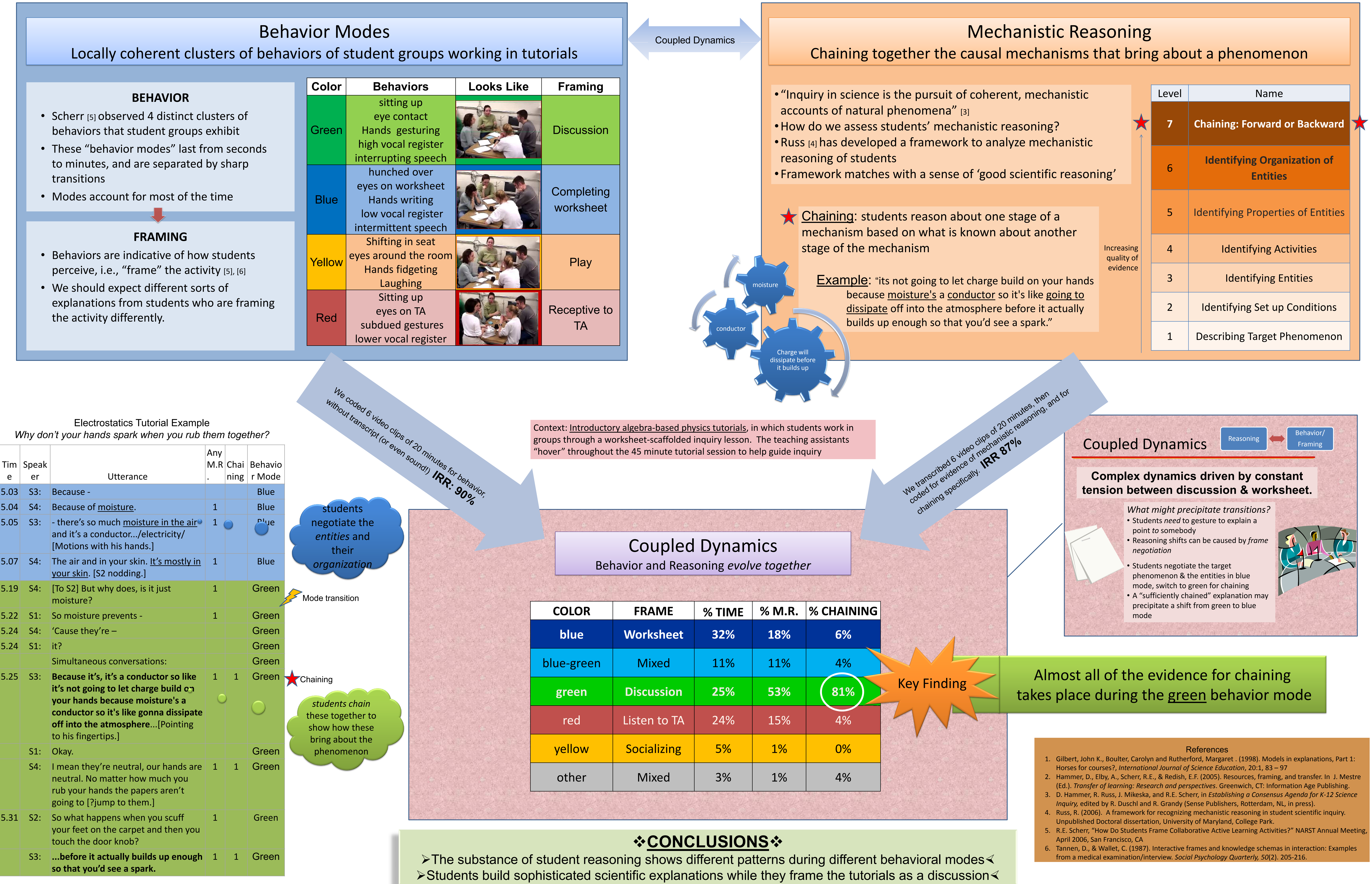# Students' Behavior and Reasoning During Physics Tutorials

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## How do student behaviors and reasoning influence each other during tutorials?

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## Behavior Modes
### Locally coherent clusters of behaviors of student groups working in tutorials

*Coupled Dynamics*

**BEHAVIOR**
- Scherr [5] observed 4 distinct clusters of behaviors that student groups exhibit
- These "behavior modes" last from seconds to minutes, and are separated by sharp transitions
- Modes account for most of the time

**FRAMING**
- Behaviors are indicative of how students perceive, i.e., "frame" the activity [5], [6]
- We should expect different sorts of explanations from students who are framing the activity differently.

| Color | Behaviors | Looks Like | Framing |
|---|---|---|---|
| Green | sitting up / eye contact / Hands gesturing / high vocal register / interrupting speech | | Discussion |
| Blue | hunched over / eyes on worksheet / Hands writing / low vocal register / intermittent speech | | Completing worksheet |
| Yellow | Shifting in seat / eyes around the room / Hands fidgeting / Laughing | | Play |
| Red | Sitting up / eyes on TA / subdued gestures / lower vocal register | | Receptive to TA |

## Mechanistic Reasoning
### Chaining together the causal mechanisms that bring about a phenomenon

- "Inquiry in science is the pursuit of coherent, mechanistic accounts of natural phenomena" [3]
- How do we assess students' mechanistic reasoning?
- Russ [4] has developed a framework to analyze mechanistic reasoning of students
- Framework matches with a sense of 'good scientific reasoning'

★ **Chaining**: students reason about one stage of a mechanism based on what is known about another stage of the mechanism

**Example**: "its not going to let charge build on your hands because moisture's a conductor so it's like going to dissipate off into the atmosphere before it actually builds up enough so that you'd see a spark."

Increasing quality of evidence

| Level | Name |
|---|---|
| 7 | **Chaining: Forward or Backward** ★ |
| 6 | **Identifying Organization of Entities** |
| 5 | Identifying Properties of Entities |
| 4 | Identifying Activities |
| 3 | Identifying Entities |
| 2 | Identifying Set up Conditions |
| 1 | Describing Target Phenomenon |

moisture / conductor / Charge will dissipate before it builds up

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### Electrostatics Tutorial Example
*Why don't your hands spark when you rub them together?*

| Time | Speaker | Utterance | Any M.R. | Chaining | Behavior Mode |
|---|---|---|---|---|---|
| 5.03 | S3 | Because - | | | Blue |
| 5.04 | S4 | Because of moisture. | 1 | | Blue |
| 5.05 | S3 | - there's so much moisture in the air and it's a conductor.../electricity/ [Motions with his hands.] | 1 | | Blue |
| 5.07 | S4 | The air and in your skin. It's mostly in your skin. [S2 nodding.] | 1 | | Blue |
| 5.19 | S4 | [To S2] But why does, is it just moisture? | 1 | | Green |
| 5.22 | S1 | So moisture prevents - | 1 | | Green |
| 5.24 | S4 | 'Cause they're – | | | Green |
| 5.24 | S1 | it? | | | Green |
| | | Simultaneous conversations: | | | Green |
| 5.25 | S3 | **Because it's, it's a conductor so like it's not going to let charge build up your hands because moisture's a conductor so it's like gonna dissipate off into the atmosphere...[Pointing to his fingertips.]** | 1 | 1 | Green |
| | S1 | Okay. | | | Green |
| | S4 | I mean they're neutral, our hands are neutral. No matter how much you rub your hands the papers aren't going to [?jump to them.] | 1 | 1 | Green |
| 5.31 | S2 | So what happens when you scuff your feet on the carpet and then you touch the door knob? | | | Green |
| | S3 | **...before it actually builds up enough so that you'd see a spark.** | 1 | 1 | Green |

⚡ Mode transition
★ Chaining

*students negotiate the entities and their organization*

*students chain these together to show how these bring about the phenomenon*

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We coded 6 video clips of 20 minutes for behavior, without transcript (or even sound!) **IRR. 90%**

We transcribed 6 video clips of 20 minutes, then coded for evidence of mechanistic reasoning, and for chaining specifically. **IRR 87%**

**Context:** Introductory algebra-based physics tutorials, in which students work in groups through a worksheet-scaffolded inquiry lesson. The teaching assistants "hover" throughout the 45 minute tutorial session to help guide inquiry

## Coupled Dynamics
### Behavior and Reasoning *evolve together*

| COLOR | FRAME | % TIME | % M.R. | % CHAINING |
|---|---|---|---|---|
| blue | Worksheet | 32% | 18% | 6% |
| blue-green | Mixed | 11% | 11% | 4% |
| green | Discussion | 25% | 53% | **81%** |
| red | Listen to TA | 24% | 15% | 4% |
| yellow | Socializing | 5% | 1% | 0% |
| other | Mixed | 3% | 1% | 4% |

**Key Finding**

Almost all of the evidence for chaining takes place during the green behavior mode

## Coupled Dynamics

Reasoning ⇄ Behavior/Framing

**Complex dynamics driven by constant tension between discussion & worksheet.**

*What might precipitate transitions?*
- Students *need* to gesture to explain a point *to* somebody
- Reasoning shifts can be caused by *frame negotiation*
- Students negotiate the target phenomenon & the entities in blue mode, switch to green for chaining
- A "sufficiently chained" explanation may precipitate a shift from green to blue mode

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## ❖CONCLUSIONS❖
➤ The substance of student reasoning shows different patterns during different behavioral modes ◄
➤ Students build sophisticated scientific explanations while they frame the tutorials as a discussion ◄

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