Eastern Great Lakes APS Meeting at WSU

Enhancing Student Learning and Sense of Belonging through Interactive Web-Based Tutorials

KATHLEEN KOENIG

DEPT OF PHYSICS, UNIVERSITY OF CINCINNATI

ALEXANDRU MARIES

DEPT OF PHYSICS, UNIVERSITY OF CINCINNATI

ROBERT TEESE

EMERITUS, ROCHESTER INSTITUTE OF TECHNOLOGY

NSF IUSE DUE 1821396 and 2416548

Rationale for Interactive Video-Enhanced Tutorials (IVETs): Support students outside-of-class

Algebra-based Intro Physics

- primarily health science majors
- 13 sections of 135 each/yr (~1500 students)
- Lab taught by graduate TAs

Calculus-based Intro Physics

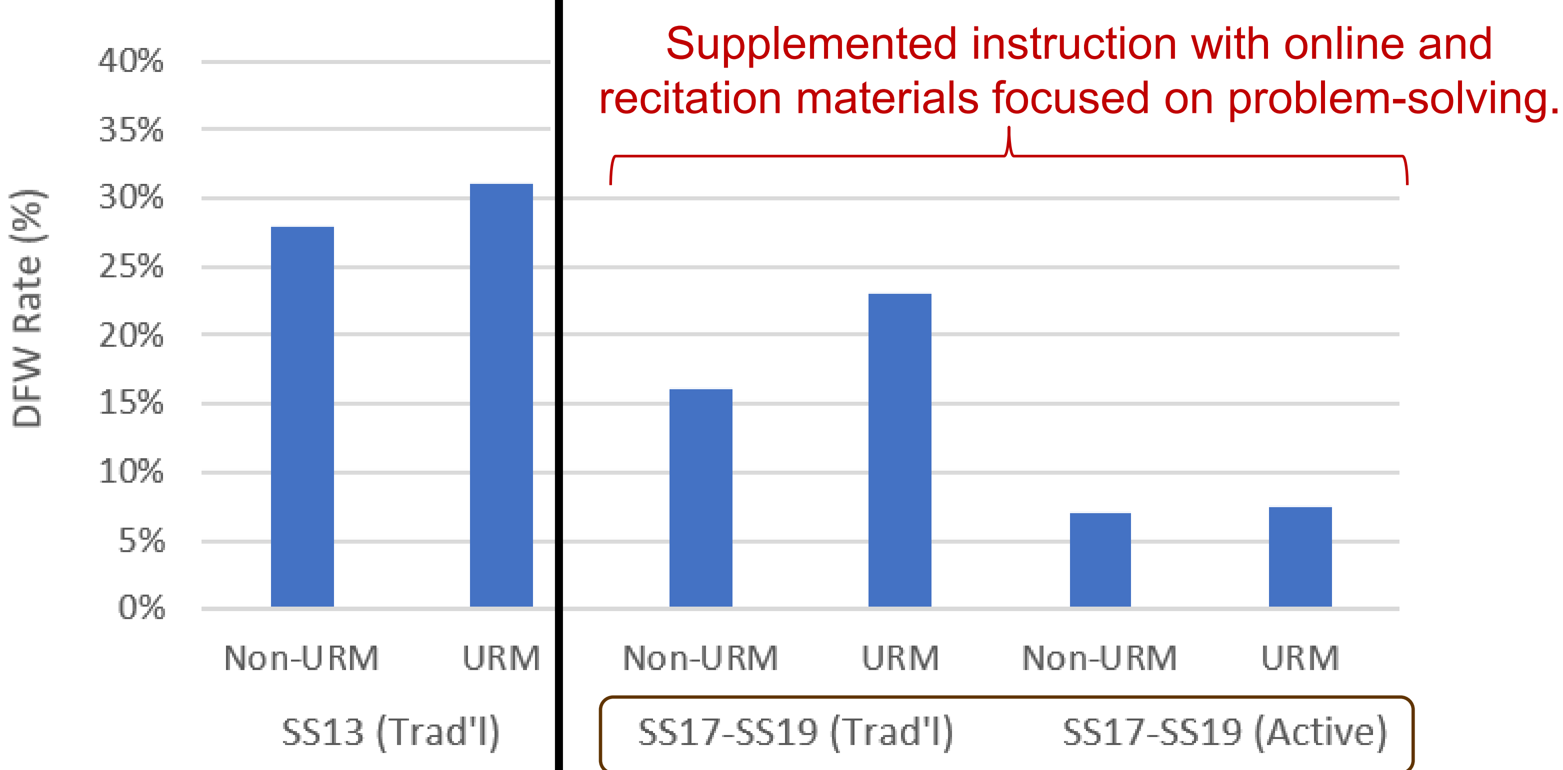
- primarily engineering majors
- 16 sections of 135 each/yr (~2000 students)
- Lab and recitation taught by graduate TAs

Supplement with resources to personalize instruction and attempt to level the playing field.

Wide variation in students' academic preparation, motivation, etc.

Wide variation in approaches to teaching

Evaluating interventions for impact



3 instructors
$N_{non\text{-}URM}$ =446; N_{URM} = 36

8 instructors
$N_{non\text{-}URM}$ =1446; N_{URM} = 175

3 instructors
$N_{non\text{-}URM}$ =688; N_{URM} = 67

URM refers to under-represented racial and ethnic minority students.

Where do students go for help with homework?

Example Homework Problem from Cengage's WebAssign (online HW system):

A brake is applied to a spinning wheel, initially moving counterclockwise, causing it to slow down with a constant angular acceleration of magnitude 5.20 rad/s^2. Immediately after the brake is applied, the wheel rotates through 50.4 rad during a 3.80 s time interval. What is the angular speed (in rad/s) of the wheel at the end of this time interval?

When stuck on homework problems, which **ONE** did you use most?

	Spring 2019
Google (ex. Chegg.com)	47%
Khan/online videos	15%
Other students	23%
Textbook	8%
Physics Learning Center	2%
Office hours	1%
SI Sessions, Peer Tutoring	1%
Didn't seek help or other	3%

Large use of resources with access outside of *work week.*

Data from Koenig's students (n=270)

When stuck on homework problems, which **ONE** did you use most?

	Spring 2019	Fall 2023
Google/internet	47%	30%
Khan/online videos	15%	11%
Textbook	8%	13%
Other Students	23%	30%**
Physics Learning Center	2%	1%
Office hours	1%	9%**
SI Sessions, Peer Tutoring	1%	1%
Didn’t seek help	3%	5%

**Held office hours 45 min before class in the classroom

Data from Koenig’s students

Significant Increase in Use of AI

20% in Fall 2023

60% in Fall 2024

68% in Spring 2025

ChatGPT/AI is the new “go-to” for getting help 24/7.

Project Goals

- Create 30 Interactive Video-Enhanced Tutorials (IVETs)
- Conduct research on
  - impact on problem-solving abilities
  - techniques that motivate appropriate behavior for learning
- Disseminate (compadre.org/ivet)

NSF DUE 1821396: 2018-2022

Features of Design of IVETs to Engage Students

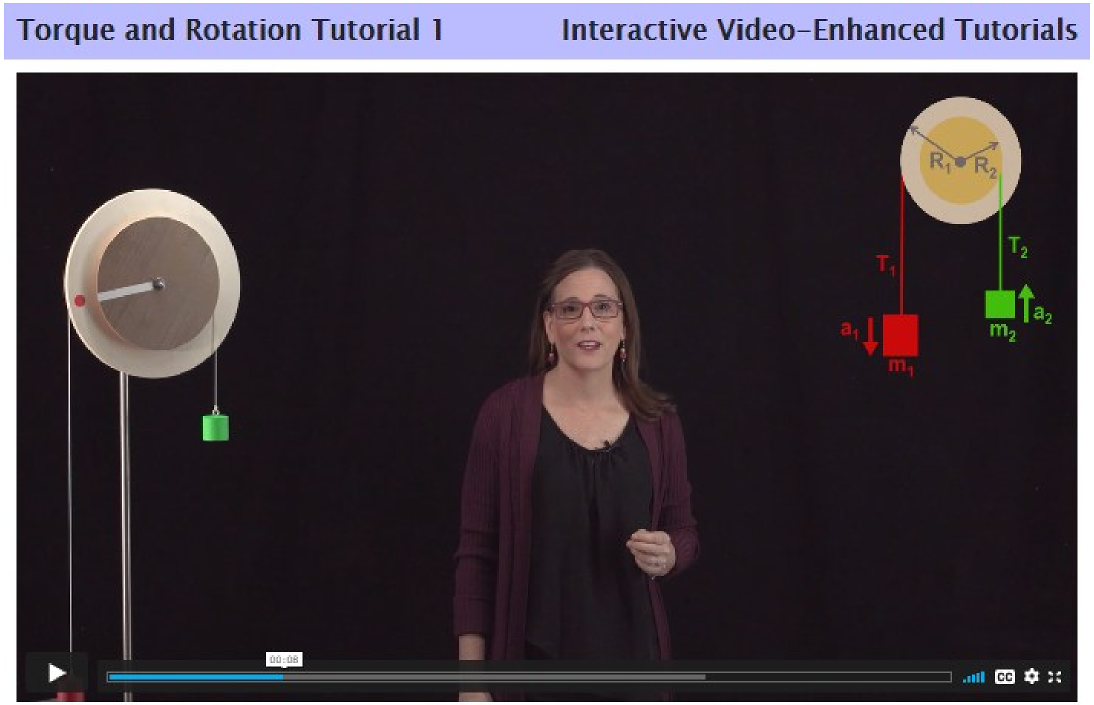
- Students **disengage** when bored, frustrated, or confused

  Problems are chosen that challenge students while providing support (Mini-lectures, hints, or encouragement by a tutor (video))

- Developed based on **multimedia learning principles** (Mayer)

  Students have choices
  - Choice text or video
  - Self-paced (students who need more support go thru slowly)
  - Choose a summary at various places

  Single problem, 10-15 minutes to complete



Q1: Which physics principle(s) should we use to solve this problem? Choose all that apply. If necessary, scroll down to see all four choices.

- A. Newton's 2nd Law for translations: $\sum \vec{F} = m\vec{a}$
- B. Conservation of Mechanical Energy
- C. Conservation of Linear Momentum
- D. Newton's 2nd Law for rotations: $\sum \tau = I\alpha$ where τ is the torque about a chosen point

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Videos interspersed with questions to teach **expert-like problem solving strategies** for specific problem types; i.e. Newton's Laws, conservation of energy, etc.

Short (10-15 minutes), self-paced, complete individually at home

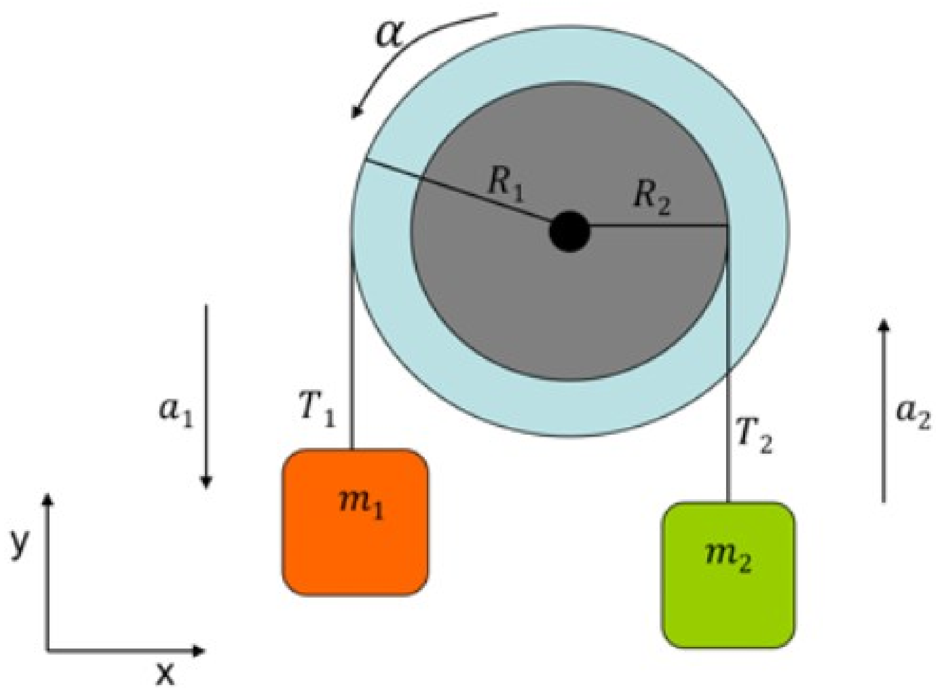
Questions branch based on student responses, providing relevant feedback for incorrect (and correct) answers

Choose complex problems that most students find challenging

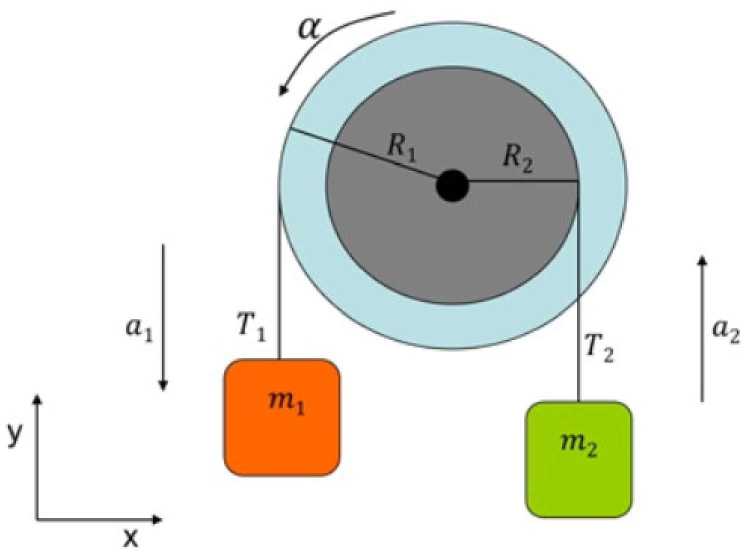
Problem Statement

Two blocks ($m_1 = 1.0\ kg, m_2 = 0.6\ kg$) are hanging from a pulley as shown in the figure below. The moment of inertia through the axis of rotation passing through the center of the pulley is $I = 1.70\ kgm^2$. The ropes are attached at two different distances from the center of the pulley ($R_1 = 30cm$ and $R_2 = 20cm$).

Find the angular acceleration α of the pulley system and the tensions T_1 and T_2.



Identify Essential Steps (decision points)

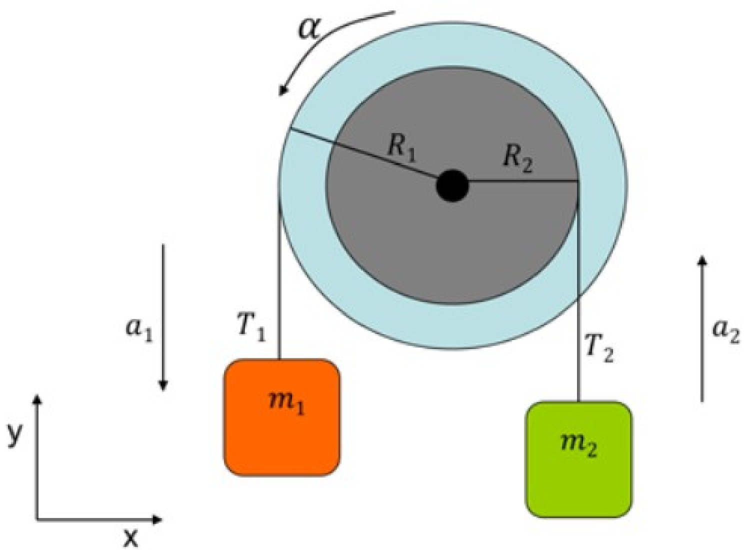


1. Identify principles that will be used.
2. Draw force diagrams of each mass.
3. Choose coordinate system.
4. Apply Newton's second law to each mass.
5. Draw extended FBD for pulley.
6. Apply Newton's second law of rotation to pulley.
7. Recognize that have 3 equations and 4 unknowns, but can relate linear and angular acceleration through $a = r\alpha$.

8. Solve 3 equations with 3 unknowns to get numerical value for α.

9. Use calculated α to calculate T_1 and T_2.

Identify Essential Steps (decision points)



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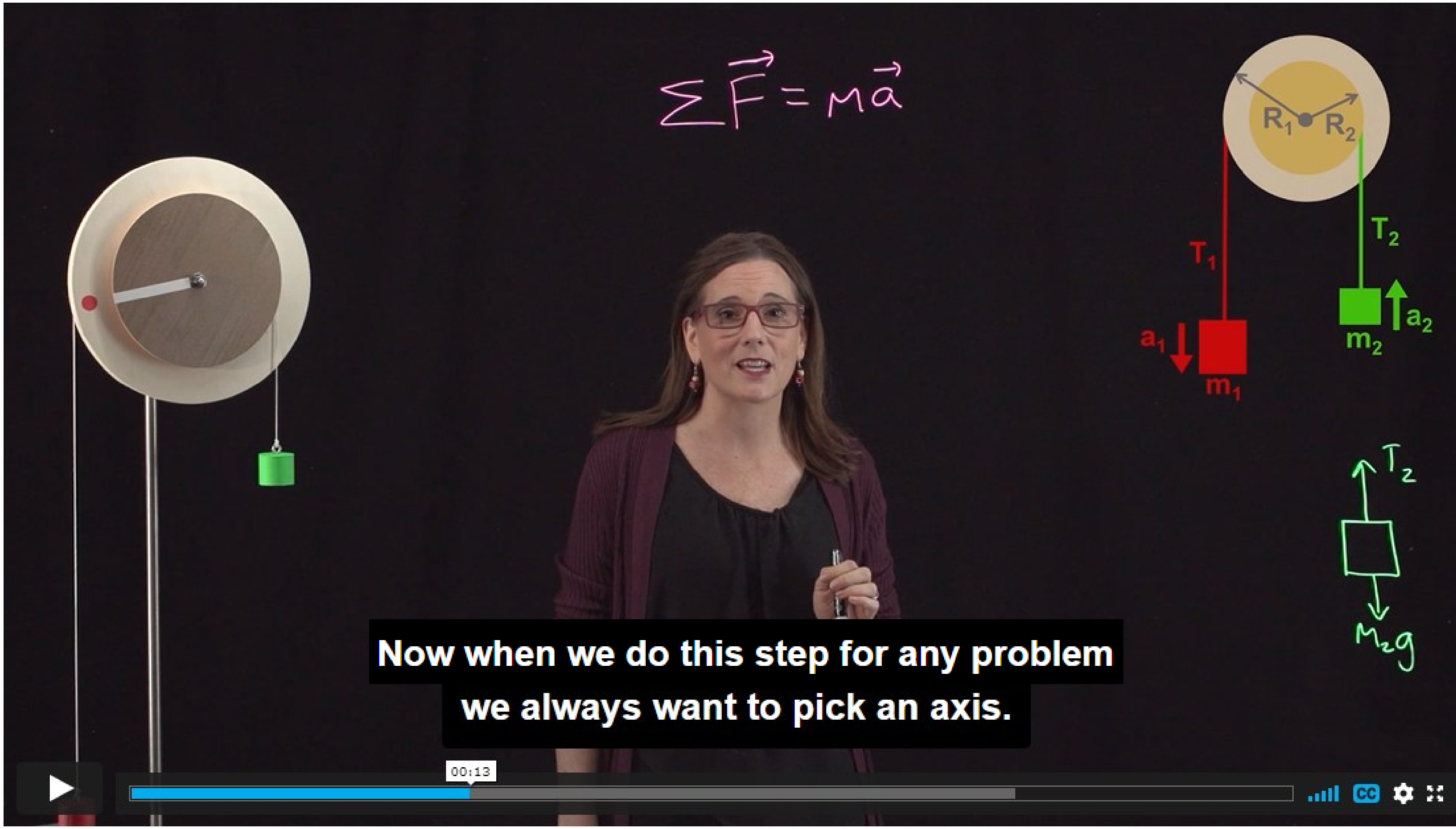
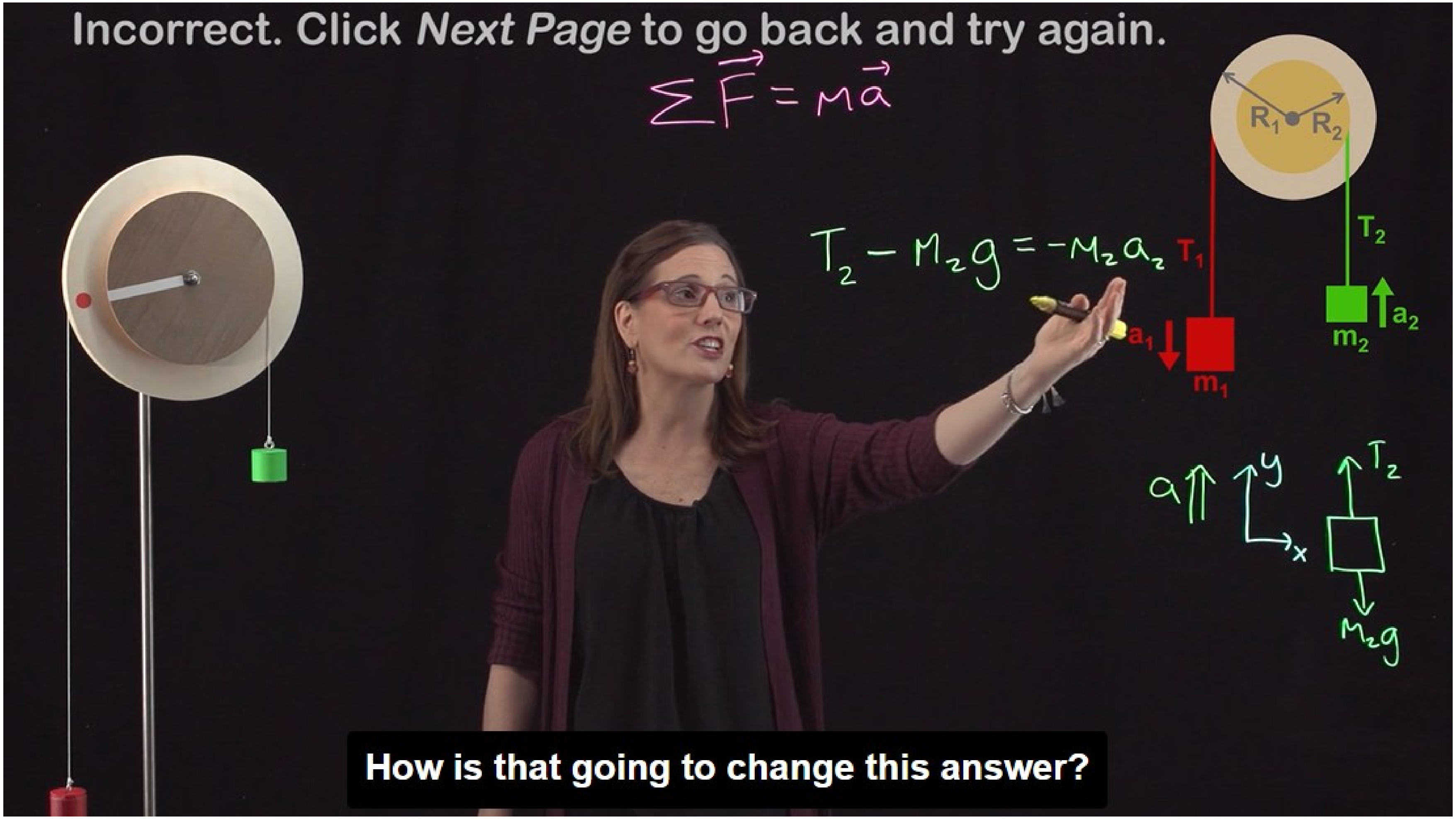


Q4: Which one of the following expressions is a correct statement from Newton's 2nd Law for the forces acting on block 2 parallel to the y-direction?

○ A. $T_2 = m_2 a_2$ ○ B. $T_2 - m_2 g = 0$ ○ C. $T_2 - m_2 g = m_2 a_2$ ○ D. $T_2 - m_2 g = -m_2 a_2$

Feedback provided for correct and incorrect



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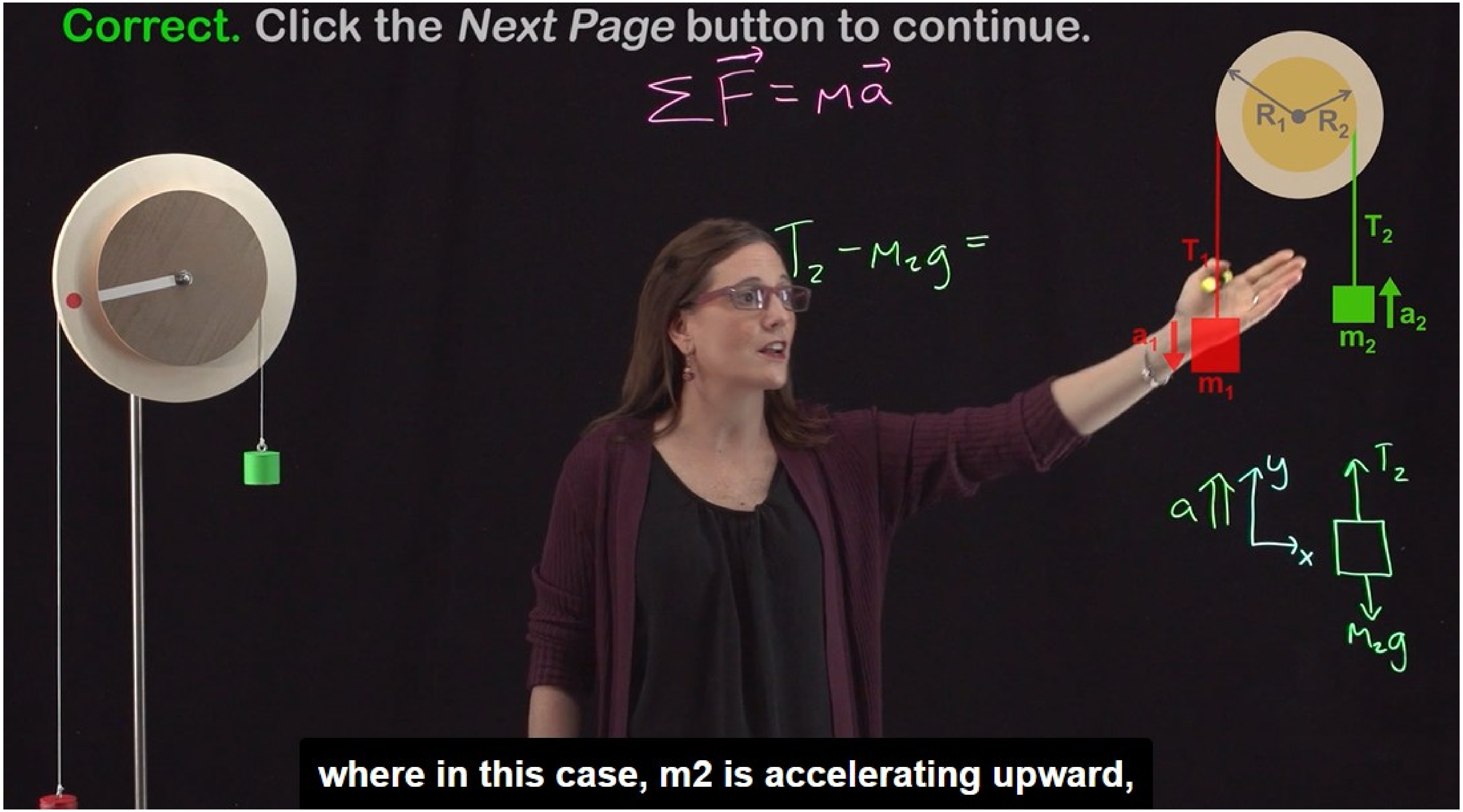

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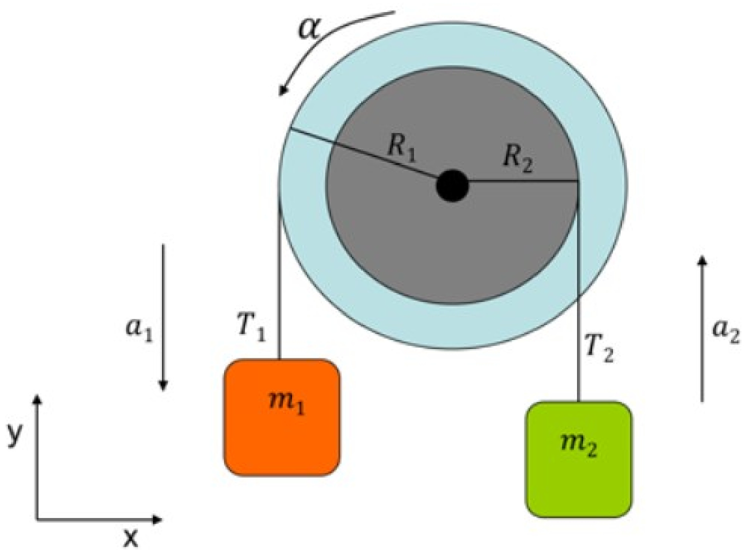

1. Identify principles that will be used.
2. Draw force diagrams of each hanging mass.
3. Choose coordinate system.
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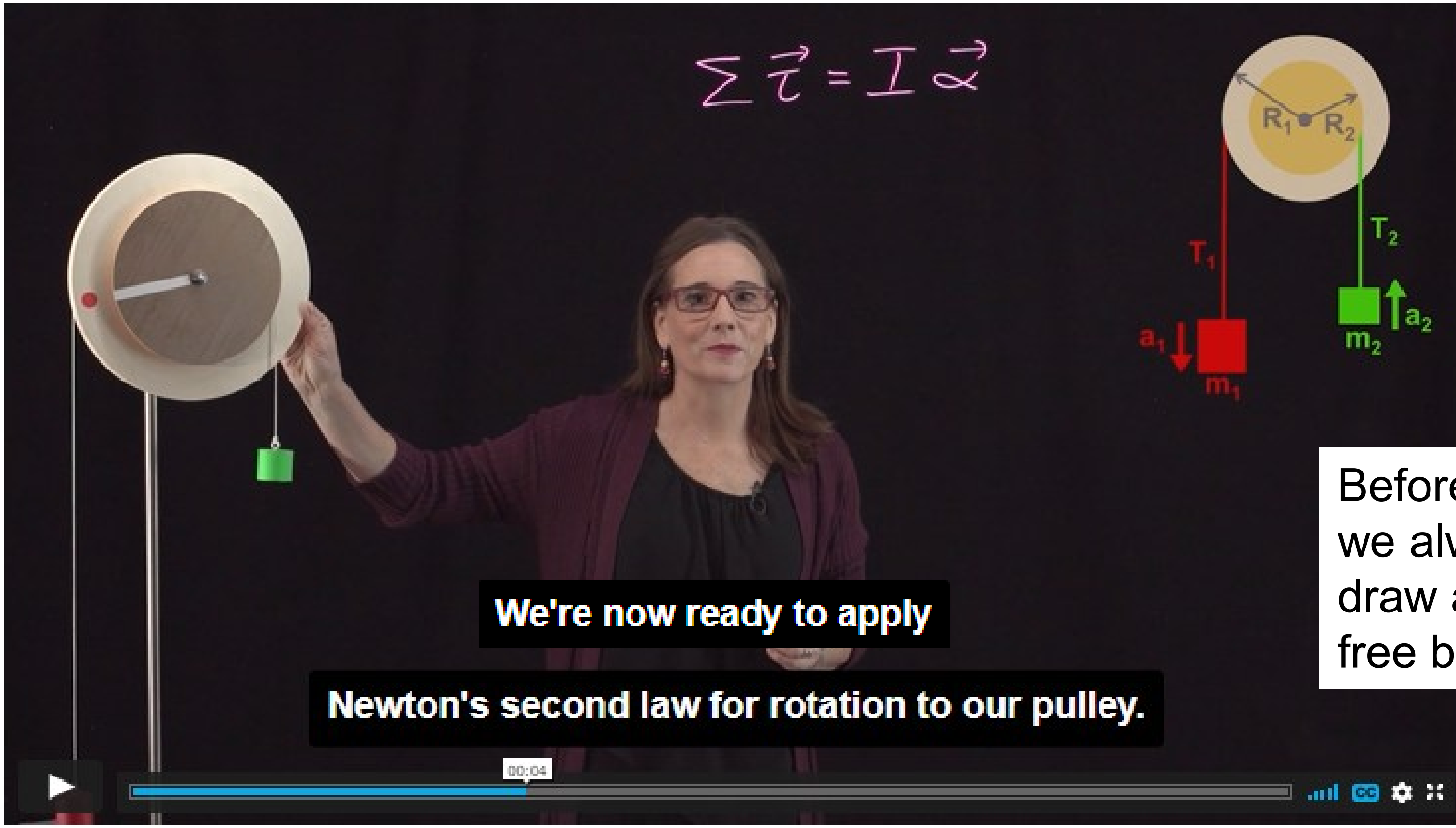
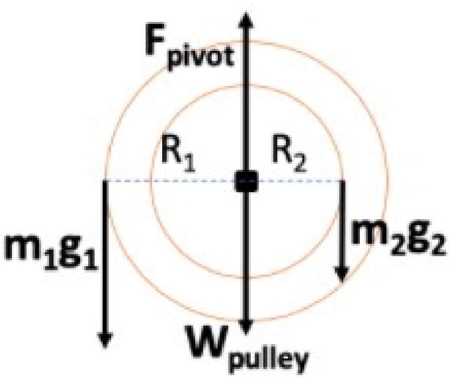


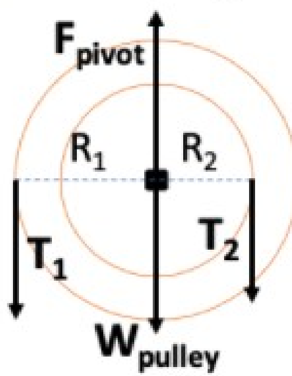
Before we do that, we always want to draw an extended free body diagram.

Q6. Which is the best extended free-body diagram for the pulley?

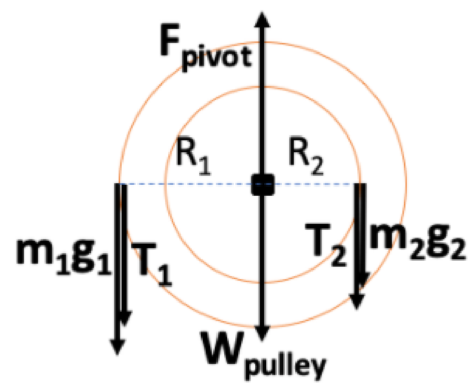
○ A.



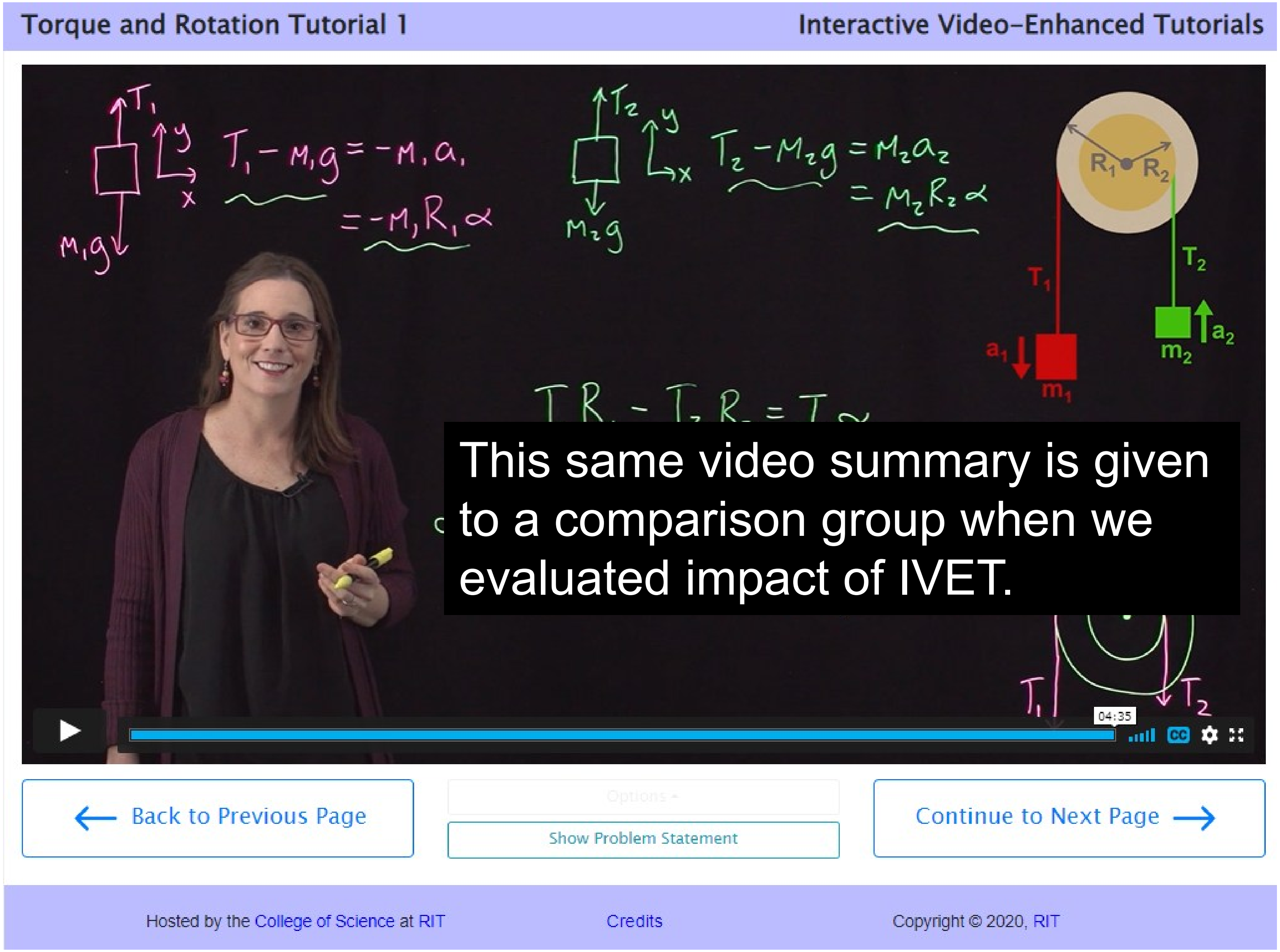
○ B.



○ C.



Video summary is ~4.5 minutes long.



This same video summary is given to a comparison group when we evaluated impact of IVET.

Research

Does IVET impact student problem-solving ability?

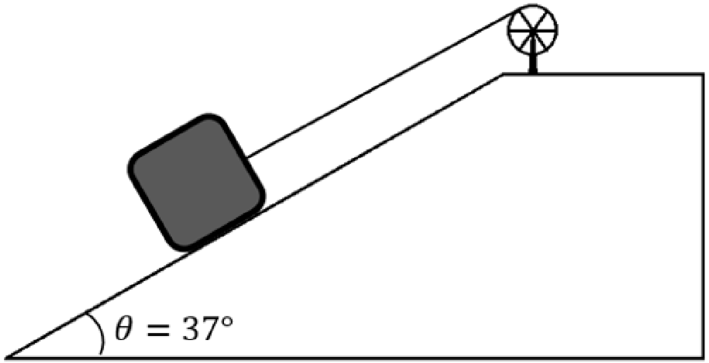
Two sections of calculus-based physics (same instructor)

- One section assigned IVET as HW
- One section assigned the 4.5-minute video summary (solution) in the IVET

Both groups given a **follow-up problem** to complete in class on the day the video assignment was due.

Assessing Impact: Follow Up Problem

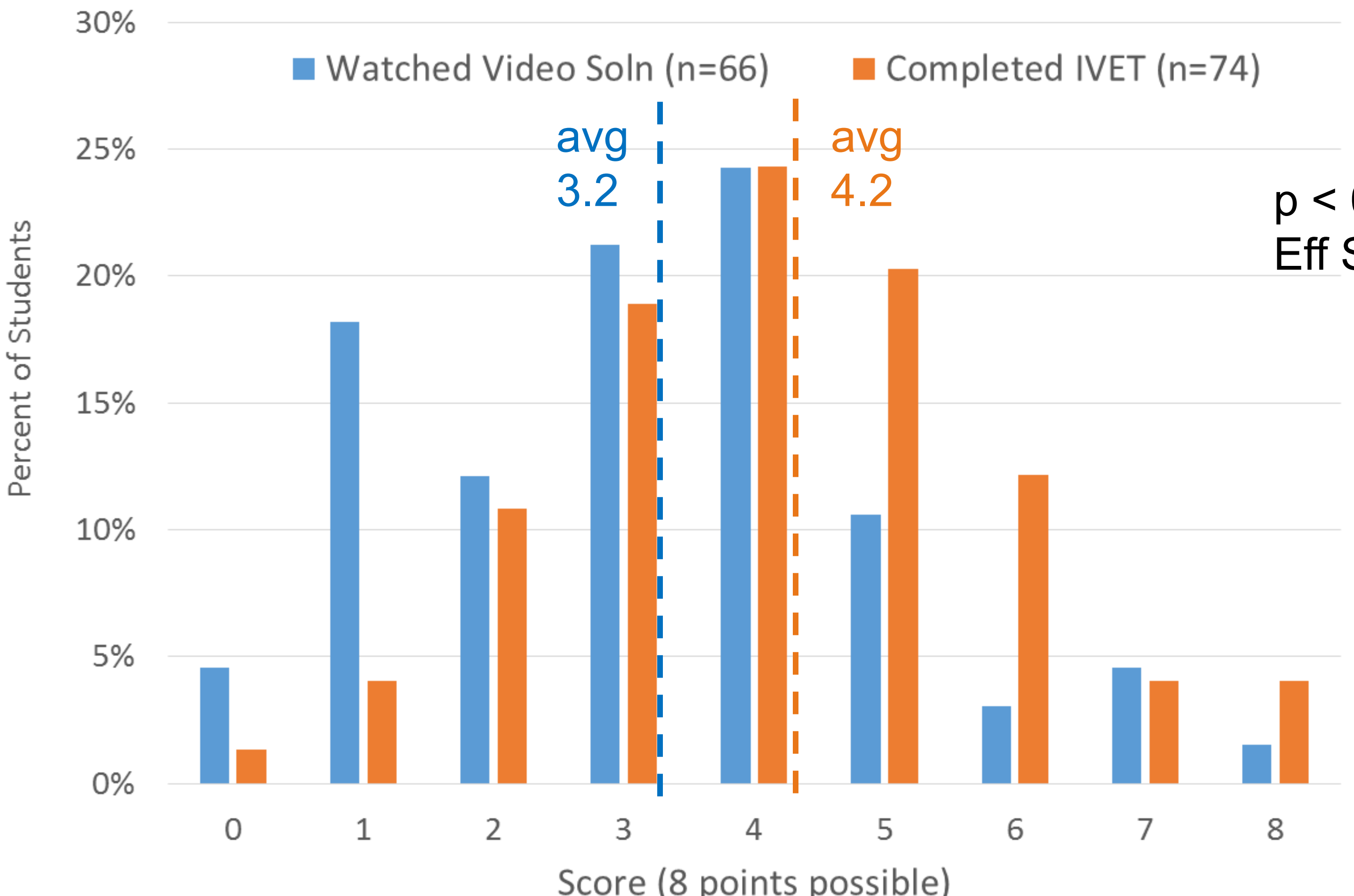
A block is connected to a wheel as shown below. The moment of inertia of the wheel is 8.0 kgm^2, and its radius is 40 cm. Find the angular acceleration of the wheel caused by the downward motion of the 10 kg mass. Assume that the incline is frictionless. Also assume that the string wound around the wheel is massless, the wheel turns without friction, and the string unwinds without slipping.



Identify Learning Outcomes & Create Rubric

(1) Draw a free body diagram for the block shown above
(2) Recognize that the block would accelerate down the ramp
(3) Apply Newton's 2nd Law to block
(4) Apply Newton's 2nd Law to pulley
(5) Generate 2 equations w/ 2 unknowns as part of solution process.
(6) Connect linear and angular acceleration ($a=r\alpha$) and solve.

Torque and Rotation IVET: Results of Scoring Follow Up Problem



$p < 0.001$
Eff Size = 0.55

Torque and Rotation IVET:
Range of solutions presented by students

No Treatment N=65	Video N=66	IVET N=74	Code Description
2.5	3.2	4.2	Mean score (of 8 possible)
3%	6%	10%	Correct solution (includes minor math errors or unit omission)
20%	41%	47%	Correct force diagram included for box on ramp
11%	24%	40%	Recognized need to solve using 2 eqns with 2 unknowns
42%	27%	8%	Appeared to have no plan

Research Outcomes for Multiple IVETs

Students who completed IVETs more likely to:

1. Recognize and apply physics **principles** to solve problem
2. **Solve problem in parts** rather in a single step
3. Make **correct assumptions** in solution
4. Approach problem with a **plan** vs using random equations

Our outcomes suggest that the interactive nature of the IVETs better engages students in the learning process over video.

Summary of *Essential Features* within IVETs

Create a…

- **personal** experience (ex. reproduce language with student in office hours)
- **motivating** experience
  - narrator's demeanor and language - "Yes! That is correct!" or "Almost!...."
- **effective learning** experience
  - use of short videos (text) interspersed with interactivity; gesturing
  - scaffolding through multiple choice questions
  - add'l *information* provided for better understanding problem-solving process
  - immediate, direct, discriminating feedback (e.g. resolve confusion)
  - hints and just-in-time explanations
- experience to **build confidence**, make more self-reliant
  - reflection problem at end to "try on your own" (answer, not solution provided)

Findings from Student Interviews

Students reacted positively to narrator

- Nodded head, made remarks during feedback (ex. “got it”, “ah”)
- Appreciated “gentle” feedback when incorrect
- Cheered/commented when correct
- Enthusiasm and support motivated students to keep going

- More likely to do something when asked by narrator
- Didn’t fast forward videos

Student Survey Findings

Preference for video or text when navigating IVETs and why this choice:

82% usually chose video (ChatGPT provides only text!)

Most indicated liked audio with visuals: better learning, easier to take notes

7% usually chose text (faster, already understood material)

7% switched between video/text (location where completed IVET)

What aspects of IVETs were helpful to learning and shouldn't be changed?

45% step-by-step nature of solution with narrator

22% solutions and hints when incorrect (and correct)

19% m.c. questions engaged them and checked their understanding

6% connection to similar problems in WebAssign HW

7% keep reflection problem at end of IVET for own practice

n = 196, FS22 PHYS 2001 (Koenig)

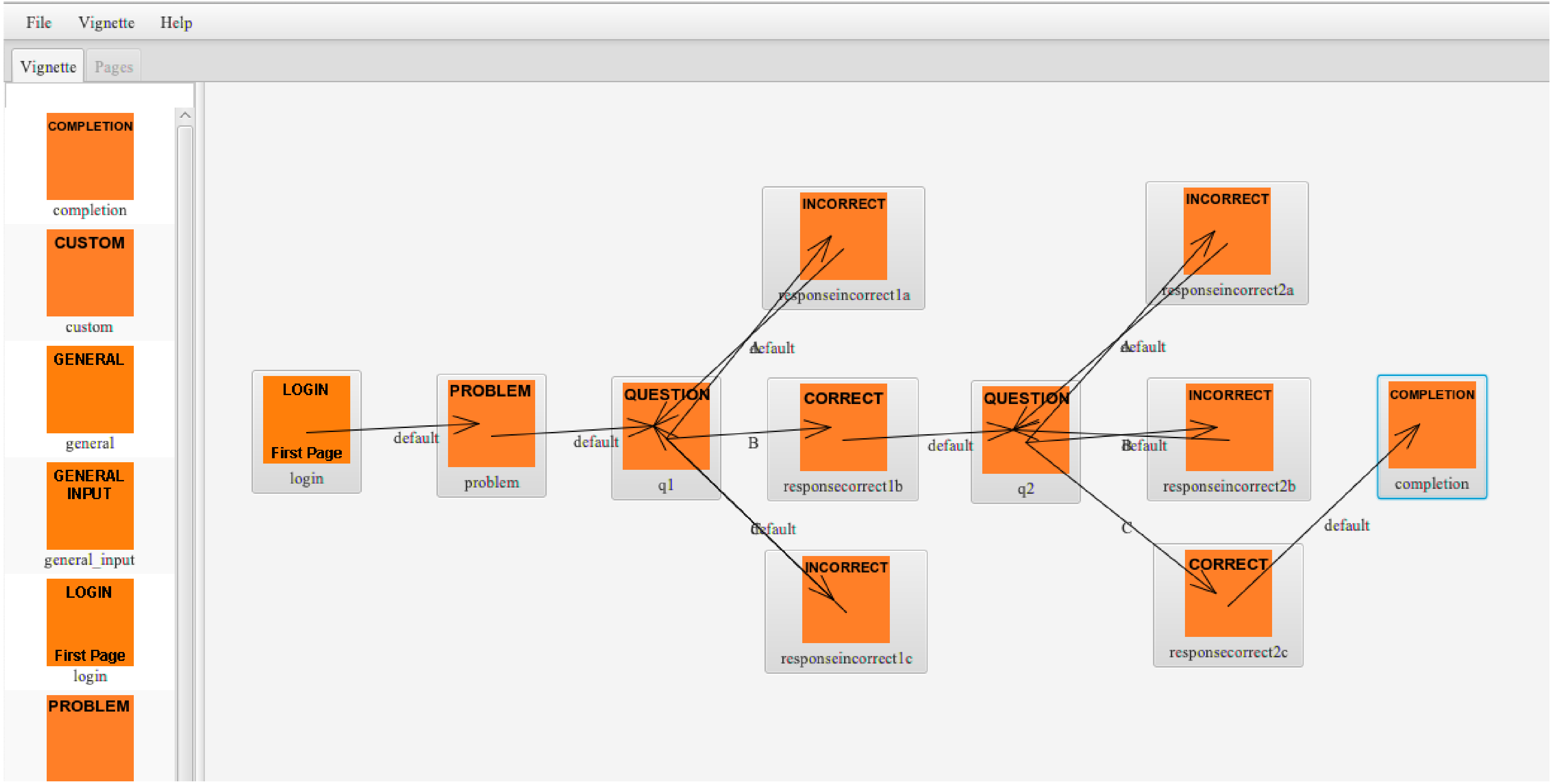
Best Practices for Implementation

- **Promote value**
  - Make integral part of course (e.g., regularly assign through Canvas, etc)
  - Assign IVETs alongside related WebAssign homework problems
  - Assign IVET for completion credit in Canvas
- **Promote accountability**
  - Students submit written solutions to narrated problem
  - Students submit written solutions to “try on own” problem (required for pts)
- **Provide students with control**
  - Can complete as many times as desired and/or rewatch videos
  - No point deduction for incorrect responses within IVET
  - Appropriate timeframe to complete

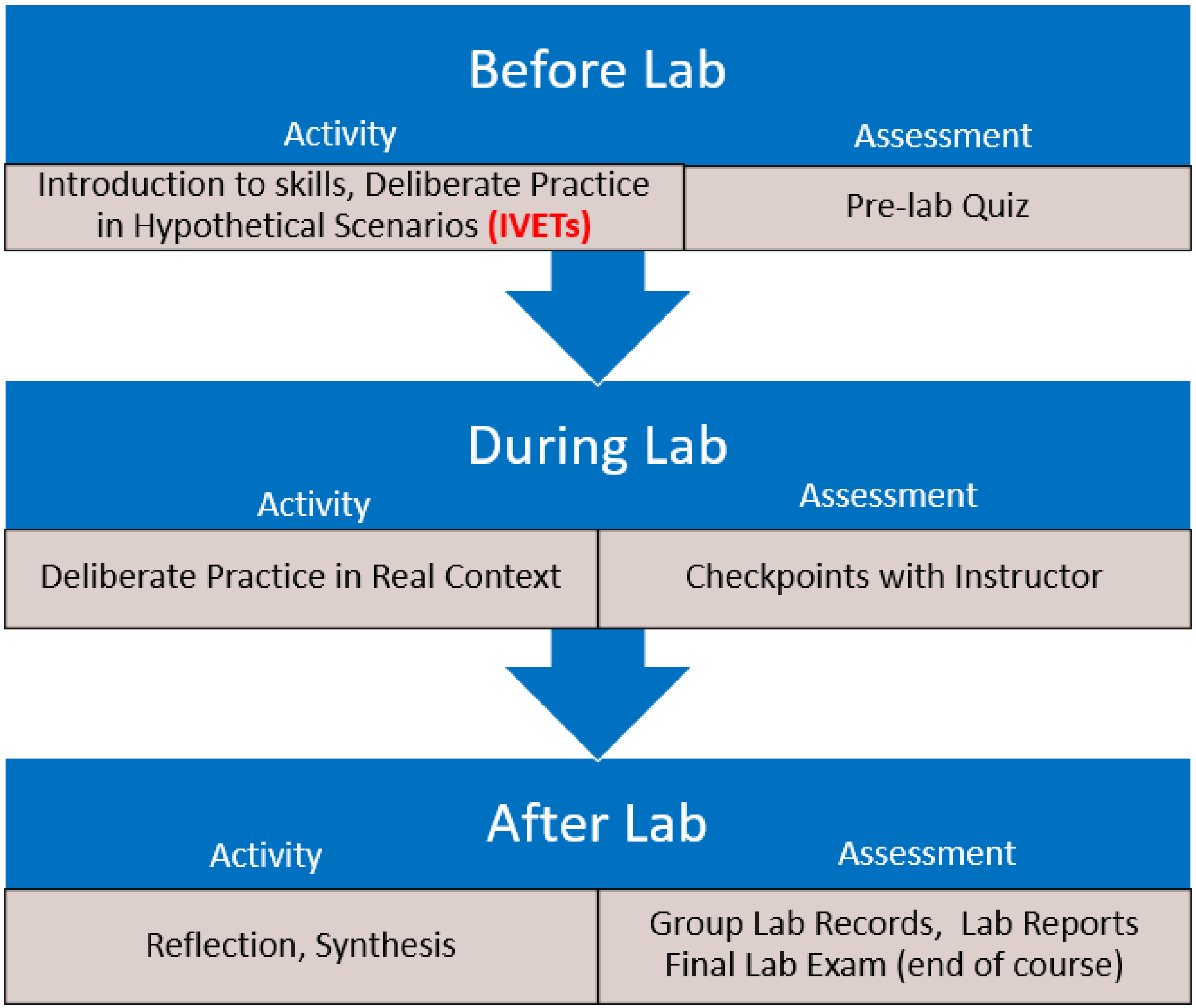
Create your own IVETs

Vignette Studio II software with printed manual or video guidance: www.compadre.org/IVET/

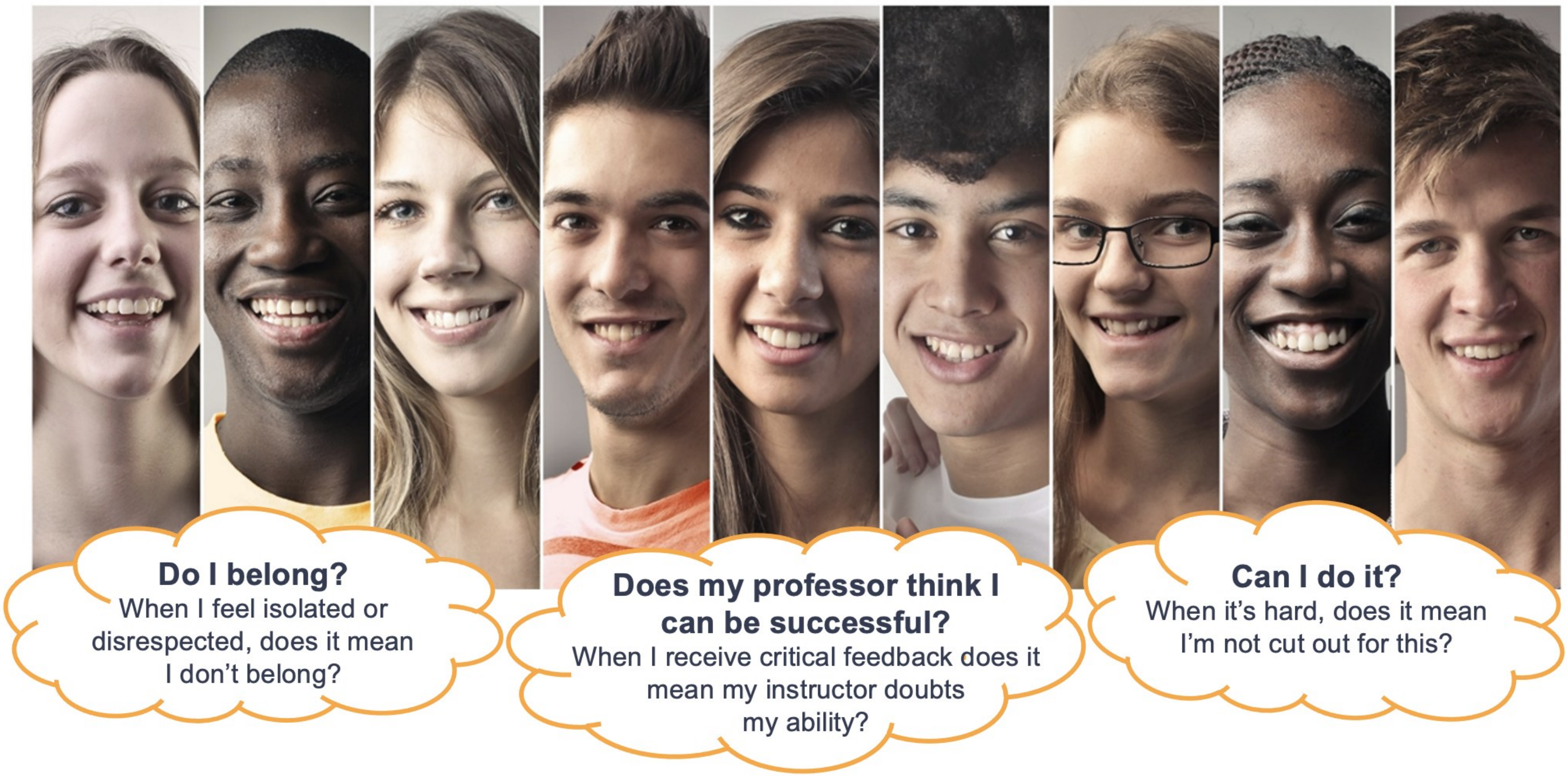
Involves dragging and dropping “pages”; requires basic familiarity with HTML; embed videos from YouTube videos, Vimeo, etc.)



Pre-lab IVETs

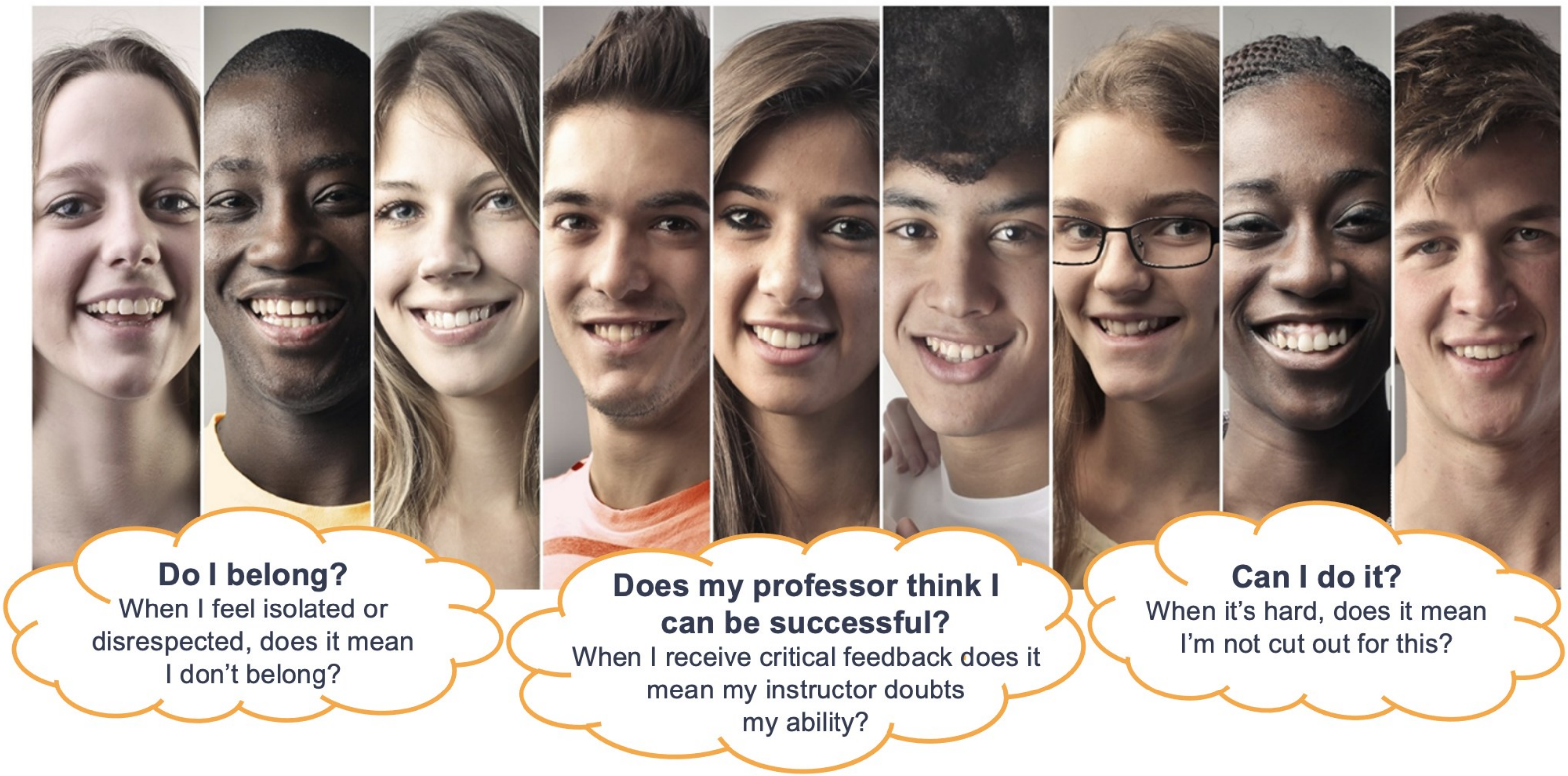


Students new to college, and at transitional moments throughout college, ask themselves key *questions* about whether they belong and if they can succeed.



Students' answers to these questions are informed by environmental and interpersonal cues from institution, instructors, and other students.

Conclusions they draw can influence how they face challenges, ultimately affecting success and retention.



Students who feel like they belong are more likely to:

- actively participate in group problem-solving
- ask questions or seek help

And are less likely to experience stress or be distracted.

Purposeful Interventions to Shift Mindsets

Brief exercises that target students' thoughts, feelings, and beliefs in and about school.

- Yeager, D. S., & Walton, G. M. (2011). Social-psychological interventions in education: They're not magic. *Review of educational Research*, *81*(2), 267.
- Walton, G. M., & Cohen, G. L. (2011). A brief social-belonging intervention improves academic and health outcomes of minority students. *Science*, 331(6023), 1447-1451.

Activities designed to encourage students to think about their place in school in more hopeful, optimistic ways.

- Aguilar, L., Walton, G., & Wieman, C. (2014). Psychological insights for improved physics teaching. *Physics Today*, *67*(5), 43-49.

First Day of Class: Brief Writing exercise

At the end of class, provide students with a quarter sheet of paper and give them 5 minutes to anonymously address the following:

1. What are you concerned about? Write down a few things in terms of college, this course, your major, etc.
2. How do you think these concerns will change over time?

Do not put your name on it. It will not be graded. But please be honest!

Collect the sheets. Read and tally responses before the next class.

Second Day of Class: Writing Exercise Follow Up

Show students the common concerns that emerged:

~60% not smart enough/do not have *right* knowledge/others smarter

~50% time management/keeping up with classes

~20% not being suc

~15% finding frienc

~5% concerned cos

Take-away message:
We share many of the same concerns.
We are ALL in this together.

Concerns will change over time…

As I get in a rhythm | If I stay focused | As I figure things out

Through practice, experience, hard work | Work with classmates

If I set up good habits | I don't expect things to get better

Investigating Impact of Interventions

Treatment Group: Two sections of Calculus-based Physics I

(Active Learning, Belonging Interventions)

Comparison Group: Two sections of Calculus-based Physics I

(Limited Active Learning, No Belonging Interventions)

All students given a *belonging* survey on first and last day of class.
All students given the same exams.

Fall 2022

Understanding the student experience: an important part of teaching and learning

Sense of belonging:

I feel comfortable in this class.

Sometimes I worry that I do not belong in this physics class.

I feel like an outsider in this class.

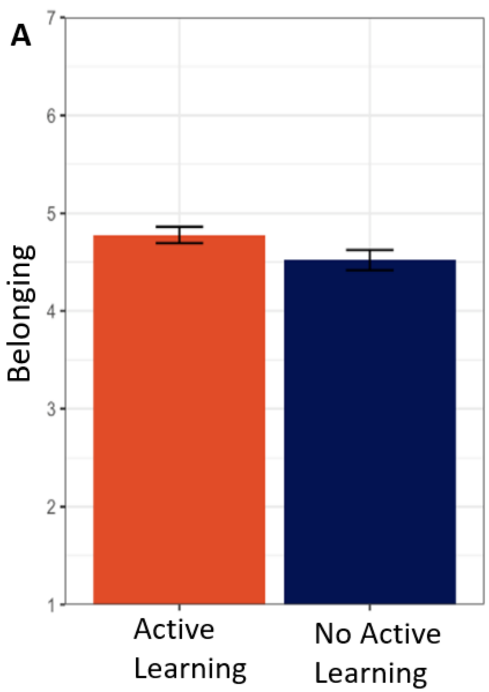
I feel like I can be myself in this class.

I feel like I belong in this class.

7-point Likert scale: 7=strongly agree, 4 = neutral, 1=strongly disagree

Kalender, Z. Y. et al. (2019). Gendered patterns in the construction of physics identity from motivational factors. *Phys Rev: PER*, *15*(2), 020119.

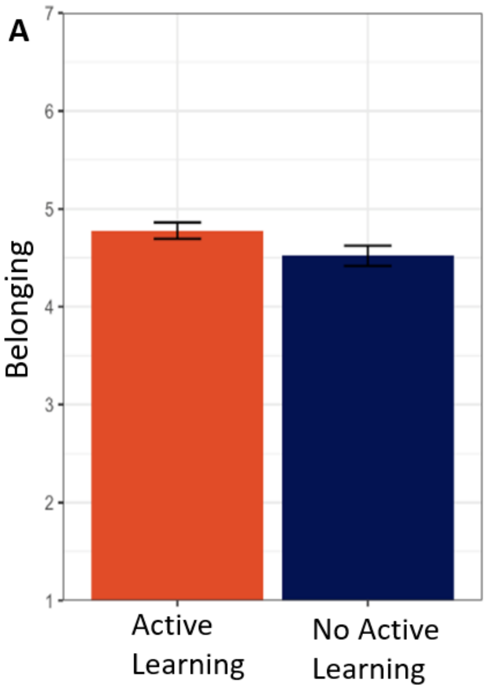
Study Outcomes



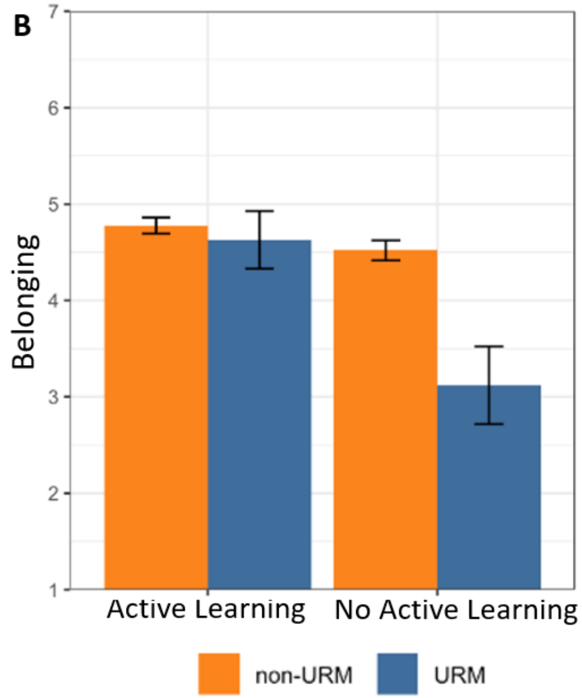
Post-Survey

7-point Likert scale: 7=strongly agree, 4 = neutral, 1=strongly disagree

Study Outcomes



Post-Survey



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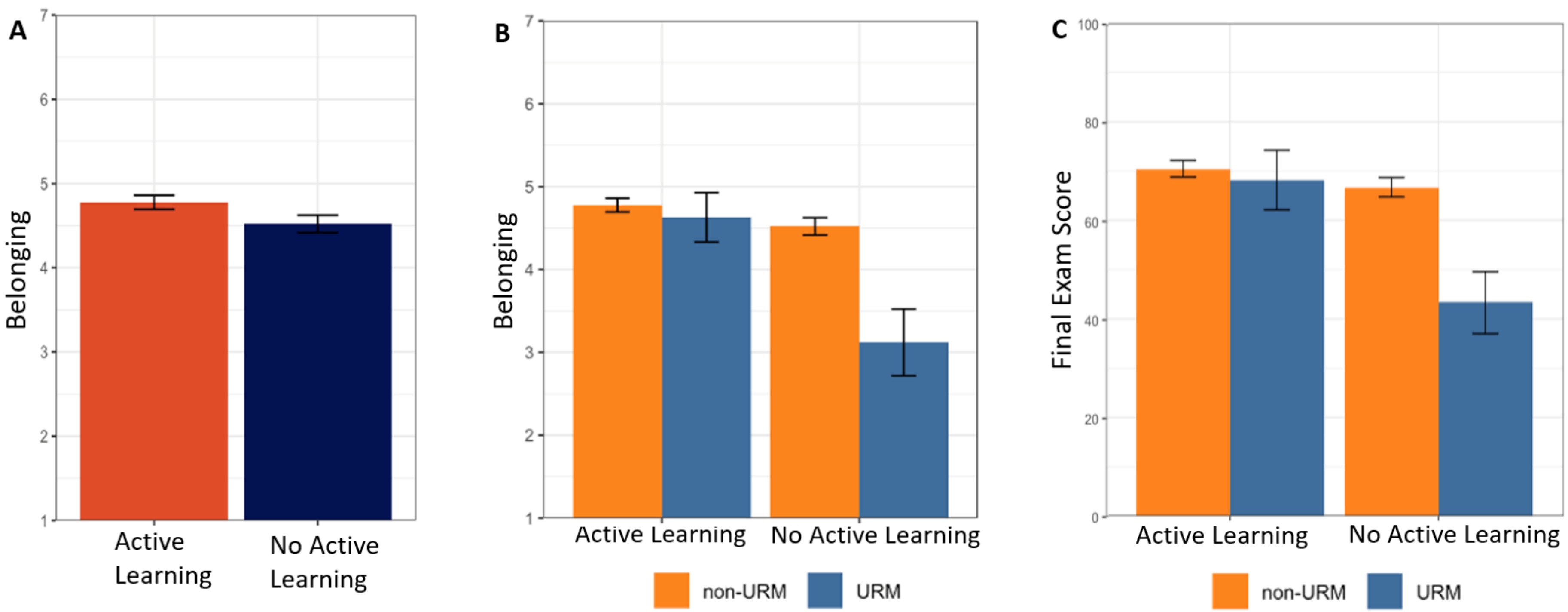

Post-Survey

Post-Survey

7-point Likert scale: 7=strongly agree, 4 = neutral, 1=strongly disagree

Current NSF Funding

Create 4 Interactive Online Interventions (IOIs)

- 3 piloted in SS25 in introductory physics (n = 800)

Evaluate IOIs using:

- Log files - determine engagement to inform revisions
- Pre-Post-belonging surveys

Summer 2025

- Revise IOIs based on pilot
- Full implementation and evaluation FS25+

NSF IUSE DUE 2416548

Interactive Online Intervention:
What worries you?

What Worries You? | Interactive Online Interventions

In the textbox, type a few sentences about what you are most concerned or worried about right now.

asdf

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Concern	%
Workload, fast pace, falling behind Time management	57%
Ability to succeed Develop good study strategies Understand material, do well on exams, get good grades	47%
Balancing school with extracurriculars Making friends, maintaining a social life Finding a study group	8%
Other: Large classes Finding a job or internship Away from home Uncertainty about choice of major	17%
No concerns	3%

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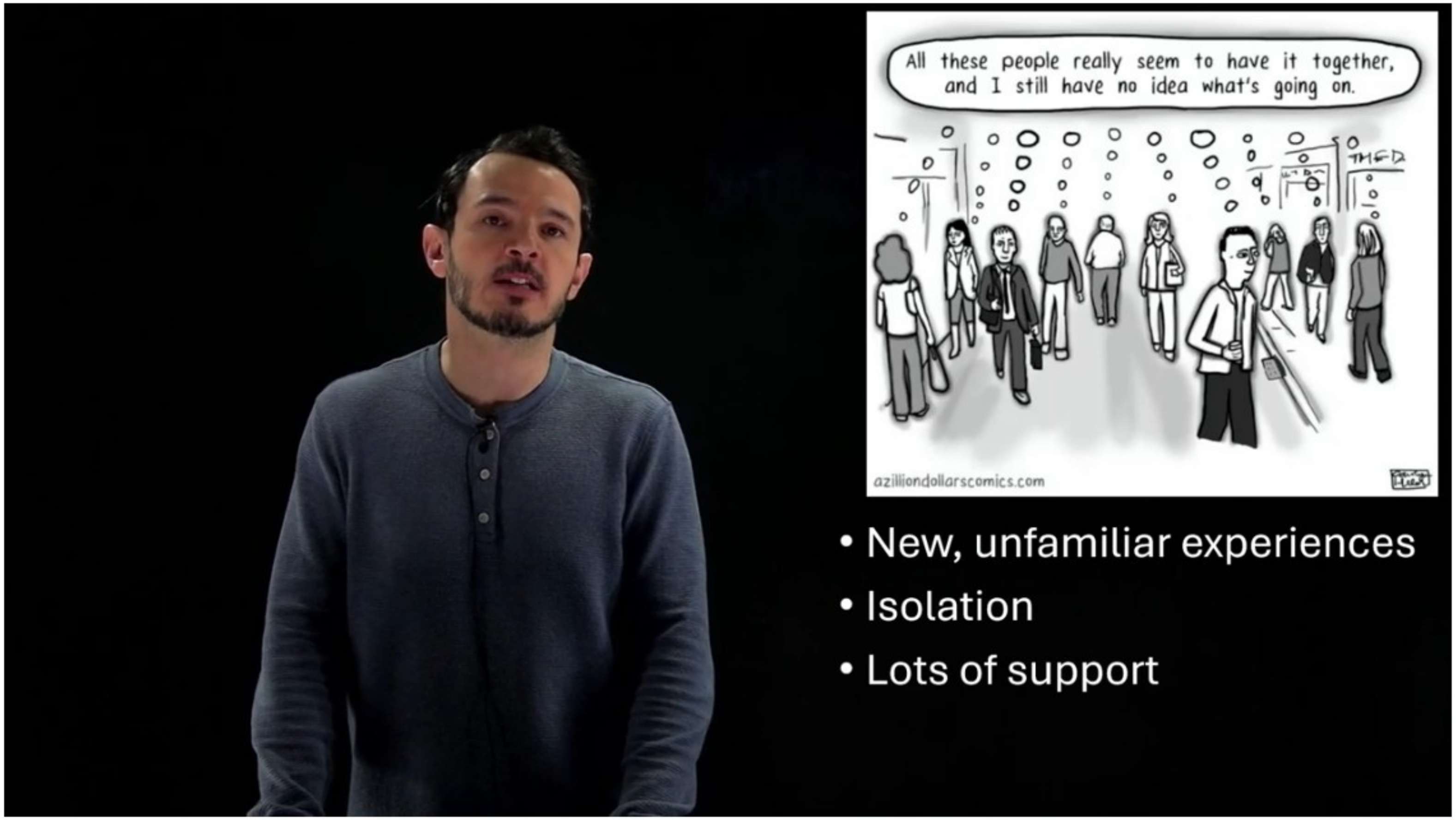

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Select the video you would like to watch, then click the *Next Page* button

Meet Nathan,
Computer Sciences senior.

Meet Allison,
Mechanical Engineering senior.

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Think back to the concerns you wrote earlier. In the text box below, write at least two specific actions that you plan to take immediately to help address those concerns.

Enter your answer here

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Questions?

compadre.org/ivet

IVETs are freely available for download into LMS's
or can give students a link.

IOIs available upon request.

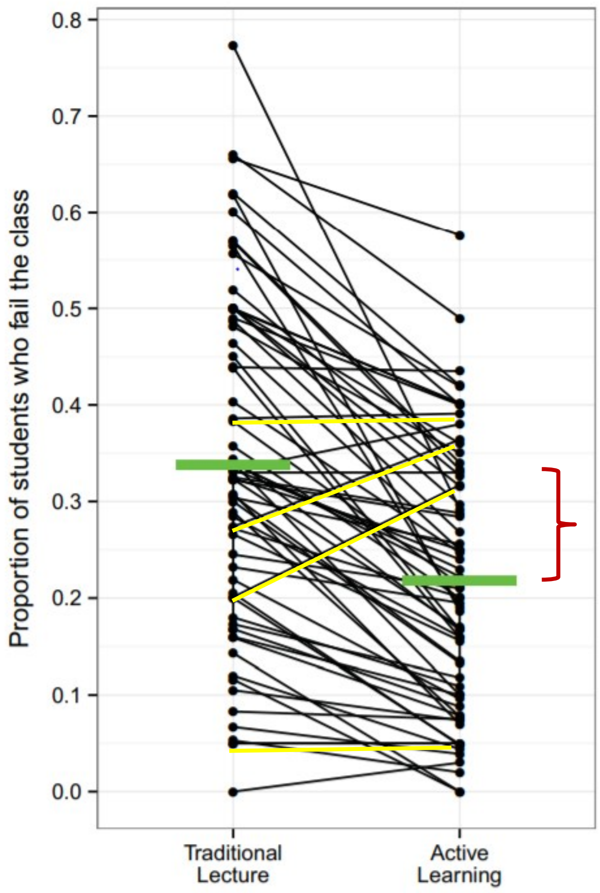
kathy.koenig@uc.edu

Making the case for Active Learning

Meta-analysis* of 225 studies that compared impact of lecture versus active learning on failure rates.

The research is clear. Lecture-based instruction does not produce effective learning for the majority of students.

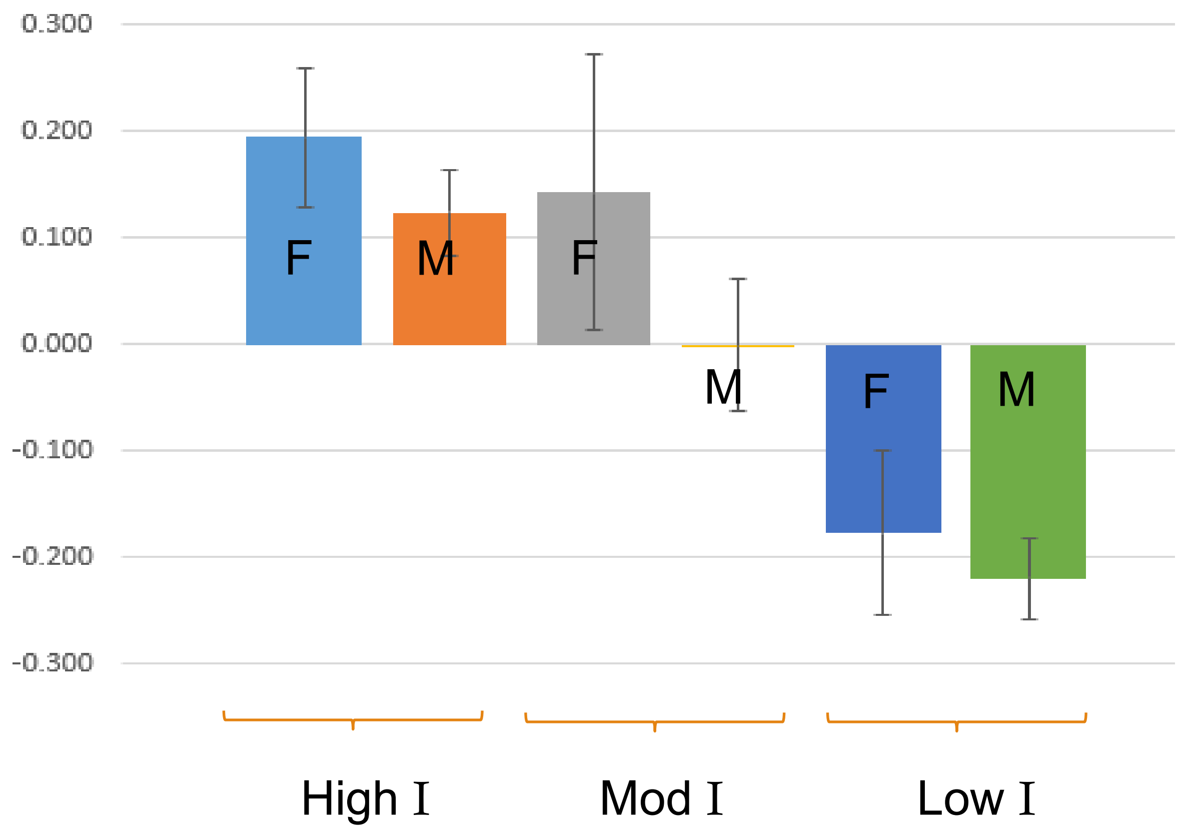
*Freeman, Scott, et al. (2014) Active learning increases student performance in science, engineering, and mathematics. N*ational academy of sciences* 111.23: 8410.



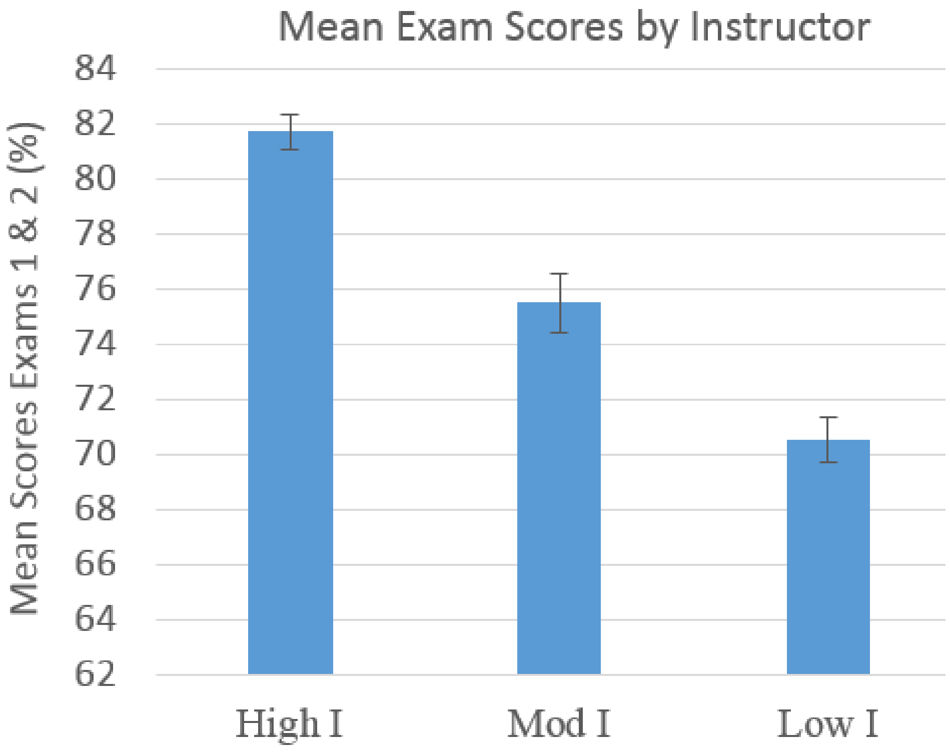
On avg, failure rates 55% higher for trad'l lecture

Theobald, E. J. et al. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate STEM. *PNAS*, *117*(12), 6476-6483.

Mean Change in Sense of Belonging by Gender



Results from exam performance



Differences should not be attributed to use of active learning or inclusive teaching strategies alone.