# Role of Group Dynamics in Analysis of Attitudes towards Metacognitive Physics Problem Solving

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## Abstract

Current investigations into pedagogical goals of introductory algebra-based physics students at the University of Central Arkansas, by choice of major and by learning orientation towards an in-class metacognitive group problem solving task, seek to determine possible relationships with attitudinal shifts and course performance. Students thus far have been untreated with known group-based learning pedagogies, so as to establish trends of common group habits, and ultimately to properly inform implementation of group-based pedagogies in reaction to these trends. We present initial analysis of group dynamics observed thus far during the problem solving task, in consideration of chosen strategies, determined learning orientations, and attitudinal shifts. In addition, current results will require further information from group dynamics in future research. A proposal for future analysis of more complete audiovisual data, in order to examine evolution of lab group dynamics during a given class period, will be discussed as informed by current results.

## Background

- Previous research[1,2]: Primarily quantitative approach to lab-group-based exercise solving a context-rich problem[3,4] and then being guided through metacognition on strengths and weaknesses of approach
- Variables that appear related to pre-post shifts in attitudes towards physics, attitudes towards problem solving:
  - Learning orientations,[5] as applied towards specific exercise (defined by coding student survey feedback about usefulness of exercise)
  - Choice of major: health science majors are in a different college than are biology majors, start the course with more novice-like attitudes, make similar gains from pre to post, but do not catch up
  - Background data (gender, semester taking course, pre-professional status, etc.)
- Next: define some categorization of lab group dynamics
  - Consider "epistemic games" as defined for physics activities by Tuminaro and Redish[6,7] – need to observe what strategies students actually use
  - Also consider how lab groups actually seem to interact: observe main means of interaction
  - Can we connect these two items to known variables?

## Procedure: Audiovisual

- Four semesters sampled from first-semester introductory algebra-based physics class: Spring 2014 (S14), Spring 2015 (S15), Fall 2015 (F15), Spring 2016 (S16)
- Students given a context-rich problem to solve in lab groups during first 50 minutes of lab
- Instructor and Learning Assistant (LA)[8] provides guidance and feedback during session, goes over solution at end of session
  - Students also perform metacognitive task on their strengths and weaknesses in solving problem
- Data collected: audiovisual sampling of live student data, FCI[9] and CLASS[10] pre-post, survey about problem solving exercise
- Audiovisual recording taken of students on group problem solving session near end of semester (topic: rotational kinematics/dynamics)
- Analysis: Look for evidence of epistemic games, primary lab group dynamic used
  - ***Issue #1:*** Insufficient personnel/cameras (between 2 and 4) available to record all lab groups for 50 continuous minutes
    - Solution: "sample" with 1-2 minute clips of data taken throughout the at times when students are visibly working on problem.
  - ***Issue #2:*** Not all lab groups got equal amount of time in recording; # of observed games are not equal between groups
    - Solution: "normalize" by dividing # of games by total recording time
  - *Can we relate games/min, primary dynamic to previous variables?*

## References

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6) J. Tuminaro & E. Redish, *Phys. Rev. PER 3*, 020101 (2007).
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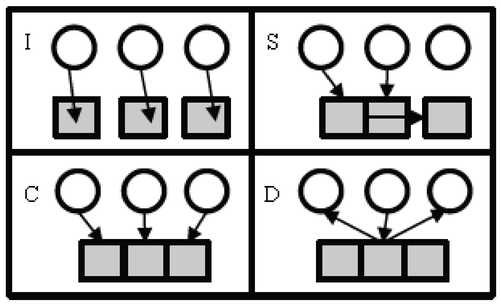
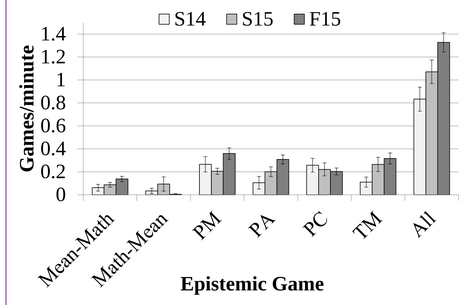
## Types of Observed Dynamics




- Independent (I): students work individually, only collaborate to compare notes when stuck/done
- Collaborative (C): students work together on solution on apparently equal footing
- Semi-collaborative (S): two students collaborate, third student is passive
- Dominant (D): one student tells two other students what to do

Note: collaborative effort, with group members playing different supporting roles, is most desirable[3]; researchers did not enforce collaboration in order to establish whether attitude towards physics affects "organic" desire to collaborate.

## Observed Epistemic Games




Compare 3 semesters analyzed so far: Spring 2014 (S14), Spring 2015 (S15), Fall 2015 (F15)

Most lab groups observed for 400-1000 s (groups observed < 60 s omitted)

Standard uncertainty range:
+/- 0.10 games/min over all games
+/- 0.01-0.08 games/min for each game
(equal variance: F = 0.93, $F_{cr}$ = 3.68, p = 0.42)

| Semester | | S14 | S15 | F15 | All |
|---|---|---|---|---|---|
| # Students | | 40 | 35 | 39 | 114 |
| # Groups | | 13 | 14 | 15 | 42 |
| Games per minute per group | Mean-Math | 0.06 | 0.09 | 0.14 | 0.10 |
| | Math-Mean | 0.03 | 0.09 | 0.00 | 0.04 |
| | PM | 0.27 | 0.20 | 0.36 | 0.28 |
| | PA | 0.10 | 0.20 | 0.31 | 0.21 |
| | PC | 0.26 | 0.22 | 0.20 | 0.23 |
| | TM | 0.11 | 0.26 | 0.32 | 0.24 |
| | All | 0.83 | 1.07 | 1.33 | 1.08 |

Significant(ish) differences:

Transliteration to Mathematics (TM)
S15 > S14 (p = 0.055)
F15 > S14 (p = 0.004)

All games
F15 > S14 (p < 0.001)
F 15 > S15 (p = 0.06)

## Can different variables be compared?

- Consider orientations, predominant group dynamics, and choices of games/minute
- Compare to attitudinal shifts
  - ***Issue #3:*** Individual members of each lab group do not necessarily share same learning orientation or similar pre-post attitudinal shifts – how to characterize each group in this way?
  - Solution: determine "predominant" learning orientation of group (either majority of group members' common learning orientation, or orientation of group member who appears to drive the group's progress the most)
  - Framework-oriented students (F) tend to shift towards expert-like attitudes on CLASS survey; performance-oriented (P) students and vague-oriented (V) students tend to shift towards novice-like attitudes

## Sample Attempt to Map Dynamics, # of Games to Orientation (F15 lab)

| Section A | Table 1 | Table 2 | Table 3 | Table 4 | Table 5 | Table 6 | Table 7 | Table 8 |
|---|---|---|---|---|---|---|---|---|
| Orientation makeup (driving orientation) | - | P, F, V (P-driven) | P, V, F (F-driven) | P, P (P-driven) | F, NA (NA-driven) | F, F, NA (F-driven) | F, NA, V (NA-driven) | F, F, F (F-driven) |
| Predominant interaction style | - | S | S | C | I | C | I | D |
| Games per minute | - | 0.91 | 1.46 | 1.26 | 0.91 | 1.18 | 1.29 | 1.05 |
| Most frequent game (games/min) | - | TM (0.30) | TM (0.67) | TM (0.56) | TM (0.30) | PM (0.41) | TM (0.52) | TM (0.37) |
| CLASS gains (overall) | - | -0.45, -0.11, ? | -0.19, -0.17, ? | +0.06, -0.05 | -0.06, ? | ?, +0.33, ? | ?, ?, ? | +0.06, -0.26, ? |
| **Section B** | **Table 1** | **Table 2** | **Table 3** | **Table 4** | **Table 5** | **Table 6** | **Table 7** | **Table 8** |
| Orientation makeup (driving orientation) | P, V, V (V-driven) | F, V (F-driven) | NA, P, V (P-driven) | V, V, V (V-driven) | P, V (P-driven) | P, P (P-driven) | V, P (V-driven) | F, V, P (F-driven) |
| Predominant interaction style | C | C | C | C | I | C | C | S |
| Games per minute | 1.56 | 1.24 | 1.38 | 1.60 | 1.80 | 1.56 | 0.81 | 1.89 |
| Most frequent game (games/min) | PA (0.52) | PM/PA (0.49) | PM/PA (0.41) | PM/PA (0.53) | PM/TM (0.45) | PM (0.67) | PA (0.41) | PM (0.72) |
| CLASS gains (overall) | 0.00, +0.14, +0.63 | -0.08, -0.11 | ?, +0.27, +0.17 | -0.05, 0.00, ? | 0, -0.42 | ?, -0.22 | -0.26, -0.23 | +0.22, +0.16, -0.25 |

## Discussion/Future Plans

- Must compare "sampling/normalization" audiovisual technique to a fully-recorded 50-minute session – how accurate is games/minute measurement?
- Individual gains difficult to ensure measurement (note all the "?"s from students who missed either pretest or posttest)
  - Driving learning orientation simpler way to look at attitudes towards problem solving
- Games/minute doesn't seem to be correlated to group dynamic or driving orientation in F15 sample; need to look at other sampled semesters

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