Student patterns of knowledge construction

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Goals

- Introduce piece of theory about student patterns of knowledge construction.

- Explain a student-TA “failure to communicate” in theoretical terms.
Intro physics homework problem

What’s the difference in pressure between the ceiling and the floor of a dorm room? (The density of air is about 1 kg/m³, and atmospheric pressure is $10^5$ Pa.)
Pressure episode  

(1 min)

Three students are working on the pressure problem together. A TA is in the room, but isn’t working with them in this episode.

(These are students in the introductory algebra-based mechanics course, doing their homework.)

Look for: 

The students’ (familiar) pattern of activity.  

[NOT CONCEPTUAL TROUBLES]
Pressure episode  

(1 min)
A familiar pattern of behavior

Identify target quantity

Find an equation relating target to other quantities

Determine which of the other quantities are known

Only the target quantity is unknown

Calculate target quantity

Some other quantities are unknown

Choose a sub-target and start over

Pressure

\[ P = \frac{RnT}{V} \]

Pressure is known

Volume is unknown

“we need the volume”
The pattern is a sort of “game.”

- It is a mildly artificial activity, separable from regular life.
- It has a routine of allowed “moves.”
  - Identify target quantity
  - Find an equation relating target to other quantities
  - Determine which of the other quantities are known
  - Only the target quantity is unknown
  - Some other quantities are unknown
  - Calculate target quantity
  - Choose a sub-target and start over

- It has “pieces” which are required for play.
  - equations
  - definitions of variables
  - rules of algebra
  - etc.
49. A 5.72-liter tank of gaseous nitrogen is maintained at 1.6 atm and 30°C. What mass of nitrogen is in the tank?

Given: $V = 5.72 \text{ L}$ \hspace{1cm} $R =$ gas constant \hspace{1cm} $N_2$ is 14g/mole
$P = 1.6 \text{ atm}$ \hspace{1cm} $N_2$ is 14g/mole \hspace{1cm} $T = 30^\circ \text{C}$

$PV = nRT$

$n = \frac{PV}{RT}$

$m = (\text{number of moles})(\text{mass per mole})$

$= n (14\text{g/mole})$

$= (PV/RT)(14\text{g/mole})$

$= (1.6\text{atm})(5.72\text{L})(0.014\text{kg/mole})$

$R (293\text{K})$

$m = 0.00003 \text{ kg}$
Theoretical vocabulary

• This game is an **epistemic game** (e-game), in that its purpose is knowledge construction.

• The “pieces” are **knowledge elements**.

• The “target structure” (e.g., solution) is an **epistemic form**.

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**Collins and Ferguson, Educ. Psych. 28 (1) 1993**

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“Plug-and-Chug” e-game

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**Other epistemic games:**

Listmaking, Pictorial Analysis, Mapping Meaning to Mathematics ….
Students playing “Plug-and-Chug” e-game

1. Identify target quantity
2. Find an equation relating target to other quantities
3. Determine which of the other quantities are known
   - Only the target quantity is unknown
   - Some other quantities are unknown
4. Calculate target quantity
5. Choose a sub-target

Pressure:
- \( P = \frac{R n T}{V} \)
- \( R \) known
- \( V \) unknown

Volume:
- \( D = \frac{m}{V} \)
- \( D \) is known
- \( m \) is unknown

Mass:
- \( M = D V \)
- \( D \) known
- \( V \) unknown

Stuck in a loop

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The problem is partly the game

*It’s not just that students have conceptual difficulties.*

Students can have difficulties due to getting stuck in an unhelpful game.
Students have a TA check their moves

**Off camera:**
- TA affirms formulas.
- The students decide:
  - $D$ is known (1 kg/m$^3$)
  - $m = 1$ kg and $V = 1$ m$^3$

**In this clip:**
The TA tries to help students spot their interpretation error.

**Look for:**
*The TA makes two different moves, neither of which work.*
Helping episode
TA’s first move: “Physicalizing”

TA: Right, so if you lived in a room that was this big [gestures], one meter cubed there would be one kilogram of air there.

S2: Yeah.

TA: I don't think you live in a room that big.

S2: Yeah, I feel silly. OK. So, it's one kilogram...

TA: So, what um...

S1: So, the mass is one kilogram, is what you're saying.
TA’s 2nd move: **Suggest estimation**

**TA:** Would you agree with me this is an estimation problem.

**S2:** Um.  
**S1:** Yes.  
**TA:** OK.

**S2:** To a certain extent, yeah.

**TA:** What this problem is about a dorm room. How big is a dorm room?

**S2:** Oh!

**S1:** Not big at all.

**S2:** He gave it in another problem. Like another homework.

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**TA pushes for them to try estimation**

**Students think he’s indicating a known quantity again.**
Interrelated claims

- The TA’s moves go unrecognized (or misinterpreted) by the students.
- The TA’s moves are not part of the plug-and-chug game.
- The students hear the TA as though he were making a plug-and-chug move (“identify known quantities”).

Their “failure to communicate” is a problem of mismatched epistemic games.
What does theory gain us?

Q. Why not just say that the students and TA miscommunicated, and leave it at that?

A. Fitting the problem into a theory provides pedagogical assistance.

Saying “they miscommunicated” is like saying “they’re wrong;” it doesn’t help you with what to do next.

“You guys are doing this plug-and-chug thing. How about you try something else?”
Summary

- Students engage in recognizable patterns of knowledge construction – epistemic games.

- In addition to conceptual difficulties, students may have difficulties due to being stuck in an unhelpful e-game.

- “Failures to communicate” may be usefully modeled as arising from mismatched e-games.