Student interactions leading to learning and transfer: A participationist perspective

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Introduction

- 39 Students in a calculus-based introductory physics class, taught using ISLE format in a studio setting.
- Class is highly collaborative, participation is believed to be the key to learning.

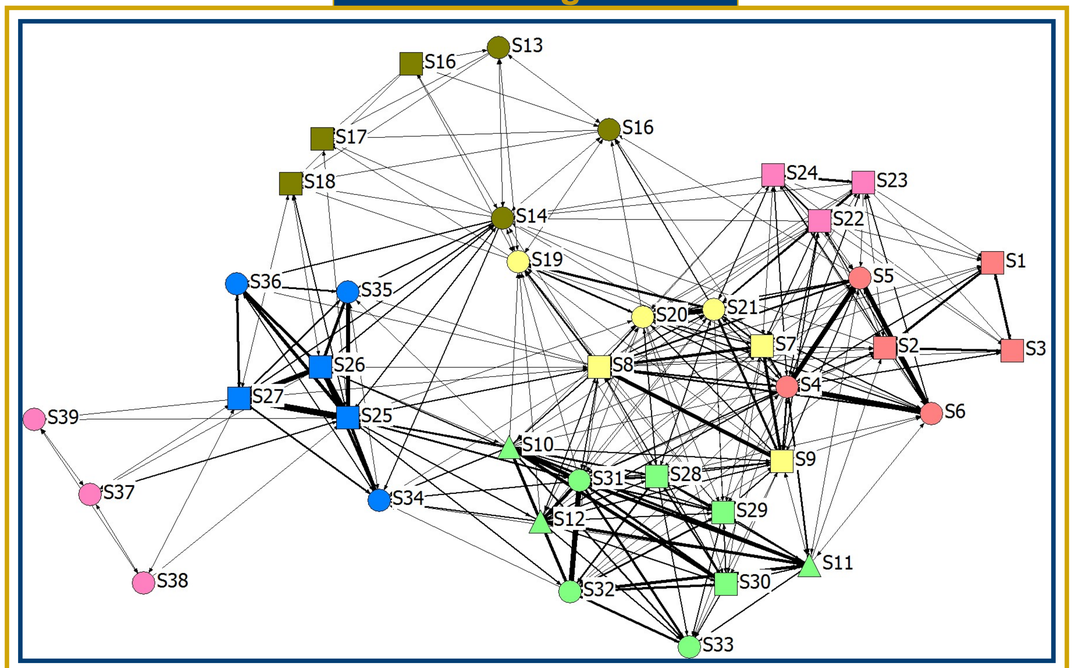
Research questions

- Is students' participation important for their learning?
- Are there more or less effective ways of participating?

Setting and Methodology

- Students take a **group exam.** Two days later they take an **individual exam.**
- **Group exam** requires students to collaborate together to learn new physics.
- **Transfer questions** related to the **group exam** are embedded in the **individual exam.**
- We video-taped the **group exam** with 4 cameras.
- In the **group exam**, learning interactions between 2 or more students were coded according to a) type of activity (sense-making, co-representing, teaching, questioning, and checking) and b) each student's role in that interaction (initiator, recipient, or both initiator and recipient)
- Coding allowed us to form social network for the whole class for three productive learning activities (sense-making, co-representing, and teaching/ learning).
- **Individual exam transfer questions** were coded for evidence of transfer from the **group exam**. Inter-rater reliability was 100% after discussion.

Sense-making network



Sense-making network: Each node is a student. Color denotes students at same table. Shape denotes students in same group. Line thickness denotes number of interactions.

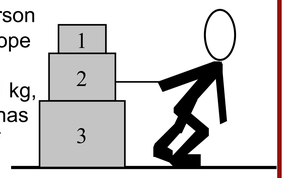
Learning activity	Correlation with individual exam transfer questions (1 & 2)	Correlation with other exam questions not involving friction
Sense-making (out) – active	0.43*	0.37*
Co-representing (out) – active	0.34*	0.38*
Teaching (out) – teaching others	0.39*	0.35*
Sense-making (in) – passive	0.34*	0.08
Co-representing (in) – passive	0.17	0.04
Teaching (in) – being taught	0.31	-0.15

Table of correlations between exam questions measuring transfer (question 1 and 2) and other exam questions unrelated to friction compared against student participation in three productive learning activities during the group exam. Out degree measures students' connectedness in initiating (leading) an interaction and in degree measures students' connectedness as receivers in learning activities.
* Correlation significant at $p < 0.05$ (two-tailed t-test).

Group Exam

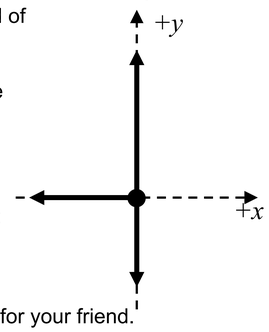
1. a) When you start walking, the frictional force exerted by the carpet on your shoes is static or kinetic? Which direction does it point when you transition from standing still to moving forwards? Clearly explain your answer with proper diagram(s).
b) Imagine Professor Brookes is pedaling his bicycle from a standstill, going faster and faster (i.e., he's speeding up). Consider him and his bicycle as a system.
I) Compare the magnitude and direction of the frictional force exerted by the road on, i) the back wheel of the bicycle, ii) the front wheel of the bicycle.
II) Explain what object is exerting an unbalanced force that allows him to accelerate.

2. In the picture to the right, a person is pulling a 3-box system with a rope attached to box 2. The rope is horizontal. Box 1 has a mass of 1 kg, box 2 has a mass of 2 kg, box 3 has a mass of 3 kg. The coefficient of static friction between box 1 and 2, and between box 2 and 3 is $\mu_s=0.5$. The coefficient of kinetic friction between the floor and box 3 is $\mu_k=0.1$. If we assume the system is already accelerating to the right (i.e., it is already sliding), what is the maximum acceleration of the system and maximum force that the person can exert on the rope without boxes slipping off each other? (i.e., box 1 should not slip relative to box 2, and box 2 should not slip relative to box 3.)



Individual Exam Transfer Questions

1. A crate sits on the flatbed of a truck that moves towards the right (+ x direction) with increasing speed. The crate does not slide but instead moves to the right with the truck. A friend draws the force diagram for the crate. (Shown in the figure.) What things are wrong with this force diagram? Explain your reasoning. Provide an improved force diagram for your friend.



2. A horse is urged to pull a wagon. The horse refuses to try citing Newton's third law as defense: The pull of the horse on the wagon is equal but opposite to the pull of the wagon on the horse. "If I can never exert a greater force on the wagon than it exerts on me, how can I ever start the wagon moving?" asks the horse. How would you reply to expose the flaw in the horse's argument and convince the horse to pull the wagon (using physics reasoning of course)?