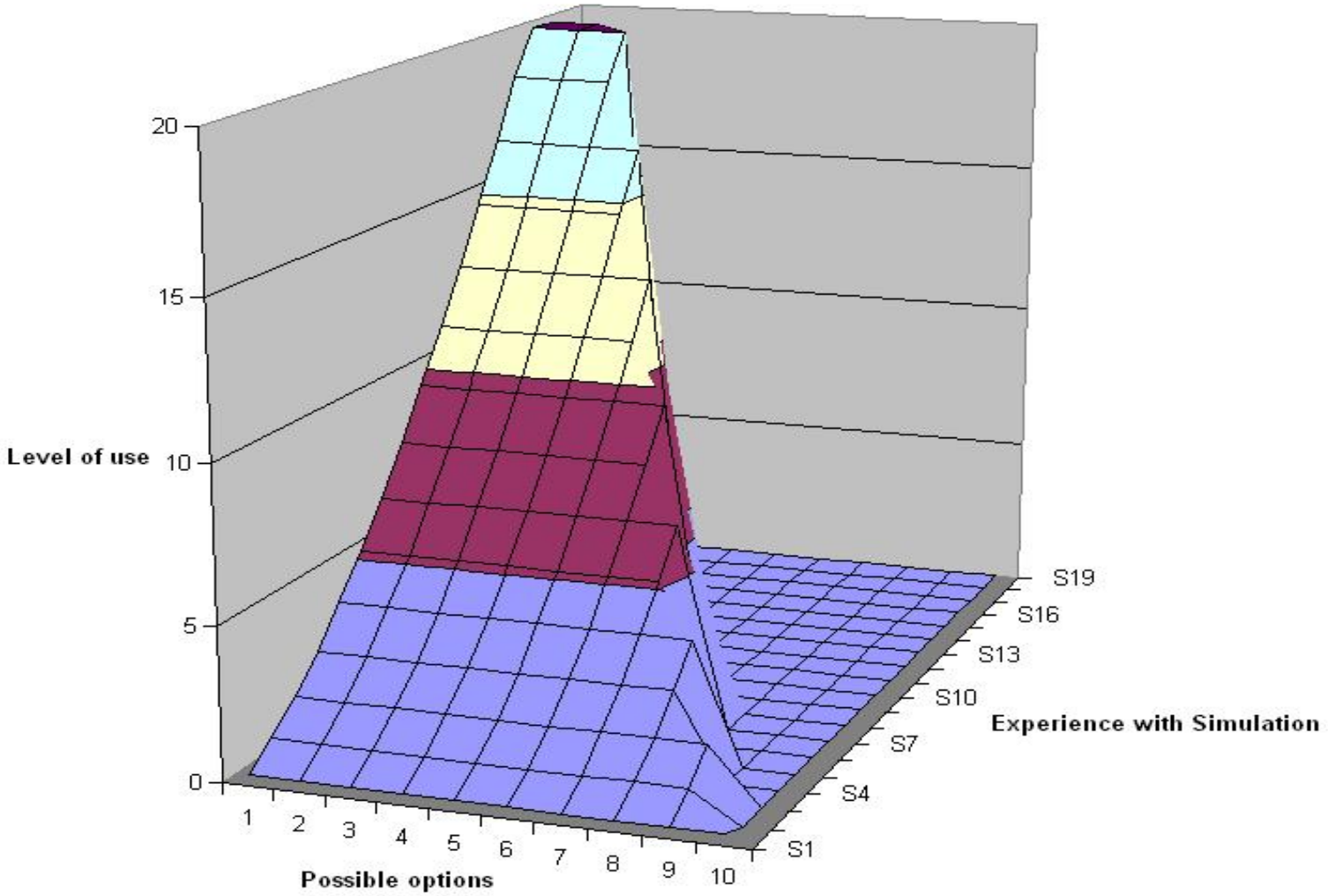
Different Reality Needs



The Three Stages of Use

Initial Use

- The first meeting

Regular Use

- Ongoing operation

Expert Use

- Everyday specialist

Different goals at each stage

Initial Use

Establishes Credibility

Is it real?

Can I transfer the learning?

What does this button do?

Regular Use

Establishes Transfer

Exploring the concepts

How do I get the outcomes I want

Adding extra depth

- The full cockpit simulator

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Expert Use

Establishes Specialisation

Possibly at the expense of Transfer

Improving efficiency

- Shortcuts / hyperkeys

Changing timescales

- Faster, slower, backwards

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Too Much Fidelity?

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Why is Fidelity Good?

Credibility

Transfer

Engagement

Credibility

What are students' options if the data doesn't match their expectations?

1. Question the data
   - Check for experimental error
2. Question the model
   - Change their understanding of the phenomema (ie **learn something**)
3. Question the credibility of the simulation
   - **"This simulation is wrong"**

Transfer

Can they use what they have learned?

Easier to use skills it if they learn them where they need them

Fidelity important for transfer

- But you can't transfer it if you don't learn it in the first place

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Engagement

Want the students to feel connected with the simulation

Competing with their Xbox

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But they engage differently: The flying pot plant

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One Specific Study (Lindsay & Good 2005)

Does the substitution of technology-mediated access for direct, unmediated access lead to differences in the learning outcomes?

How do different access modes affect learning outcomes?

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The Laboratory Class

Calibration of a Piezoelectric Accelerometer

Use of multiple control signals for calibration

Identifying (and explaining) non-idealities

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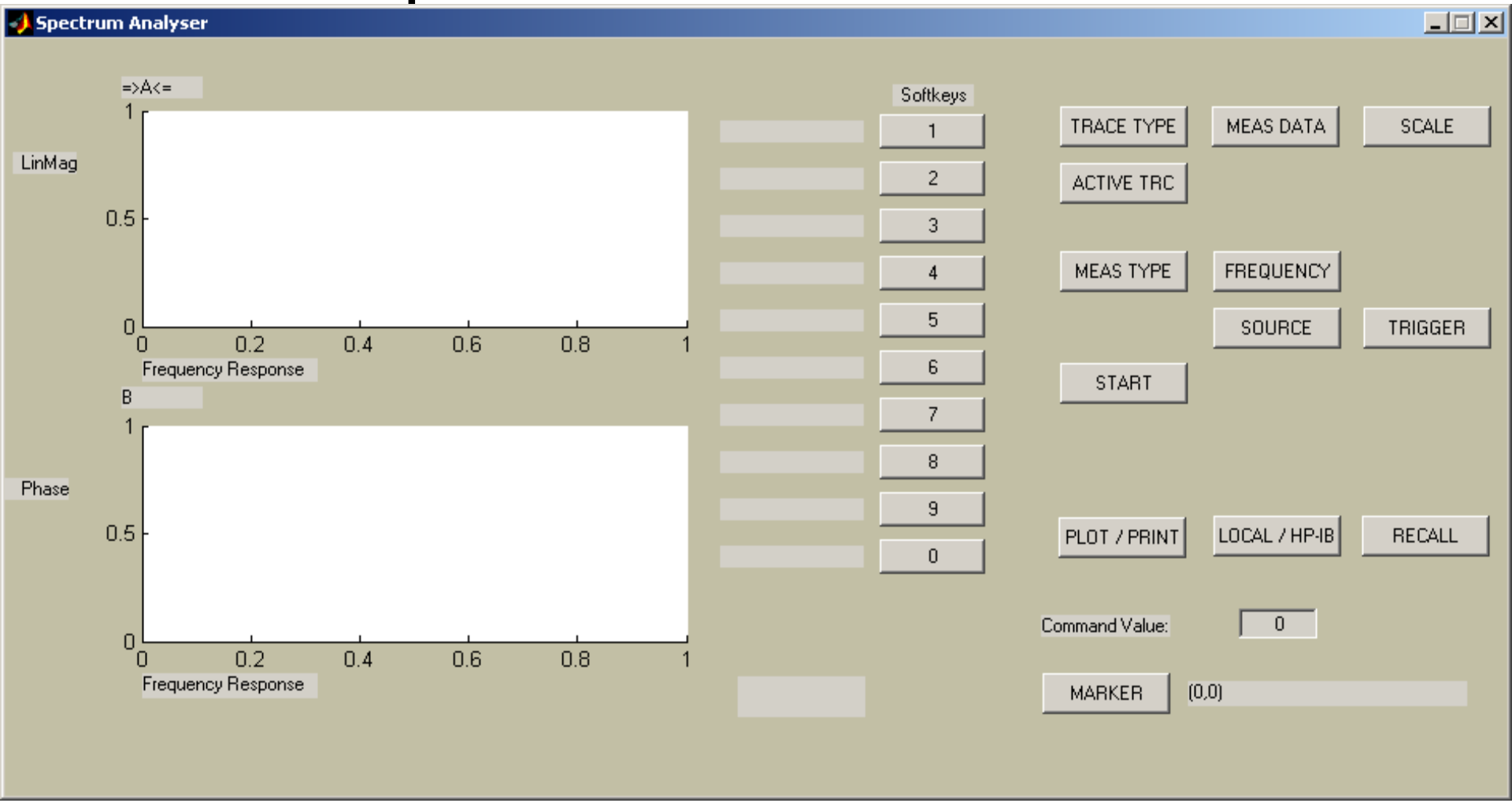
The Class (cont'd)

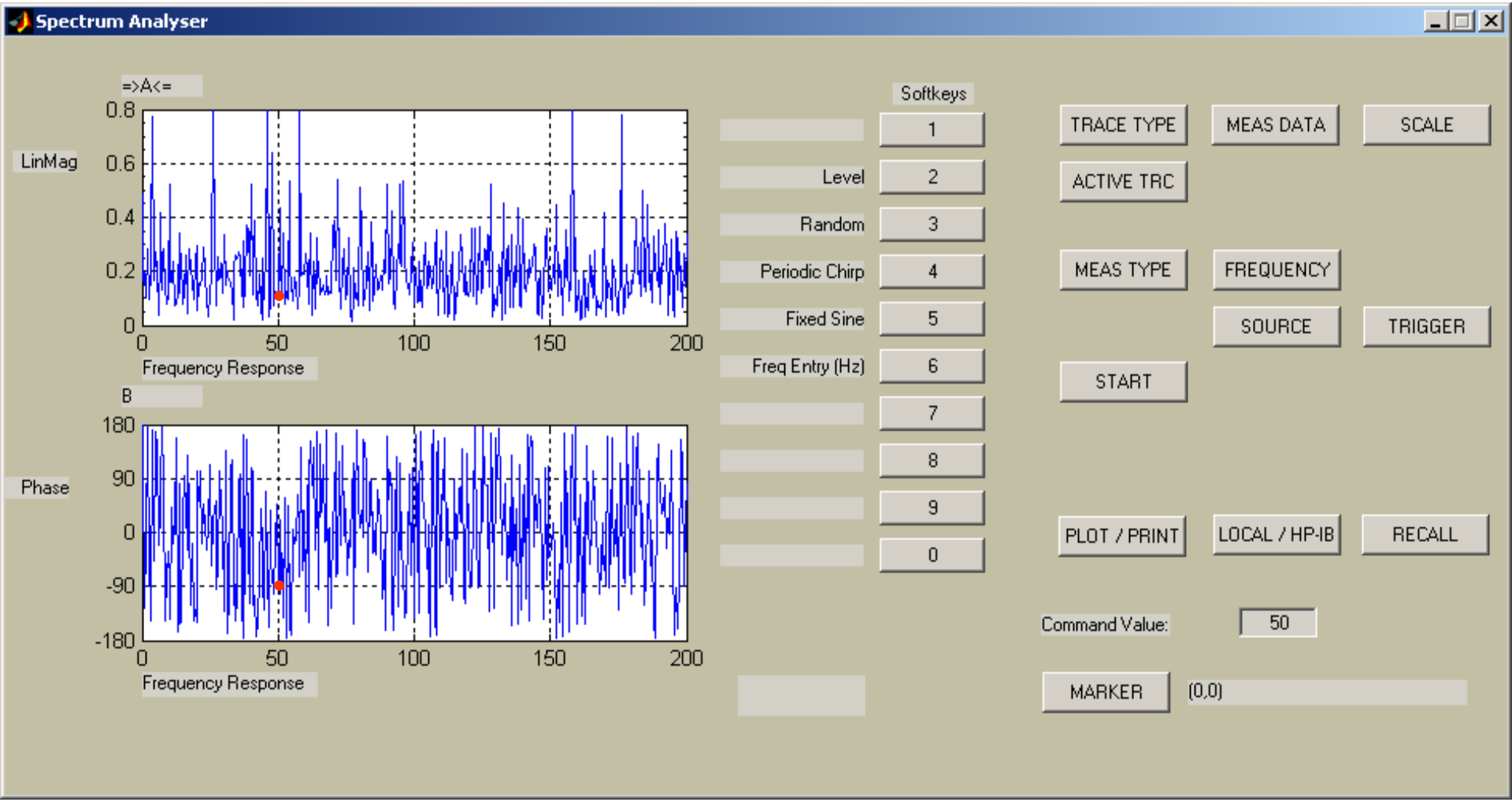
- 3rd year Data Acquisition subject
- Students' 3rd semester of control studies
- Cohorts of 120 and 146 split into three groups – Proximal, Remote and Simulation access modes

$H(\omega) = \frac{V_{ACCELEROMETER}}{V_{LASER\ DOPPLER}} = B\omega \cdot \angle -90°$

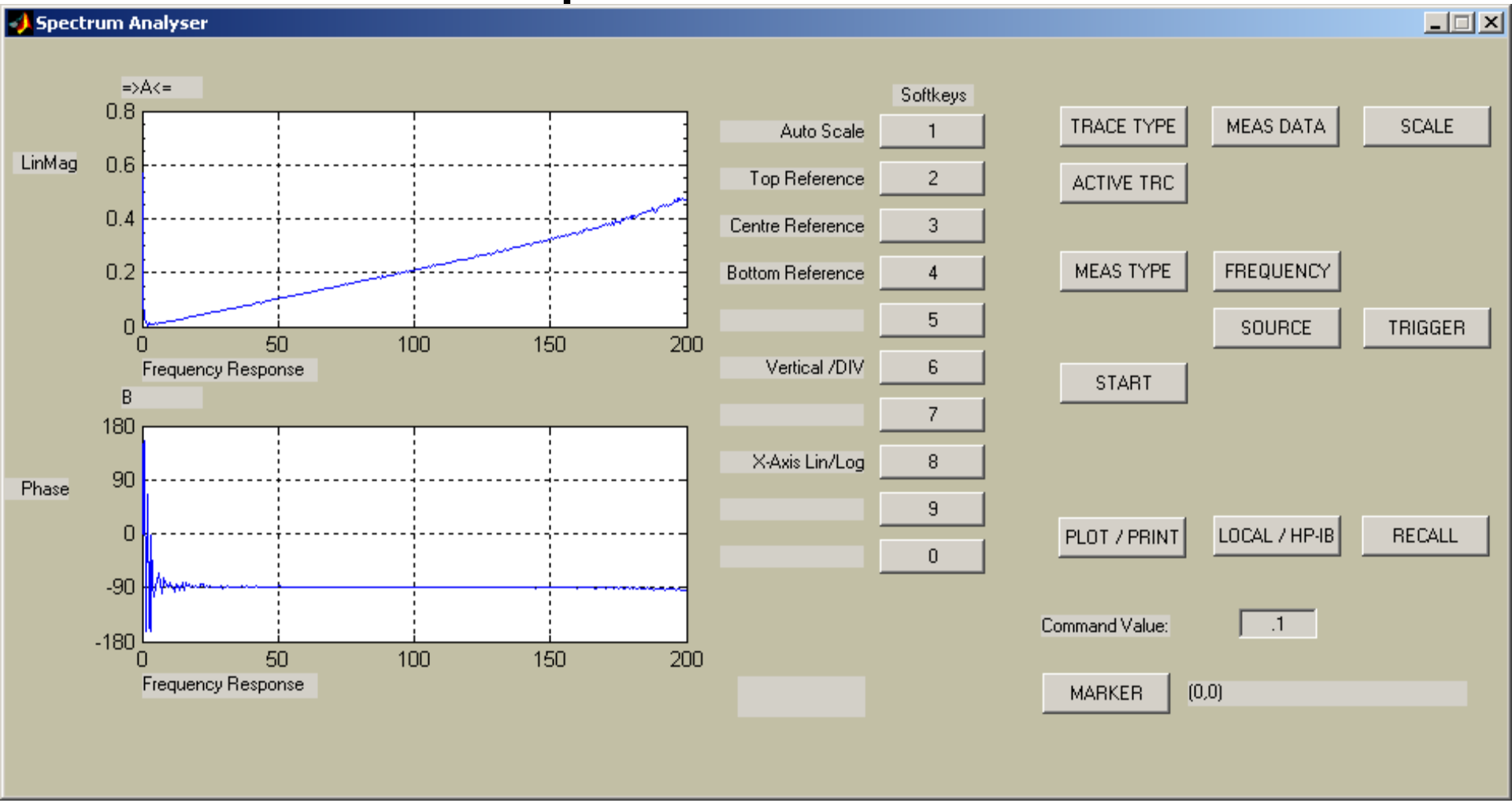
The Computer Interface



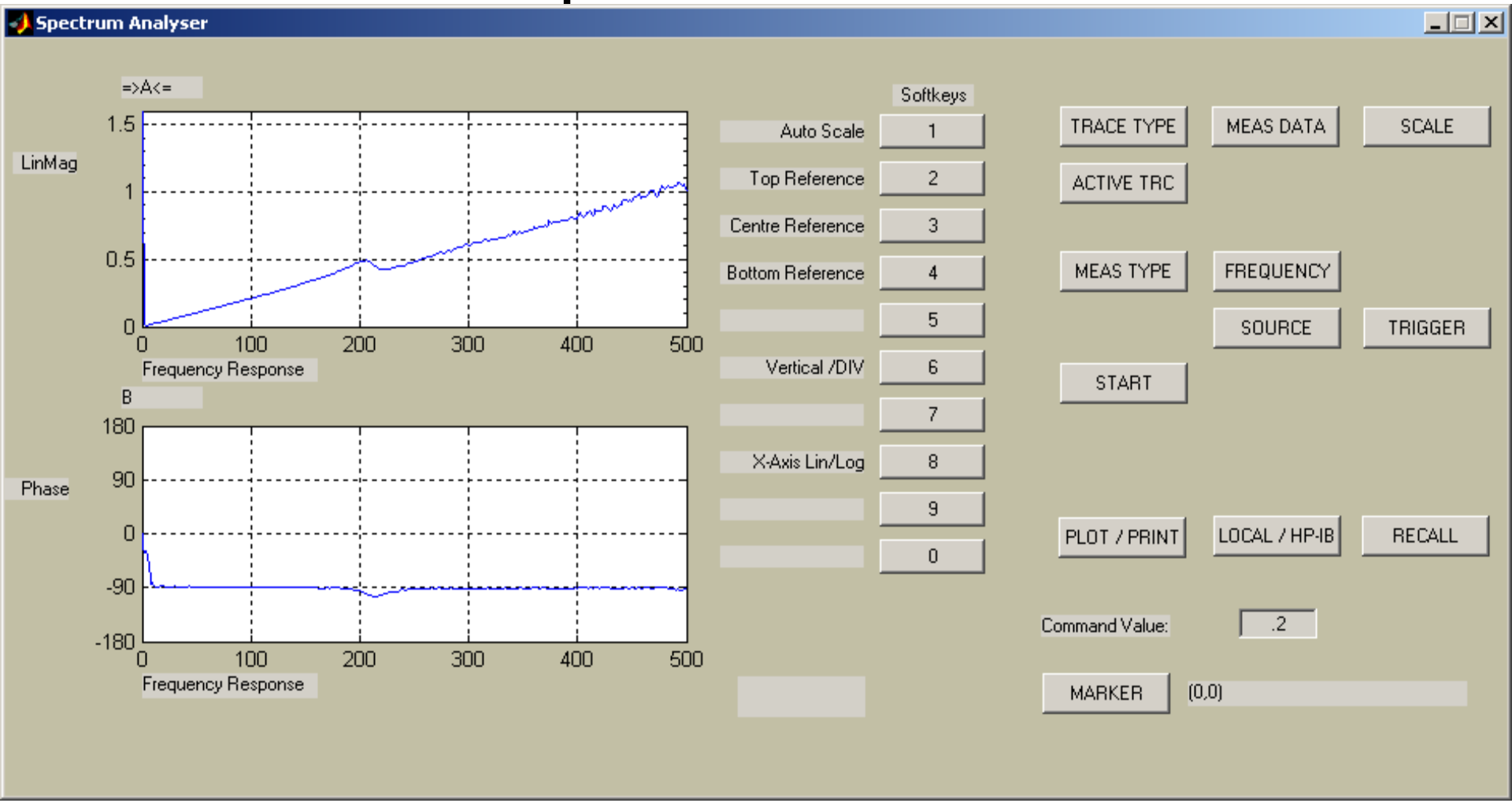
Frequency response measurement: 50 Hz Sine wave



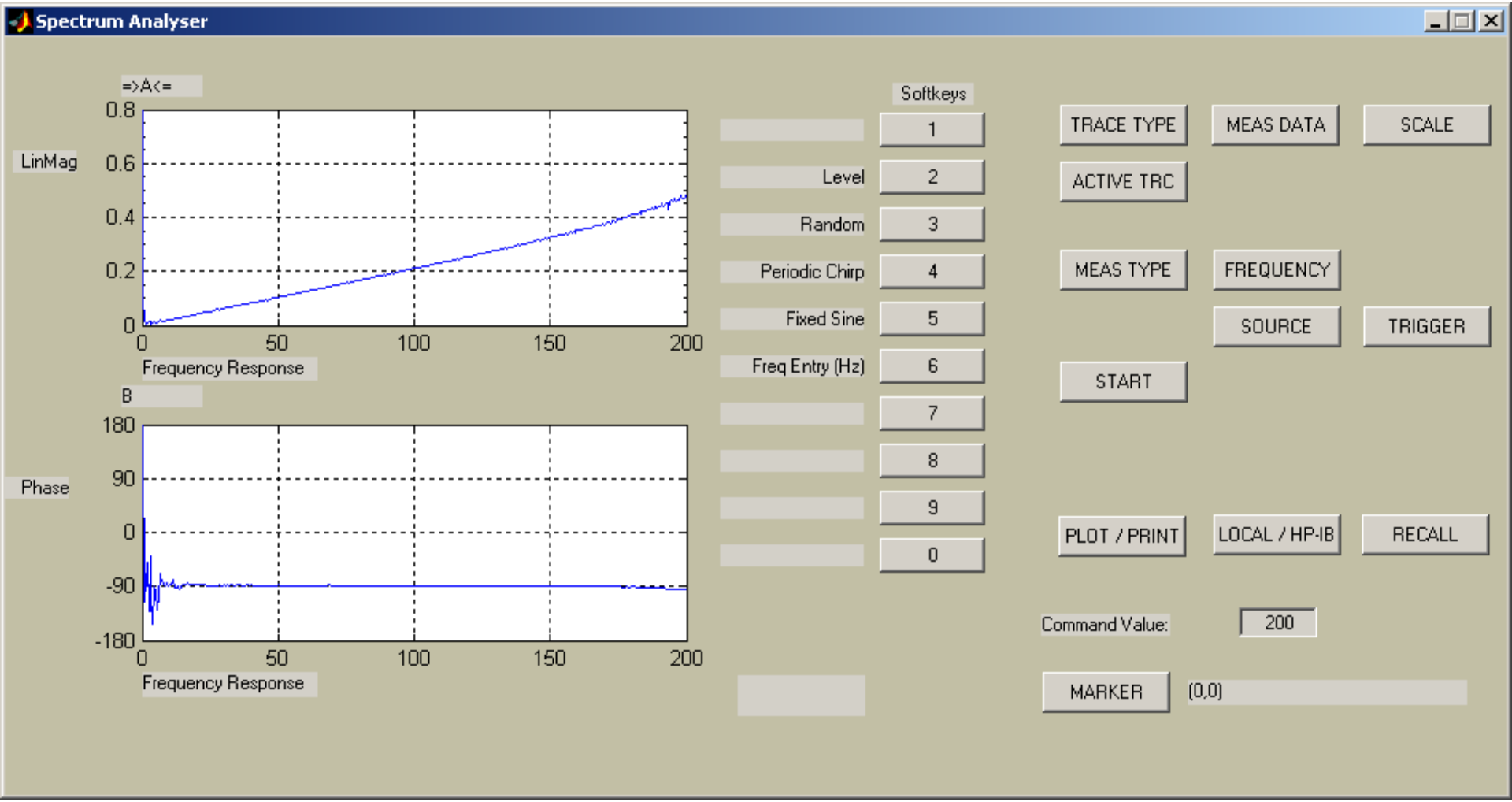
0-200 Hz Chirp



0-500 Hz Chirp



White Noise


Spectrum Analyser
=>A<=
LinMag
0.8
0.6
0.4
0.2
0
0
50
100
150
200
Frequency Response
B
Phase
180
90
0
-90
-180
0
50
100
150
200
Frequency Response
Softkeys
1
Level
2
Random
3
Periodic Chirp
4
Fixed Sine
5
Freq Entry (Hz)
6
7
8
9
0
TRACE TYPE
MEAS DATA
SCALE
ACTIVE TRC
MEAS TYPE
FREQUENCY
SOURCE
TRIGGER
START
PLOT / PRINT
LOCAL / HP-IB
RECALL
Command Value:
200
MARKER
(0,0)

The Findings

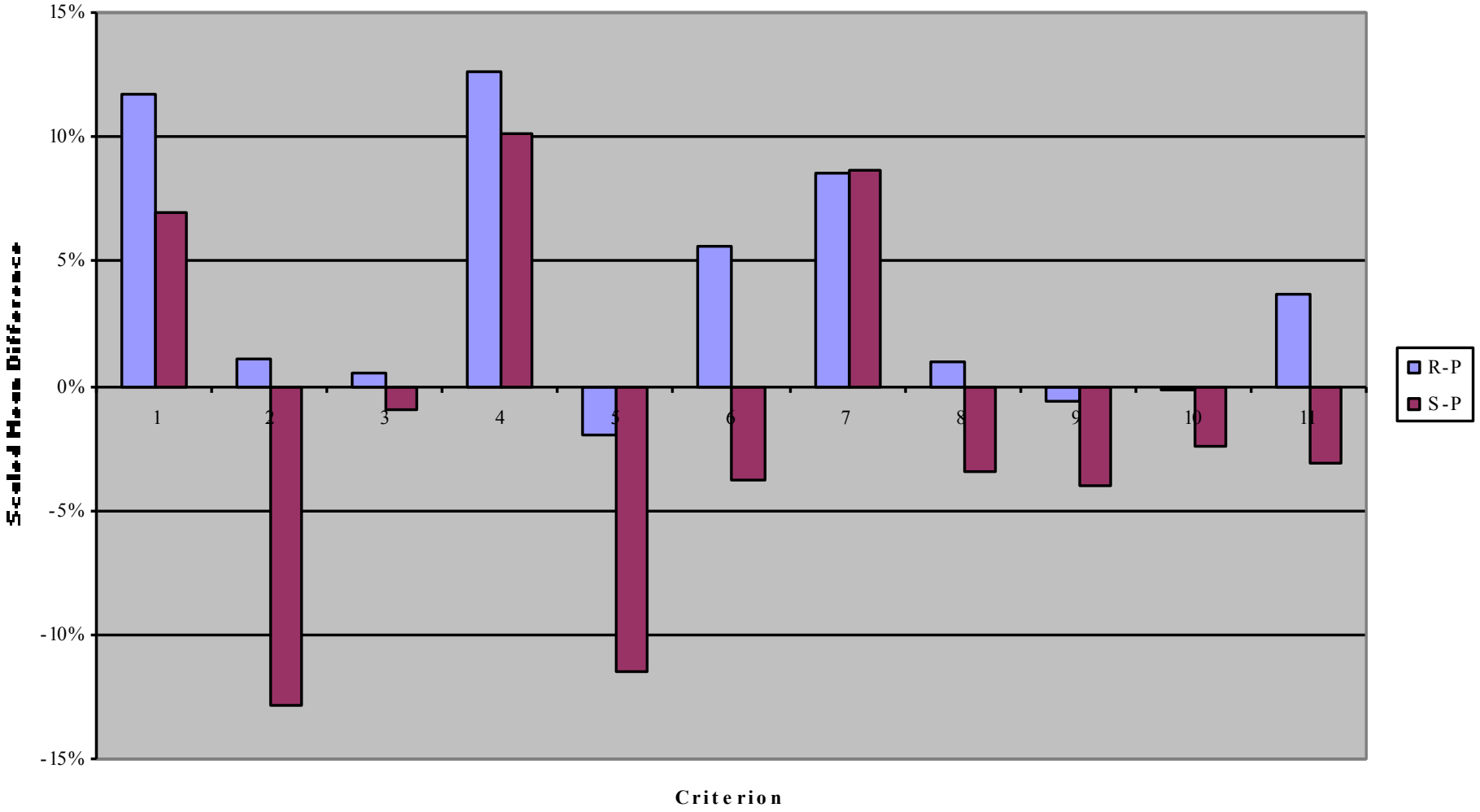
Not equivalent at all

Differences in perceptions of objectives

No differences in perceptions of outcomes

Differences in performance on criteria

Differences in Learning



Criterion Four: Deviation from the 'ideal' H(ω) vs ω straight line response.

The actual response of the system will deviate from the 'ideal' straight line response assumed in the laboratory handout.

I) The student identifies that the response deviates from the 'ideal' straight line.

II) The student observes that the gradient of the line changes with frequency.

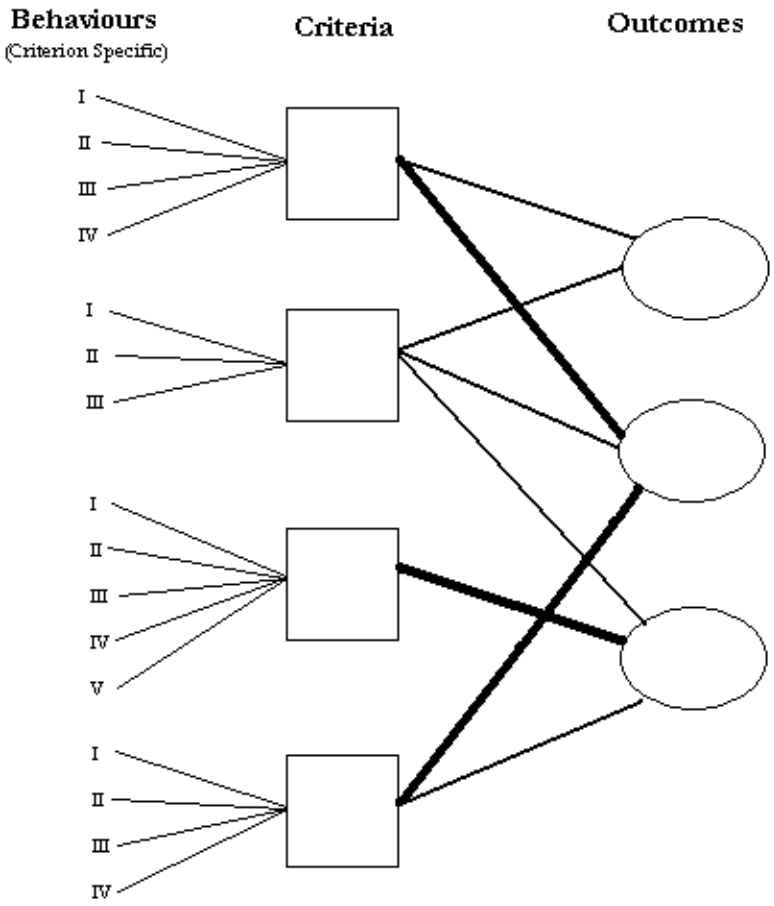
III) The student observes that response contains oscillation around the ideal straight line response.

IV) The student observes that the response does not have a zero magnitude at ω = 0

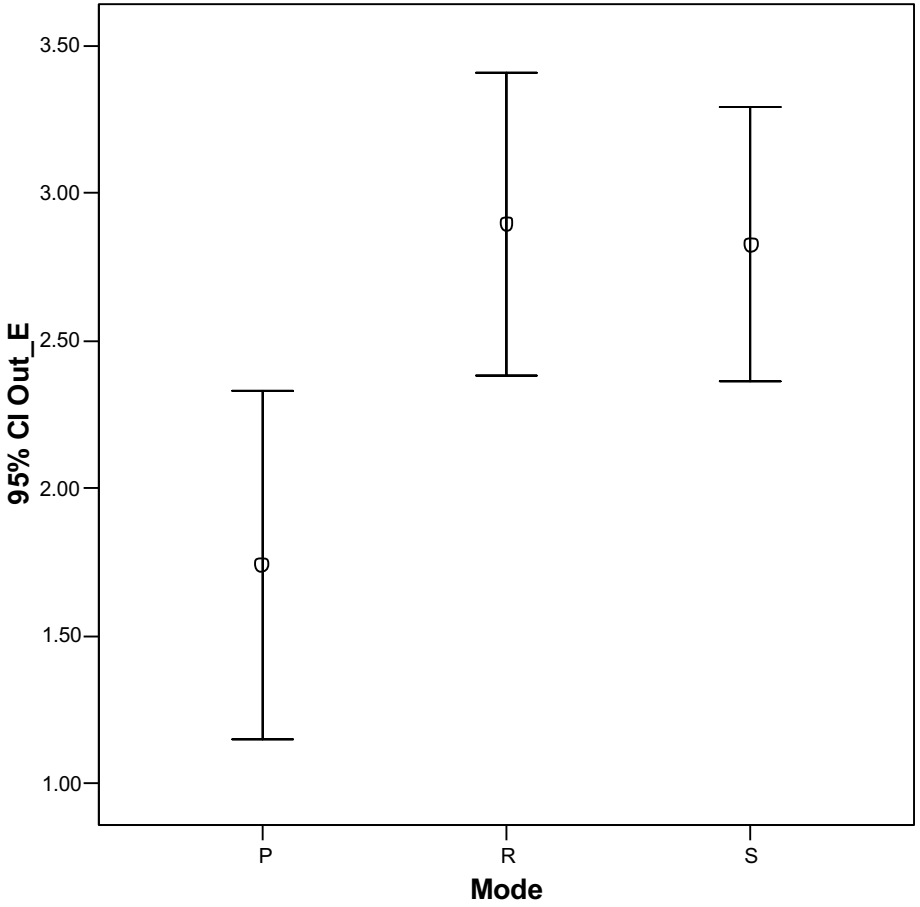
V) The student provides explanations to explain this deviation.

VI) The student identifies that this deviation compromises the calibration of the accelerometer as a sensor.

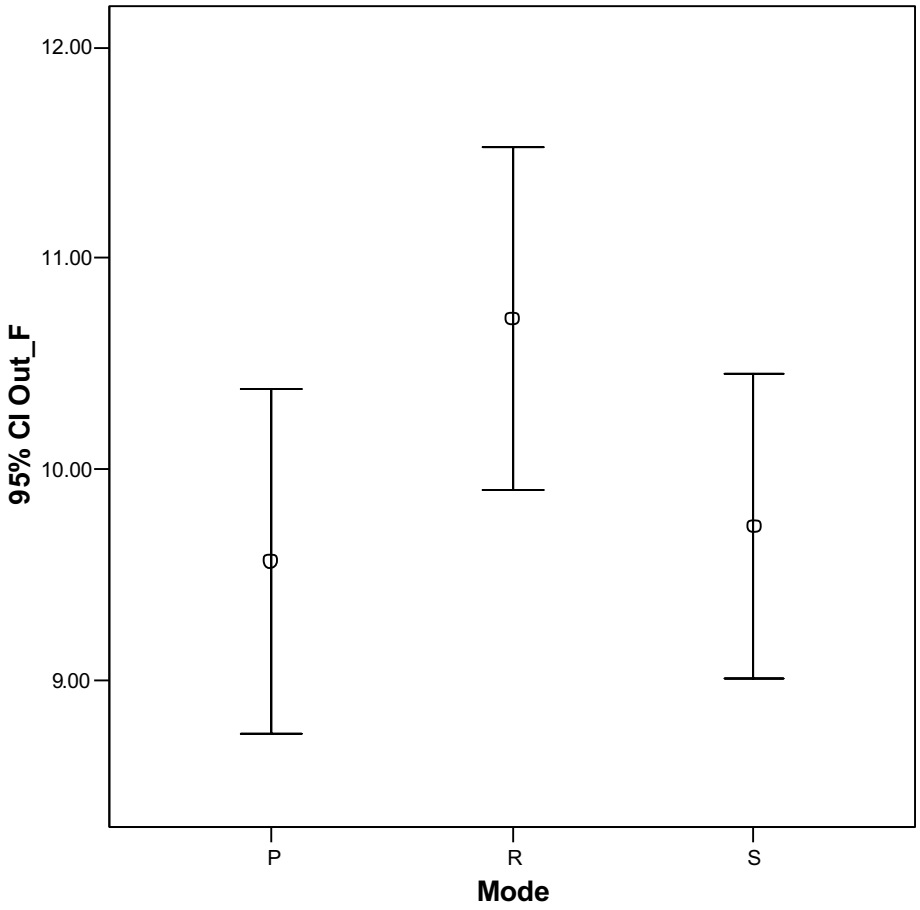
Criteria -> Outcomes



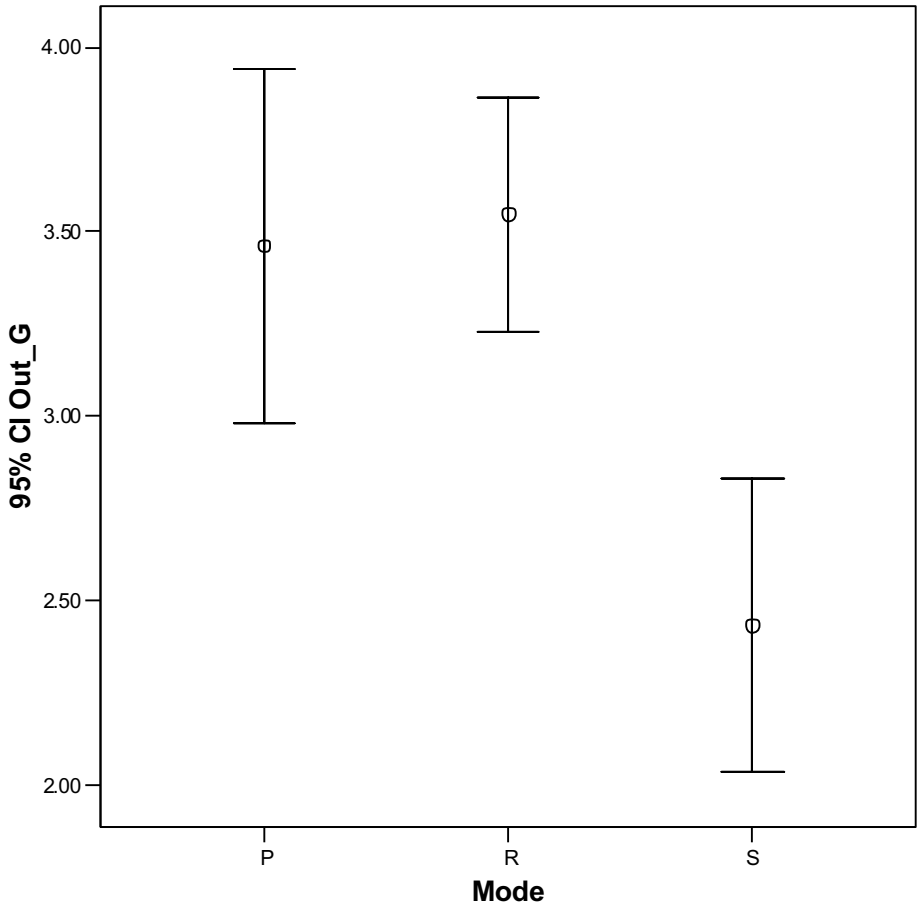
Outcome E: Exception Handling



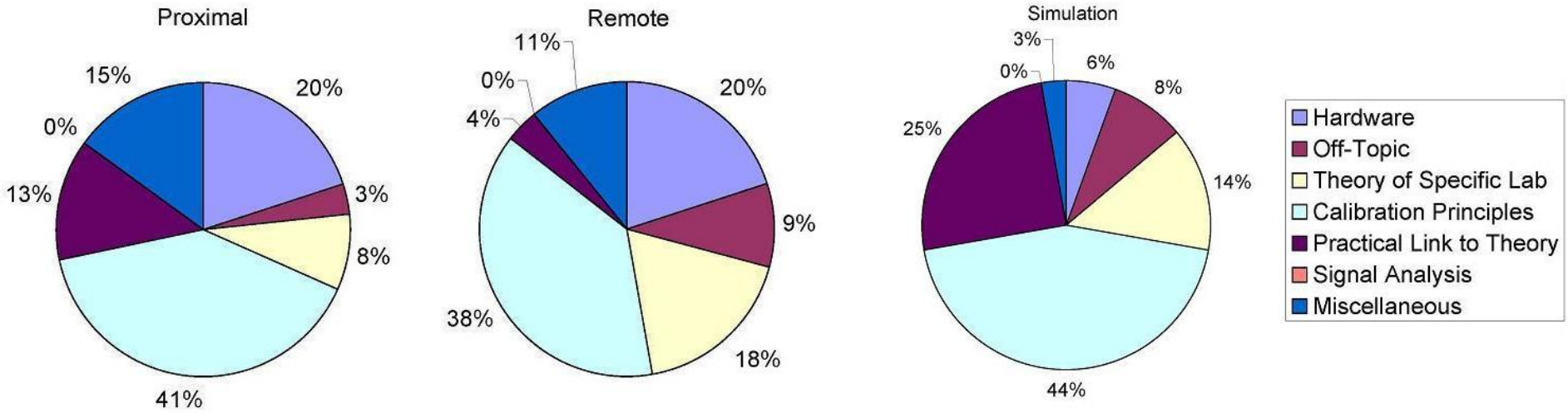
Outcome F: Processing of Data



Outcome G: Limitations of Accuracy

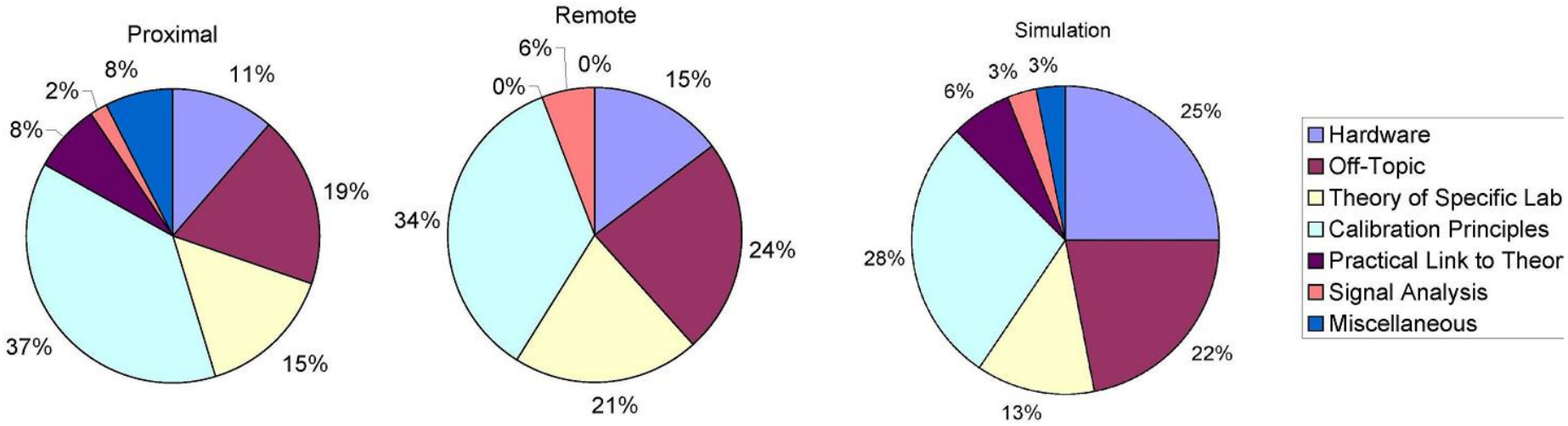


Perceptions of Objectives



Category	Higher Mode	Lower Mode	P Value
Hardware	Proximal (20%)	Simulation (6%)	< .05
Hardware	Remote (20%)	Simulation (6%)	< .05
Practical Link to Theory	Proximal (13%)	Remote (4%)	< .05
Practical Link to Theory	Simulation (25%)	Remote (4%)	< .01
Miscellaneous	Proximal (15%)	Simulation (3%)	< .05

Perceptions of Outcomes



Mostly the same

No significant differences

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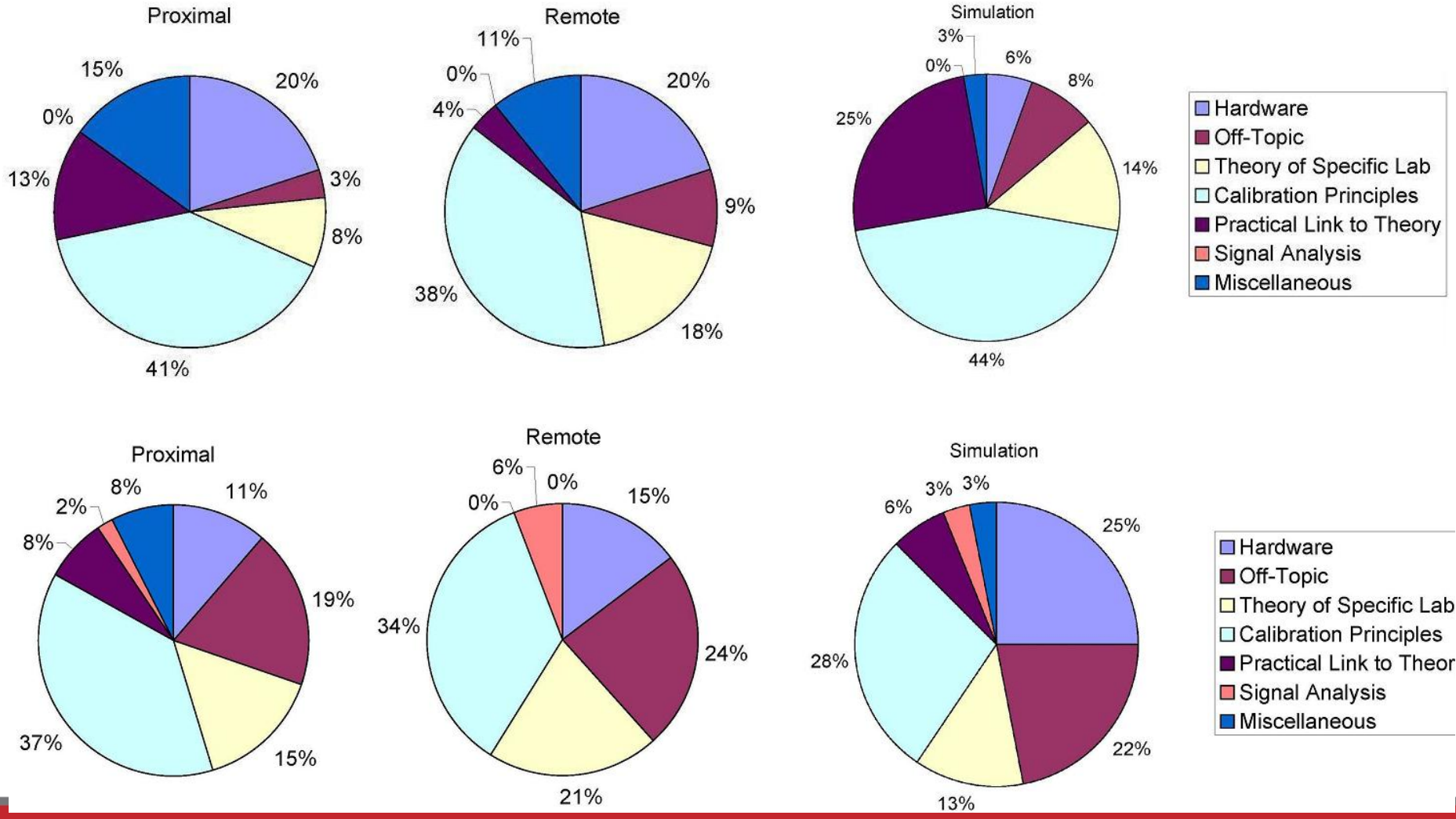
Objectives vs Outcomes



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What is happening?

Interaction between separation and interface

Richer interface potentially reduces the distance

Significant differences between remote and simulation outcomes

- Despite the same interface
- Students' attitudes and beliefs must have an impact

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Simulation mode

Distance is set solely by the separation

- The hardware isn't real, so the way in which they interact doesn't matter

Separation promotes abstraction

- Lose sight of the context that is being simulated, and the real hardware that is being modelled

Promotes understanding of theory

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So What Does It All Mean?

Different access modes lead to significantly different learning outcomes, and to different perceptions of their learning outcomes

- Even through the same interface

Remote mode distance is dependent upon interface

Simulation mode distance is due to perceptions of artificiality

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A Different Kind of Different

The different access modes are significantly different learning experiences, and the students construct significantly different outcomes – outcomes that will be the prior knowledge for their future learning.

The modes are not simply interchangeable

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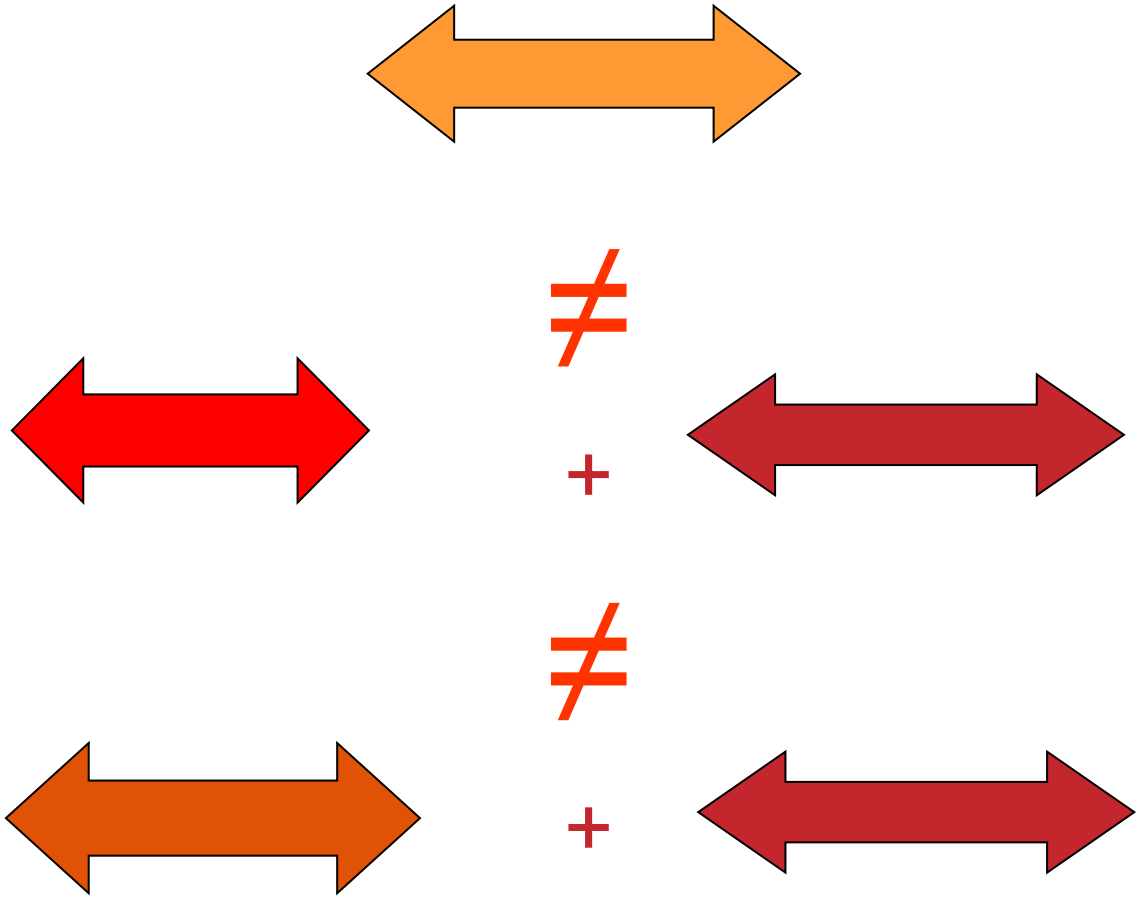
Not Equivalent



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