Examining the Impact of Coordinating Multiple Representations on Student Learning and Performance in Digital Electronics

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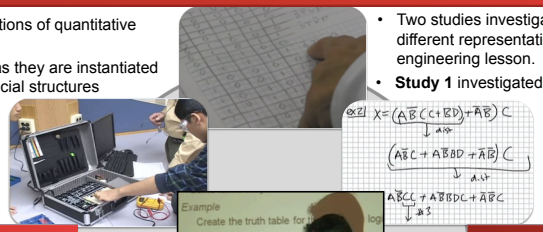
Background

- In engineering courses, students encounter a broad range of representations of quantitative and qualitative relationships that take on different surface forms.
- Students often fail to perceive the ***cohesion*** of central STEM concepts as they are instantiated in a variety of different representations across a range of settings and social structures (Kozma, 2003; Nathan et al., 2011).
- Thus, to be successful in project-based STEM classrooms, students need to develop high levels of representational fluency (Lesh & Lehrer, 2003; Nathan & Kim, 2007), perceptual fluency (Kellman, Massey, & Son, 2010), and meta-representational competence (diSessa, 2004).



- Two studies investigated the overarching hypothesis that making explicit connections across different representations—a process we call ***coordination***—can enhance learning from an engineering lesson.
- **Study 1** investigated how observing explicit coordination affected post-test performance after a live lesson presented in small groups.
  - **Study 2** presented the lesson via video segments to individual participants; collected measures of engagement, interest, and confidence; and measured students' performance on (1) an initial post-test and (2) a delayed post-test and a transfer task administered two weeks later.

Study 1

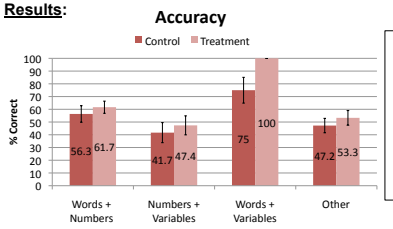
Hypotheses:

- Hypothesis 1.1: Explicitly linking multiple representations of a single mathematical concept via coordination will improve participants' **accuracy** on a content-based post-lesson assessment.
- Hypothesis 1.2: Coordination will improve participants' **fluency** on a post-lesson assessment, as measured by completion time.

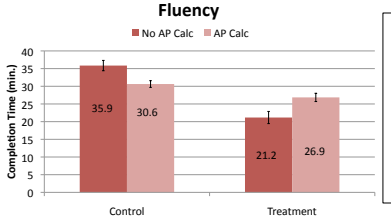
Quick Facts:

- *N* = 37 undergraduates watched a live lesson on digital electronics in groups of 4-6 and were randomly assigned to control (*N* = 18) or treatment group (*N* = 19)
- Completed a familiarity survey, post-lesson assessment, and demographic questionnaire

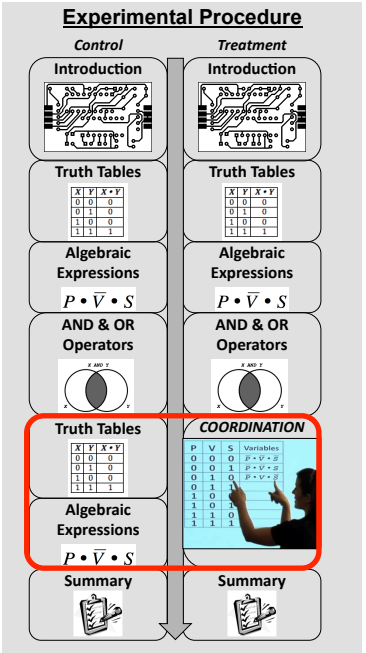
Results:



- No significant main effect of accuracy
- Descriptively, experimental group outperformed control group
- Indicates need for increased power



- Coordination led to a significant reduction in completion time overall
- Marginal interaction (p = .083) with math background
- Coordination may be more beneficial for those with less math experience



Study 2

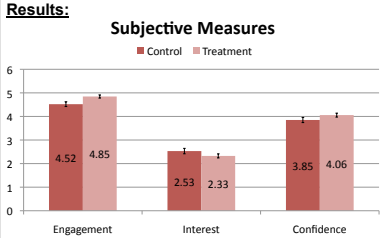
Hypotheses: *(In addition to the hypotheses from Study 1)*

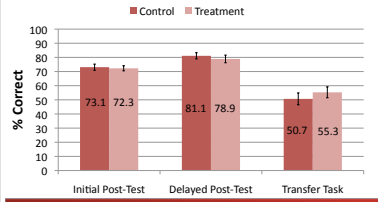
- Hypothesis 2.1: Coordination will increase participants' **engagement** during the lesson, **domain interest** after the lesson, and **confidence** in their answers on a post-lesson assessment.
- Hypothesis 2.2: Coordination will promote participants' **retention** of lesson content over 1 to 2 weeks.
- Hypothesis 2.3: Coordination will result in more successful **transfer,** as measured by performance on a Preparation for Future Learning assessment.

Quick Facts:

- *N* = 51 undergraduates watched a video lesson on a computer individually and were randomly assigned to control (*N* = 25) or treatment group (*N* = 26)
- Followed same protocol as Study 1, but also answered questions on engagement, interest, and confidence in their answers on the post-lesson assessment
- Returned two weeks later for a delayed post-test and transfer task

Results:





- None of the hypotheses were supported
- Treatment group was *marginally* more engaged (p = .061)
- Both groups improved from the initial post-test to the delayed post-test (p = .003)

Conclusions

• Coordination can influence representational fluency and perceptual fluency in STEM education

• Gauging its effectiveness may depend on the learning environment (i.e., live vs. video lesson) and forms of assessment

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