Conceptual Gains with the Synthetic Groupwork-based Newton's Third Law Open Source Tutorial

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Introduction

Asynchronous learning

- Recently, AI tutors have become widespread and personalized learning has evolved. [1]
- One particular challenge for online participants (e.g. military personnel, parents raising children, full-time employees) is how to provide them with the experience of collaborating with others.

Benefits of groupwork

Learners might learn even better from synthetic classmates from a ZPD (Zone of Proximal Development)[2] standpoint.

Guiding question

How can we deliver the benefits of group work to online learners?

Newton's Third Law Open Source Tutorial[3]

An interactive worksheet-based activity designed to help students reason through Newton's Third Law (N3) in a way that refines their intuitions.

Potential solution

Synthetic Groupwork based OST (SynG-OSTs)

Objective

To examine whether synthetic groupwork-type teaching materials can provide the benefits of collaborative learning online.

Research Questions

RQ1: Is N3 SynG-OST as effective as in-person OST?
RQ2: Does synthetic groupwork provide added value over a lecture-based interactive video?
RQ3: How do students perceive the synthetic groupwork format?

Methodology

Participants: Asynchronous AlgPhys & in-person CalcPhys

Comparison: ① SynG-OST (2024) vs Lecture Video (2023)
② FCI & FMCE items pertaining to N3

Format: PlayPosit (video stops for each question and you enter the answer)

* A satisfaction survey was also conducted using a questionnaire (Likert scale).

Results

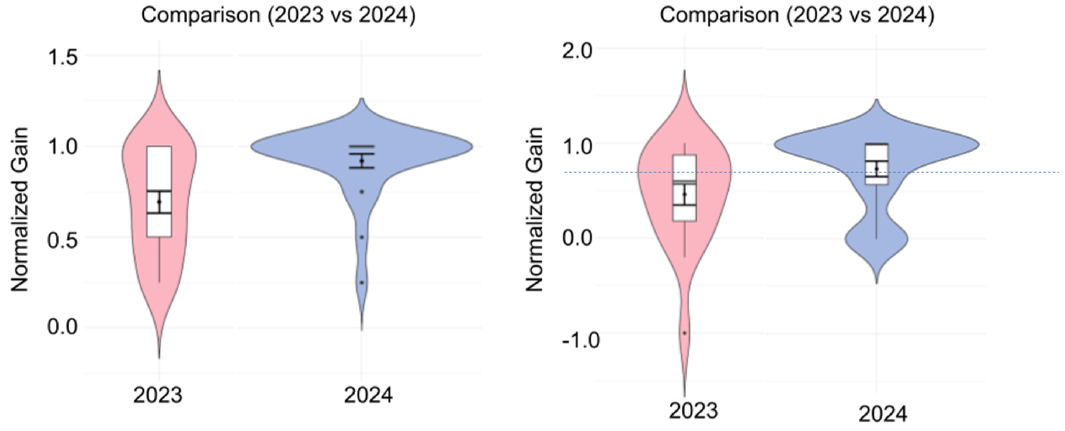
RQ1 & 2: Is N3 SynG-OST as effective as in-person OST, and does synthetic groupwork add value over lecture video?

- **FCI Post-test Scores**[4]

  SynG-OST (2024) : 92% ± 19%
  Lecture (2023) : 69% ± 29%

- **FMCE Normalized Gain**[5]

  SynG-OST (2024) : 0.74 ± 0.4
  Lecture (2023) : 0.46 ± 0.5

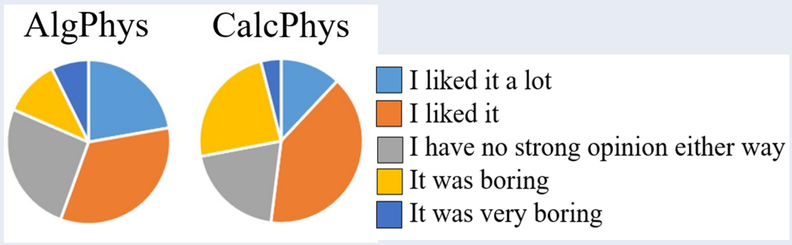


Comparison of student learning gains between 2023 (Interactive Lecture) and 2024 (Synthetic Groupwork-based OST) cohorts. Error bars represent ±1 SEM. Only students who took pretest, module, and post-test are included: 2023 (N=22), 2024 (N=25). p-values: FCI = 0.001 (d=0.86), FMCE = 0.035 (d=0.58). The dashed line shows the published value for the in-person Tutorial.[5]

RQ3: How do students perceive the synthetic groupwork format?

★ Many positive reactions!

Some students expressed dissatisfaction with the tempo and naturalness of the piece.



More than half of the students who learned with the N3 SynG-OST (N = 51) reported enjoying it.

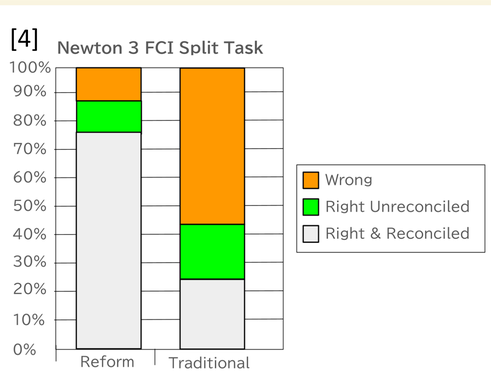
Limitations and Future Work

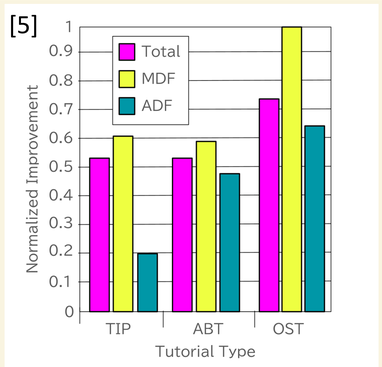
- Small sample size (N=25); Further research is needed before generalization can be made.
- Possibility of self-selection bias → We will analyze entire FCI and conduct Rash analysis[6]
- We will incorporate branching logic (where the story unfolds differently depending on the choices made).
- We also want to evaluate epistemological growth[7]

Conclusion

- The key features of Tutorials in general (groupwork, conceptual focus, confrontation of misconceptions) and of OSTs in particular (epistemological focus, refining intuitions) can be realized at least in theory in an online asynchronous environment
- Although only a pilot study, the **N3 SynG-OST seems to promote understanding on a par with actual groupwork** and is suitable for flexible learning styles.
- Synthetic group work is an innovative approach meriting further investigation.

【References】

[4]


[5]


[1]: e.g., aiPlato, Democratizing 1-on-1 education. https://Aiplato.Ai/ (2023).
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[4] Redish and Hammer, Reinventing college physics for biologists: Explicating an epistemological curriculum. (2009).
[5] T. I. Smith and M. C. Wittmann, Comparing three methods for teaching Newton's third law. Physical Review Special Topics-Physics Education Research 3, 020105 (2007).
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[7] e.g., E. F. Redish, J. M. Saul, and R. N. Steinberg, Student expectations in introductory physics. Am J Phys (1998).

Graphic designer: Shizuka Nakayama