

# Do we make students do too much or too little? A cognitive load study

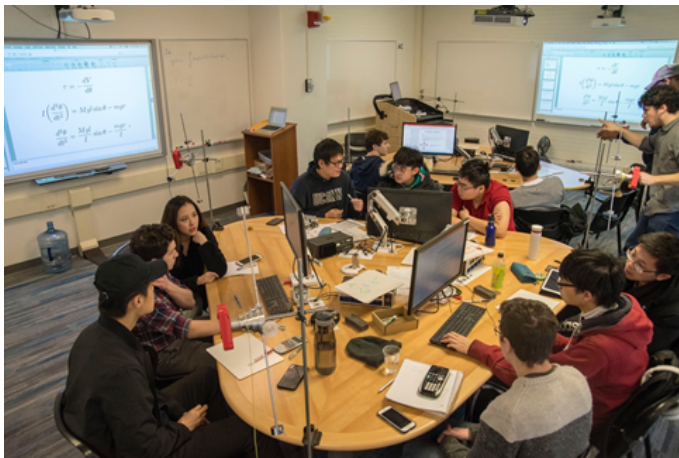
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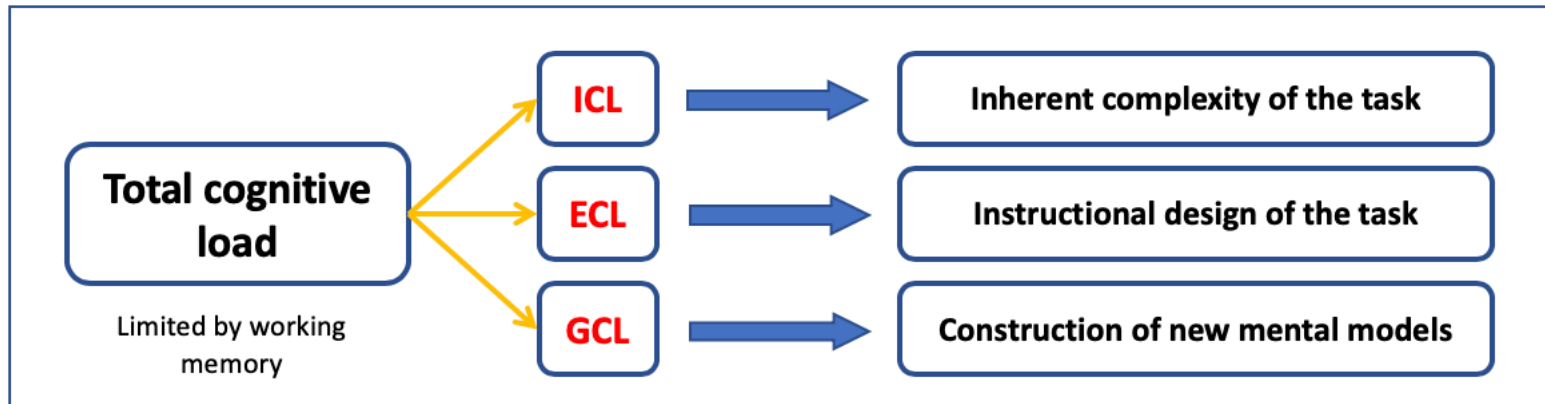
# Motivation

- 3 introductory physics course sequences at UConn are undergoing a major transformation (all calculus-based)
- Many learning interventions, including labs, demos, problem-solving tutorials, short quizzes are either in development or have recently been developed
- Quality control:
  - Evaluation of teaching (for instructors and TAs)
  - Learning outcomes (concept inventories and conventional exams)
  - Evaluation of learning intervention: cognitive load theory



# Cognitive Load Theory

- Usage of working memory resources during problem solving
- Three discrete categories: Intrinsic (**ICL**), Extraneous (**ECL**), and Germane cognitive loads (**GCL**)



# Measuring Cognitive Load

- Ways of measuring cognitive load:
  - Unidimensional methods: physiological parameter measurements and dual-task estimation
  - A differentiated method: self-reporting questionnaires with Likert-scale items designated to specific cognitive load categories:
    - “difficulty of the content”: **ICL**
    - “difficulty to learn with the material presented”: **ECL**
    - “concentration/mental effort during learning”: **GCL**
    - We adopted the survey designed and validated by Klepsch et al. (2017)

# The 2019 Spring Study

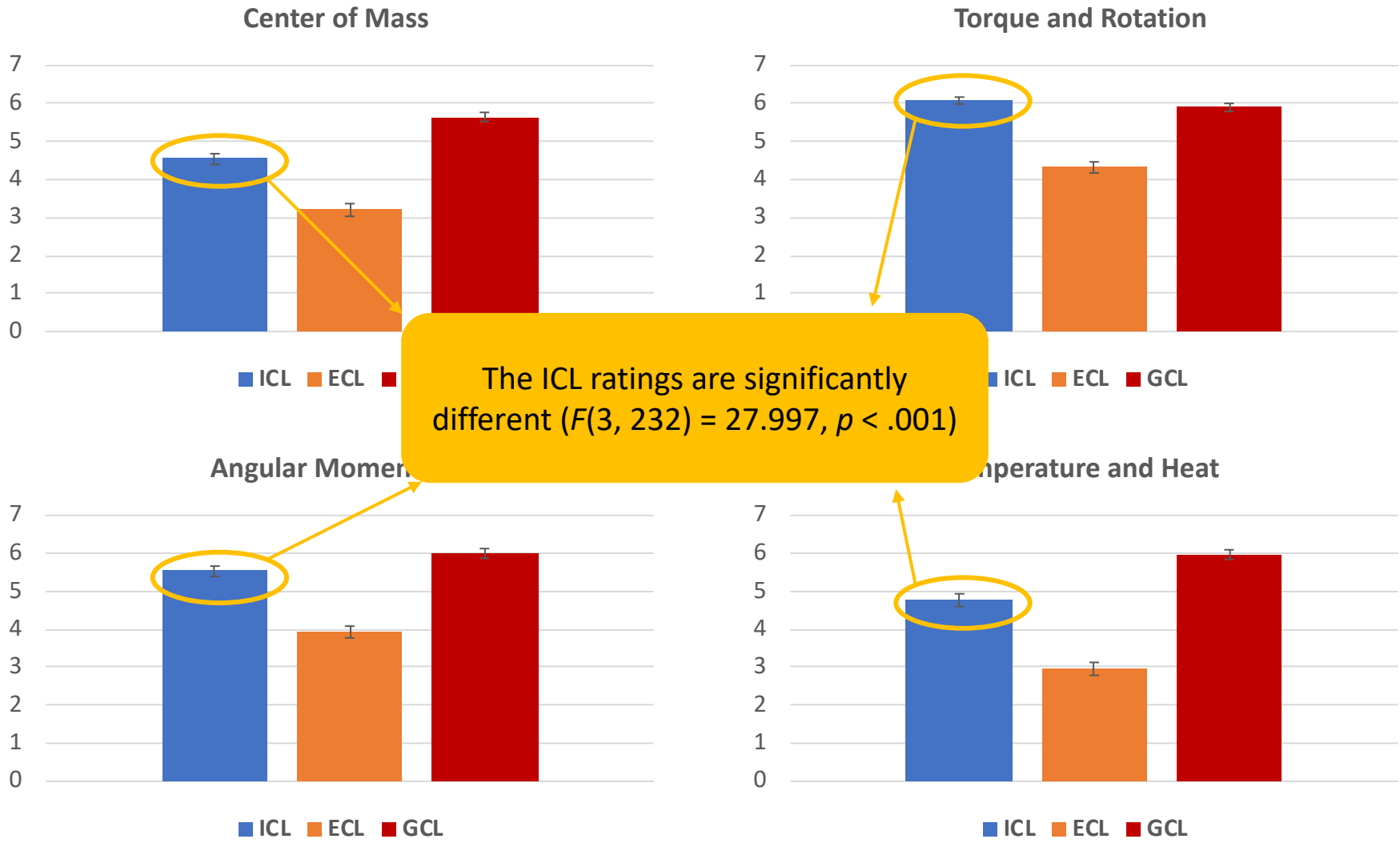
- A calculus-based intro-physics course with 69 students (most are life-science majors) enrolled
- A tutorial-based teaching approach was facilitated when possible
- Four tutorials were administered with the questionnaires:
  - Center of Mass
  - Torque and Rotation
  - Angular Momentum
  - Temperature and Heat
- The cognitive load surveys were handed to students at the end of the classes with tutorials when time permitted; students completed the surveys in class.

# The Cognitive Load Survey

Type of load	Item	Cronbach's alphas
ICL	1. For this task, <b>many things</b> needed to be kept in mind simultaneously. 2. This task was very <b>complex</b> .	0.790*
GCL	3. I made an <b>effort</b> , not only to <b>understand</b> several details, but to <b>understand</b> the overall context. 4. My point while dealing with the task was to <b>understand</b> everything correct. 5. The learning task consisted of elements supporting my <b>comprehension</b> of the task.	0.752 (0.816* excluding item#5)
ECL	6. During this task, it was <b>exhausting</b> to find the important information. 7. The design of this task was very <b>inconvenient</b> for learning. 8. During this task, it was <b>difficult</b> to recognize and link the crucial information.	0.826

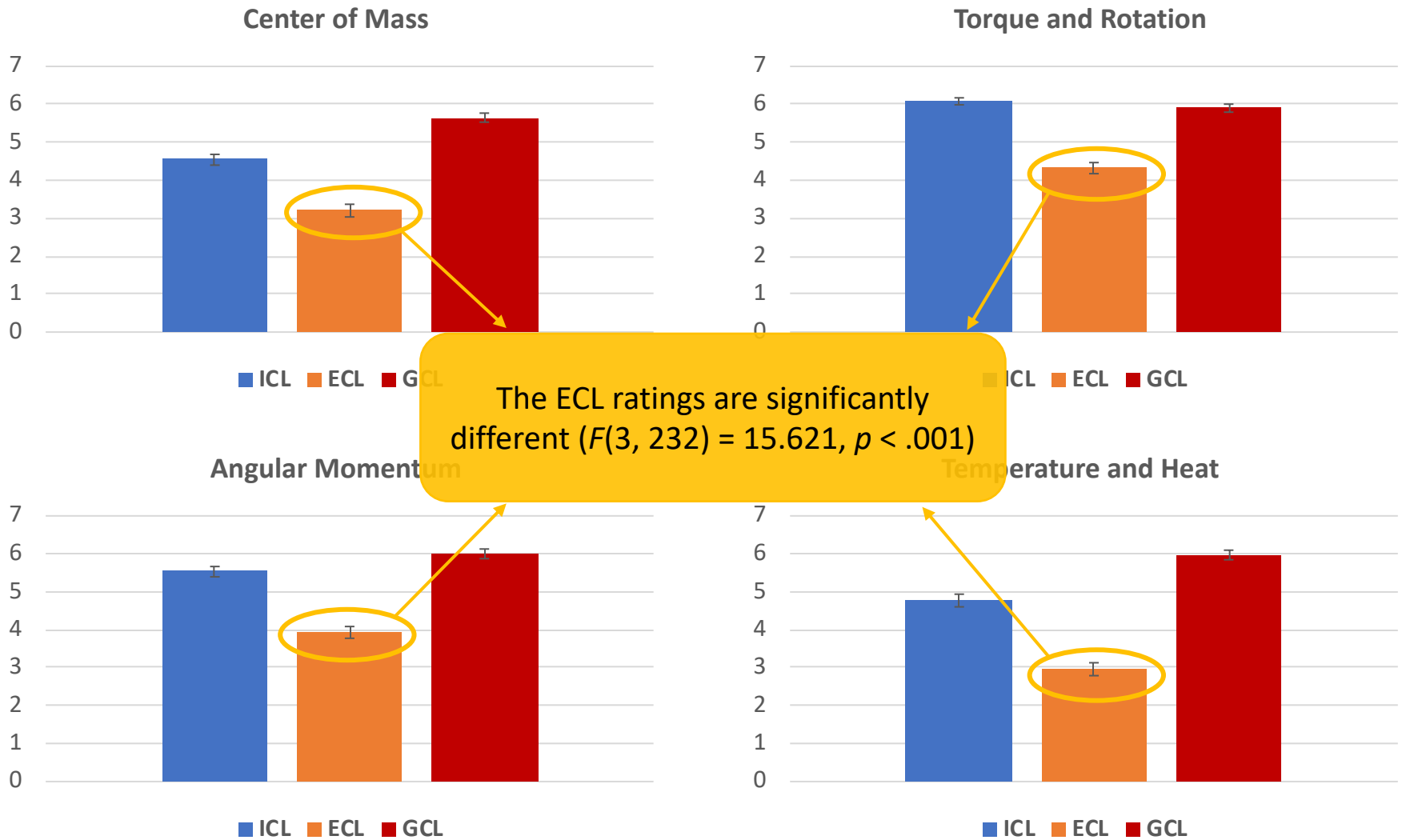
\*Cronbach's alpha with two items was adjusted by the Spearman-Brown Prophecy formula to address the item number difference

# Survey Results: Cognitive Loads on Tutorials



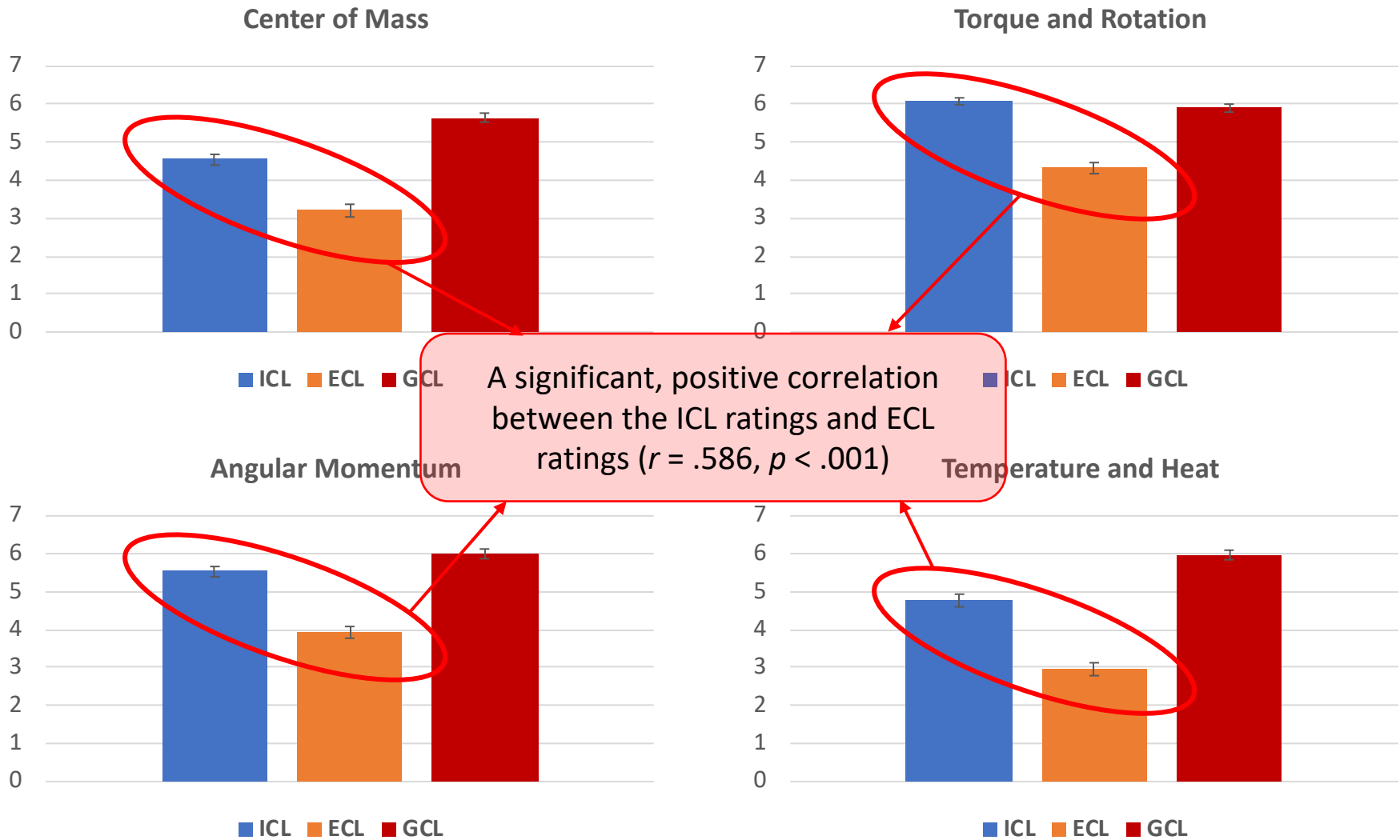
See PERC Posters Wednesday evening: B28 and B56

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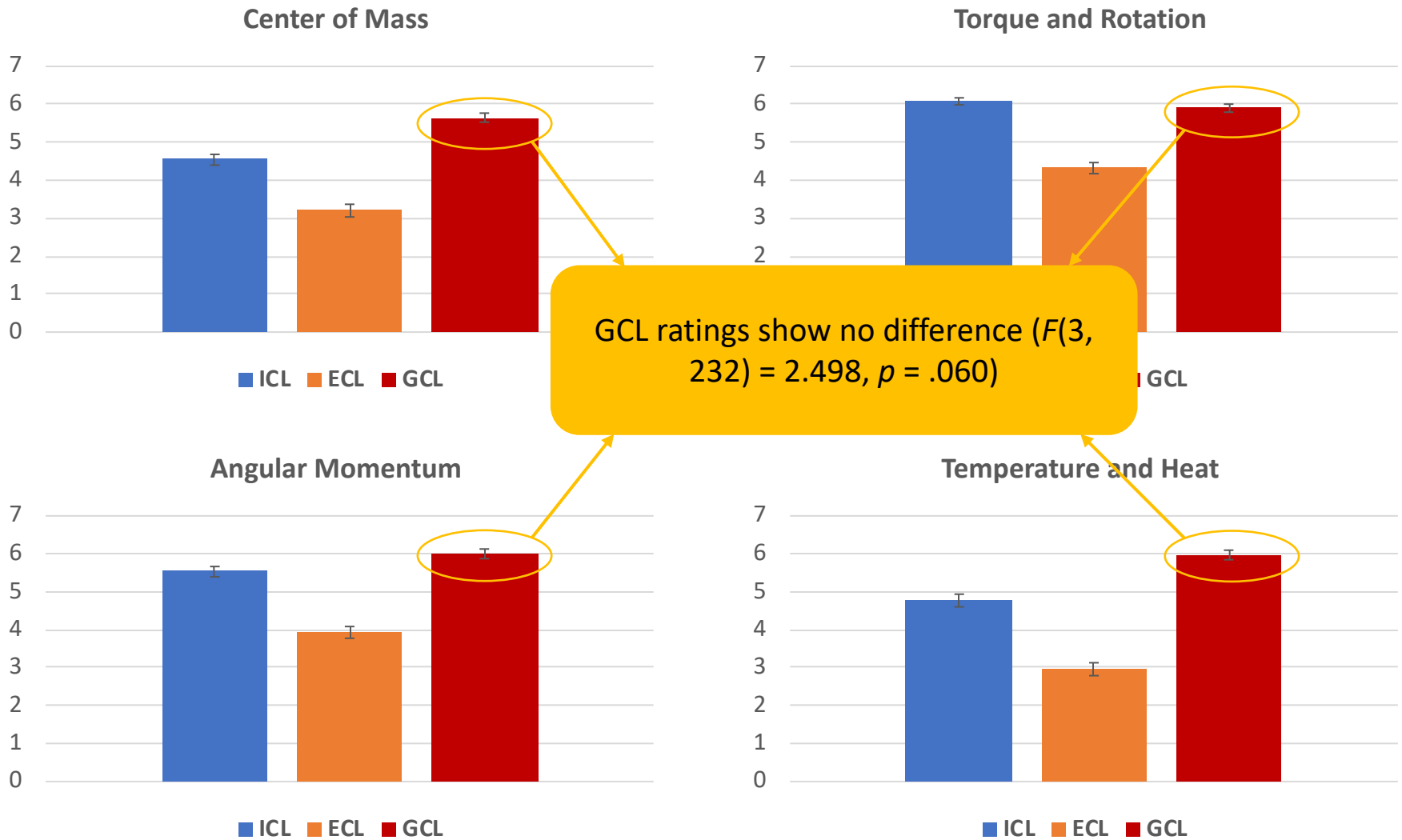




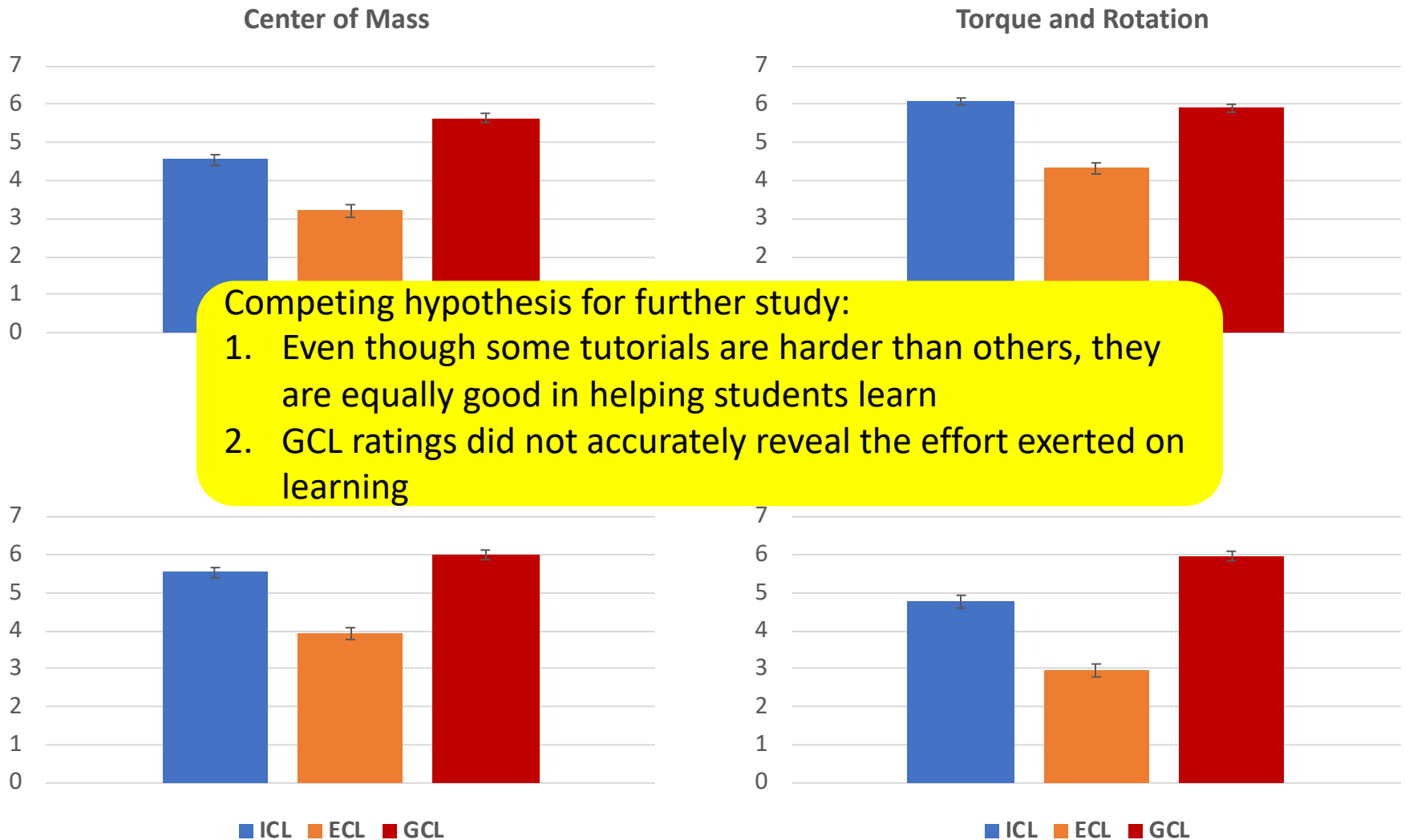
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# Initial Reflections

- Challenges to be faced in measuring three aspects of cognitive load in a differentiated way:
  - Students can differentiate the content and the representation of a task, but it is hard to expect them to report their feelings toward these two aspects separately
  - GCL items are measuring motivation more than the actual effort spent toward learning (for self-reporting items only)
  - Lack of clear theoretical boundaries between ICL, ECL, and GCL
- The items of the cognitive load survey need to be further polished

# Future Directions

- Interviewing (orally or in writing) students on how they consider each survey item related to a specific learning intervention
- More data is needed: we will use the cognitive load survey to assess more learning interventions
- Measuring learning outcomes (i.e., pre/posttest, clicker questions, exams, etc.) to get more objective information on how much students learn
- Designing an ICL/ECL-controlled experiment to possibly decouple these two categories (**Challenging**)