Coding Integration in Introductory STEM Courses

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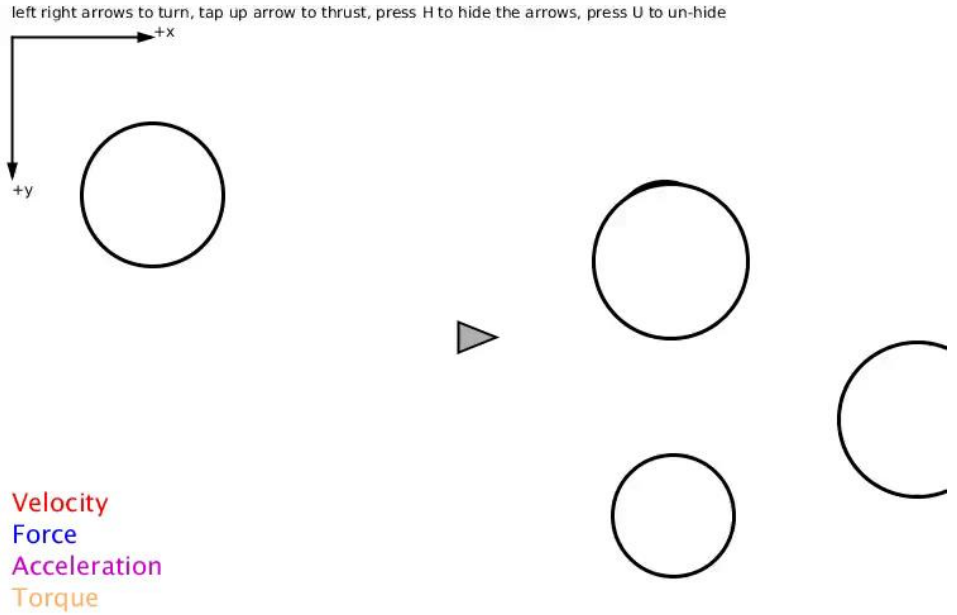

Presented at the PKAL 2018 Conference, The University of Mount Union

THE OHIO STATE UNIVERSITY

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UNIVERSITY of MOUNT UNION
Be Exceptional

Why are we passionate about introductory physics activities?

- Most of the students who take physics are in non-major introductory courses – this is the biggest audience we have
- Intro courses are BORING!
- If we care about diversity, we should care about engaging the students in our introductory courses.
  - Students from underrepresented groups might leave STEM before they ever get to the *fun stuff*
    - And before they ever get exposed to coding…
- We want to develop fun, engaging material that introduces students to coding, and makes them want to come back for more.

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Our goal

- Break the mold
  - Allow students to see themselves as a person who codes
  - Remove the ‘fear of the unknown’
- Have fun
  - We can’t teach them all there is to know about programming in a couple hours. This is not a computer programming course.
  - We want them to have fun.
  - We want them to get excited about programming and come back for more.

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What does the student see?

```
x = 0;
y = 0;

vx = 0;
vy = 0;

dt = 0.1;

function draw(){

    // Update location
    x += vx*dt;

    // velocity is zero unless keys are pressed
    vx = 0;

    // Turn or thrust the ship depending on what key is pressed
    if (keyIsDown(LEFT_ARROW)) {
        // Do nothing
    }
    if (keyIsDown(RIGHT_ARROW)) {
        vx = 10;
    }
    if (keyIsDown(UP_ARROW)) {
        // Do nothing
    }
    if (keyIsDown(DOWN_ARROW)) {
        // Do nothing
    }

    // Draw axes and other stuff
    // This will clear the screen and re-draw it
    display();

    drawBlob(x,y,vx,vy);

    // Add more graphics here before the end of draw()

} // end draw()
```

- Focused on the lines of code containing the relevant physics content.
- Hide everything else
- Remember… many of these students will be absolute beginner programmers.

Design Goals:

- Simplicity – involving fewer than 75 lines of well-commented code
- Easy-to-access and Easy-to-use – e.g. with browser-based coding tools
- Step-by-step – with the ability to interact with intermediate stages of the “correct” program
- Thoughtfully integrated – e.g. by illustrating velocity and acceleration vectors

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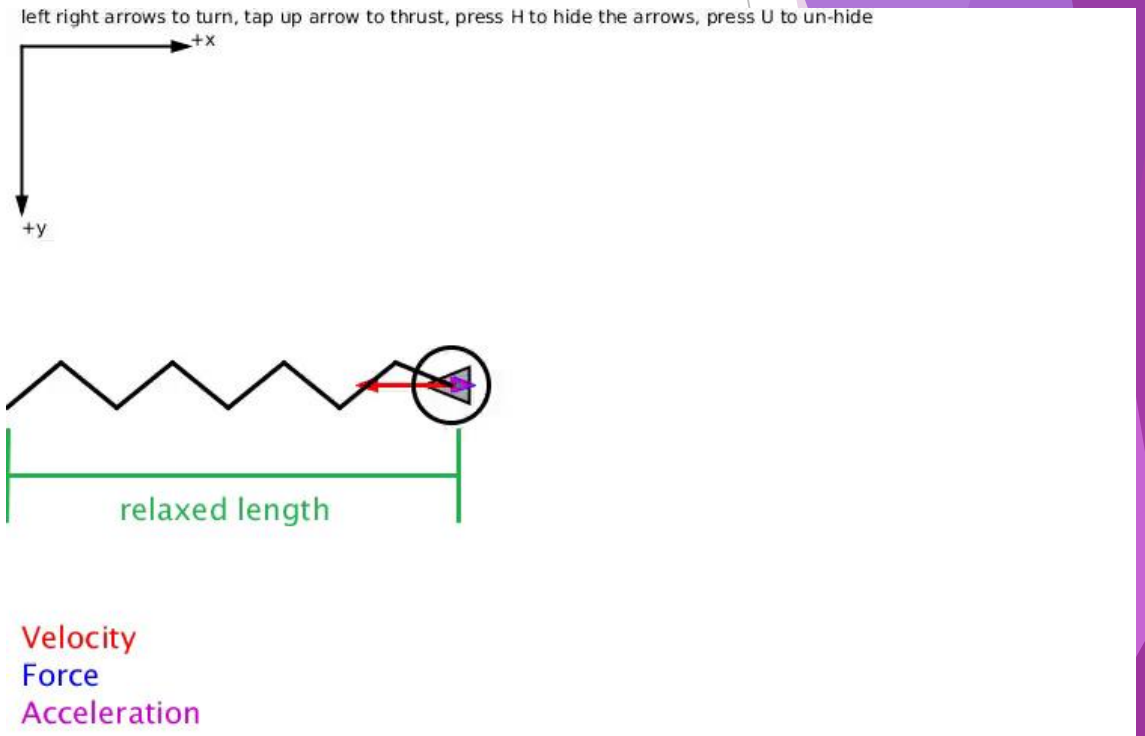
STEMcoding Programming Content

- Move the blob!
- Accelerate the blob
- Planetoids (like Asteroids)
- Lunar Lander
- Bellicose Birds (like Angry birds)
- Planetoids with momentum
- Planetoids with torque
- Planetoids with a spring (harmonic motion)
- Bellicose birds with energy
- Pong!
- Slingshot with gravity (Astronomy!)



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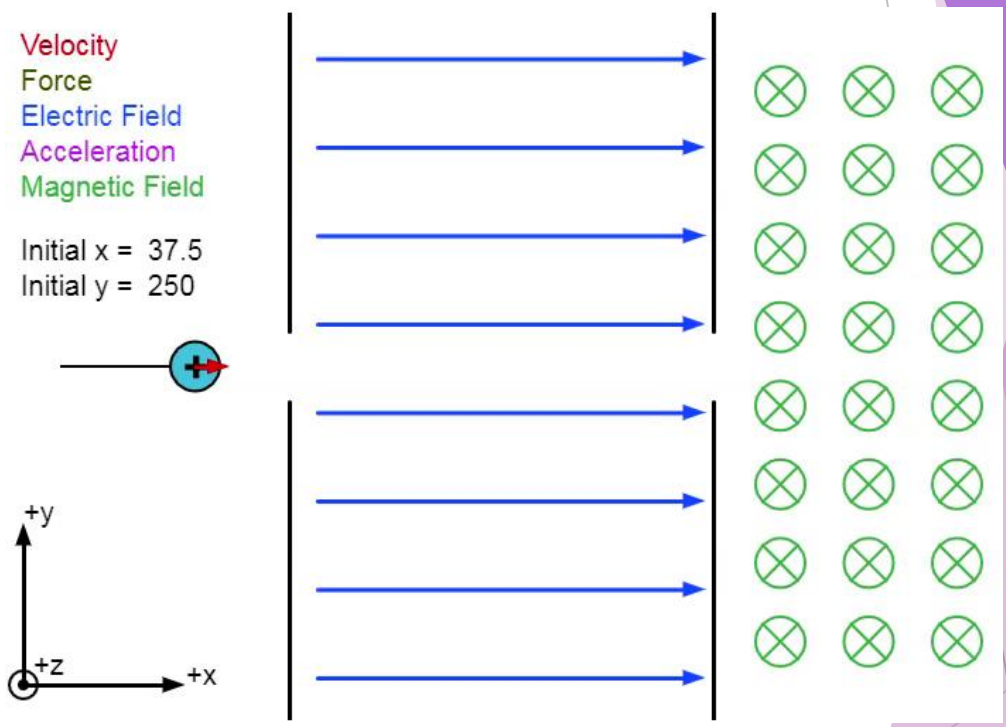
STEMcoding Programming Content

- Particle accelerator (constant E field)
- Particle accelerator (electric potential)
- Particle repulsion
- Discharging RC circuits
- Particle deflection in a magnetic field (mass spectrometer)
- 2D Wave interference (ripples on a pond)
- Thin film interference



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Integrating these activities into an actual classroom…

- What are the challenges?
  - TIME!
  - We already cover a HUGE amount of content in introductory courses.
    - I cover 14 chapters, 2 midterms, and a final in 16 weeks
    - We have 14 hands-on labs in 16 weeks
  - So how do you make the time?
    - Do it in class?
    - Assign it as a homework?
    - Do it in lab?
  - What do you take out to make room?

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How we did it at Mount Union

- Our labs are modular
  - 3 or 4 45-60-minute activities each lab
  - Of ~50 activities we do in the semester, we substituted 6 of them with equivalent coding activities. (~12%)
    - Equivalent in regards to content: Same concepts covered by the coding activities
    - Equivalent in regards to time: Each coding activity requires 45-60 minutes
- One additional homework assignment
  - We started the students in PHY102.
  - They needed to see the introductory mechanics programming exercise to become acclimated to the coding environment and learning management system.

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Integrating these activities into a classroom…

- What else?
  - Training teachers, lab instructors, and TAs
    - Teachers in high schools with no prior coding experience? - See our Youtube channel and check out our teacher training course in the summer (for continuing education credit)
    - Lab instructors and TAs require additional training – as with any curriculum change
  - Bugs in the learning management system

- With each of these we saw significant improvement from semester 1 to semester 2.
  - We all survived!

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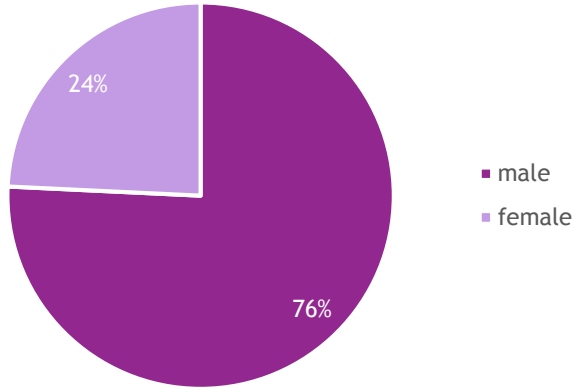
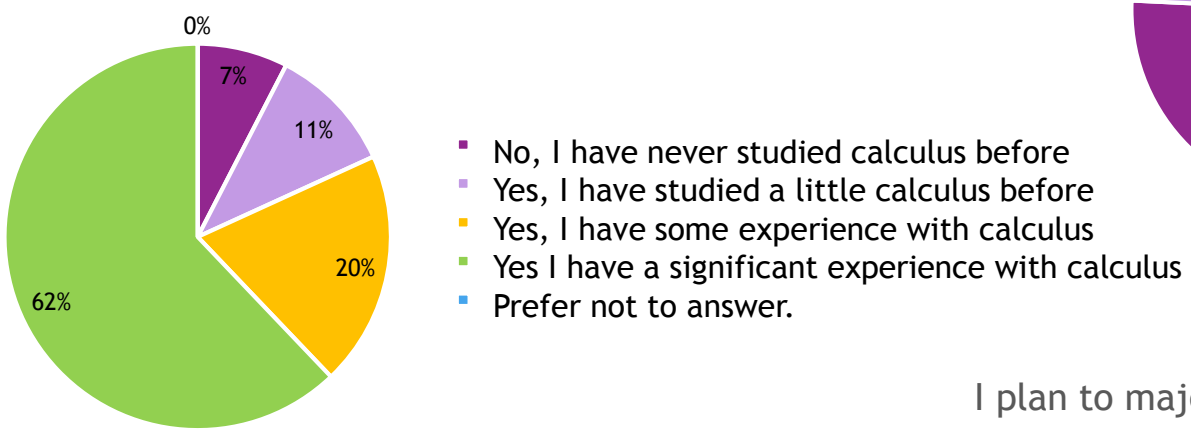
Who are our students?

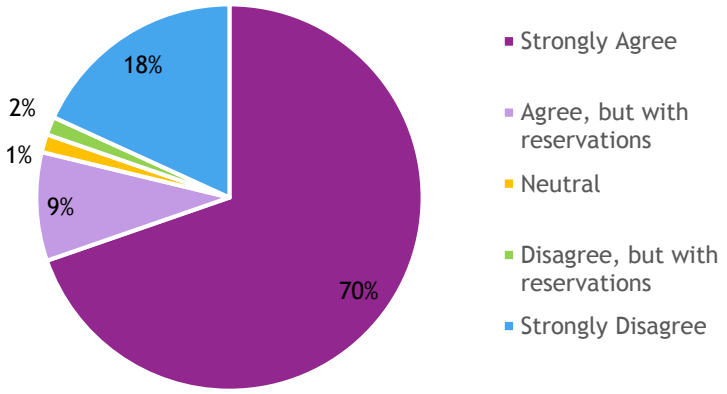
Breakdown of Students by Gender



Have you ever studied calculus?



I plan to major in STEM



Data from 66 students, taken over Fall 2017 and Spring 2018 in PHY102

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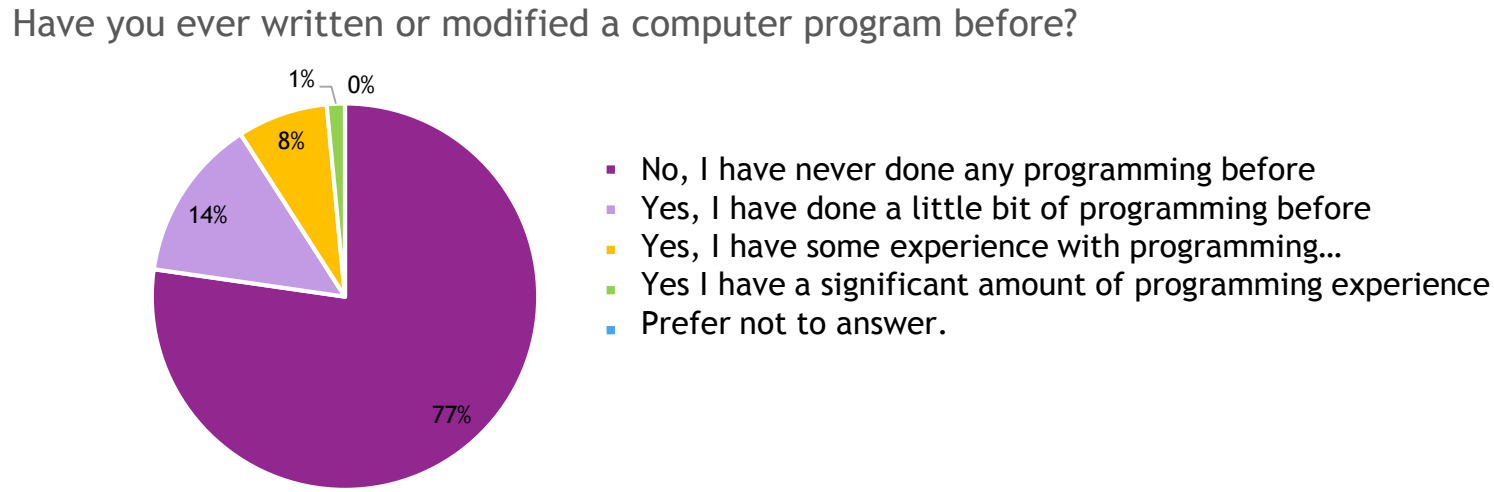
Have you ever written or modified a computer program before?



Data from 66 students, taken over Fall 2017 and Spring 2018 in PHY102

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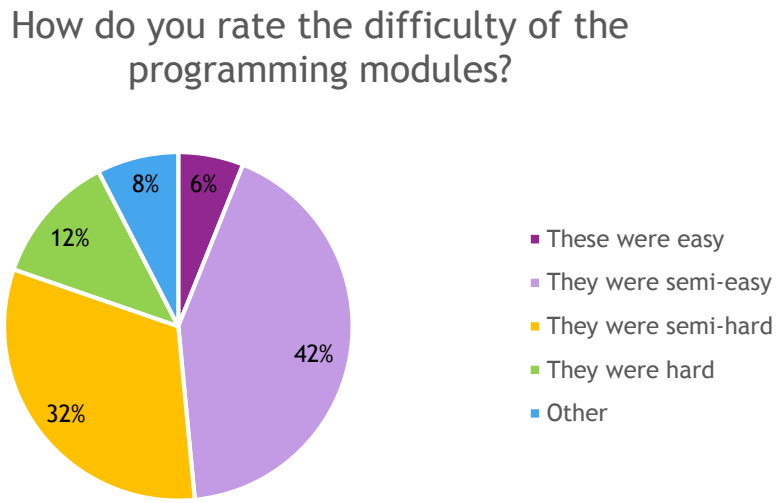
How did they rate the modules' difficulty?



Data from 66 students, taken over Fall 2017 and Spring 2018 in PHY102

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Assessment Questions

- Similar to FCI and BEMA (Standard assessments used in physics education)
- Some content was taken from the animated FCI by M. Darcy

What do we really want to assess?

Great question!

- Conceptual gains in physics content? (Yes)
- Impact on student attitudes and engagement? (Yes)
- Conceptual gains in computer programming? (Not as much…)
- Computational thinking? (Yes, but what is it? – PERC conference parallel session in DC in August)
  - What are the goals of integrating programming at this level?
  - Is it sufficient to introduce coding just to raise student familiarity with computer science?
  - Is the goal to make physics instruction more effective through coding?
  - Or is the main goal to emphasize computational thinking as a kind of new learning objective and programming is simply a means to that end?

We are only *just scratching the surface* on the issue of assessment.

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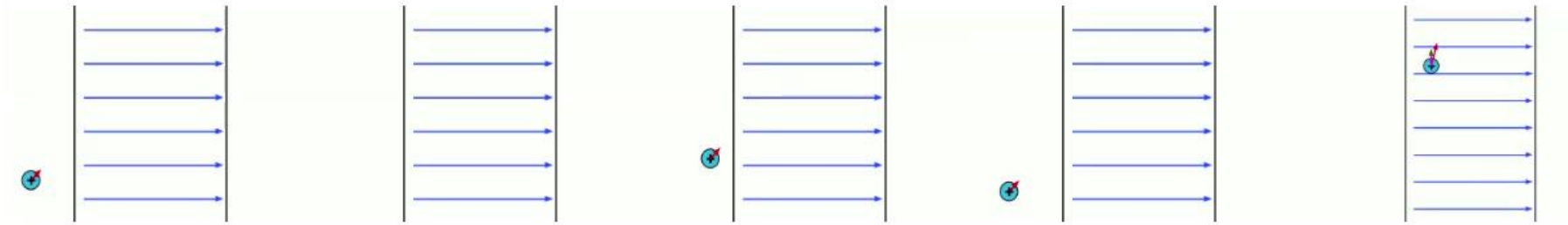
Particle Accelerator –Animated Assessment Questions

Question 2 and 3

Use the animations below to answer question 2 and 3



Which of the following animation show the correct trajectory for particle with the same initial x and y velocity in a uniform electric field

- Animation A
- Animation B
- Animation C
- Animation D
- Animation E

What is the speed of the particle when it is in the accelerator?

- Increasing at first then constant
- Constantly increasing
- Constant at first then increasing
- Deacreasing at first then constant

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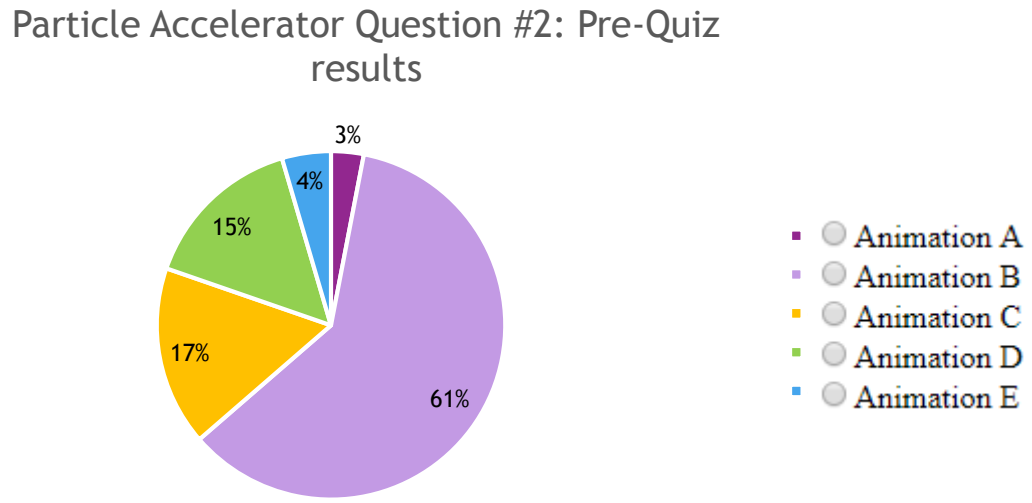
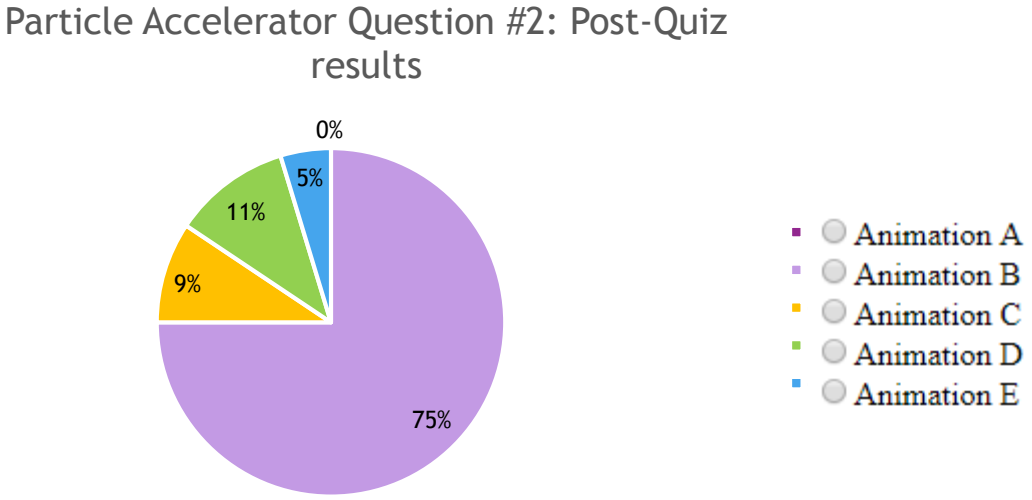
Particle Accelerator Assessments



61% had the correct answer before doing the activity



75% had the correct answer after doing the activity

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Opportunities for teachers and students

- Summer training opportunities – earn continuing education credit!
  - Visit https://u.osu.edu/stemcoding/ for more information

- STEMcoding summer camp!

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Summer Camp 2018

For: High school girls (entering 9th-12th) interested in Science, Technology, Engineering, Math, and learning to code!

When: July 16 – July 18, 2018 (9:00am – 4:00pm)

Where: University of Mount Union (UMU)

Bracy Science Hall, Alliance, OH

Hosted By: The UMU Department of Physics and Astronomy and the STEMcoding Project

Breakfast, Lunch, Snack, and a Free T-Shirt are included!

Visit our page to register! https://bit.ly/2rz1x3N

Questions?

Email: Dr. Richelle Teeling-Smith
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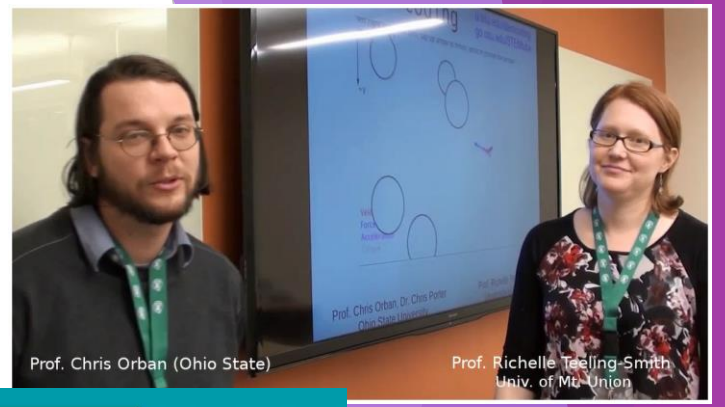
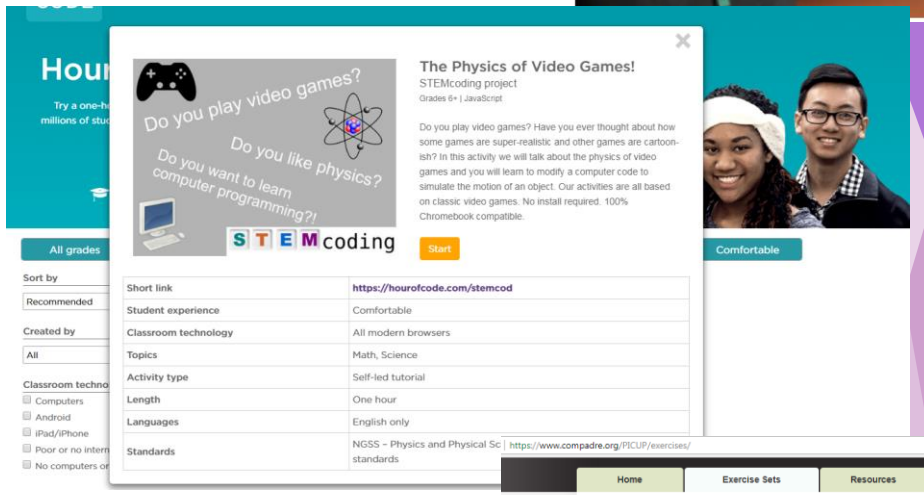
Where can you find us?

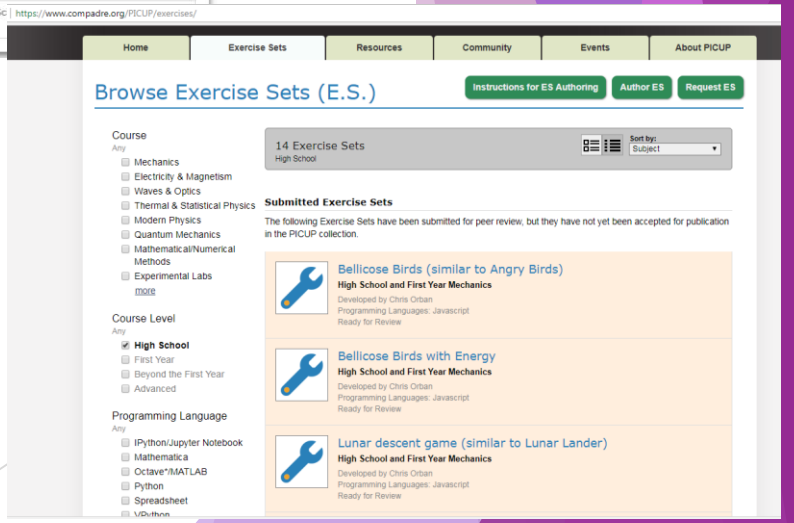
- NSF STEM For All Video Submission

- Hour of Code at Code.org
  - https://hourofcode.com/us/learn
  - Select ‘Science’, ‘Typing’, and ‘Comfortable’

- PICUP.org
  - https://www.compadre.org/PICUP/exercises/
  - Select ‘High School’







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Visit our STEMcoding Youtube Channel and Suscribe!

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Questions? Find us at…

- https://u.osu.edu/stemcoding/

- Dr. Richelle Teeling-Smith: teelinri@mountunion.edu

- Dr. Chris Orban: orban.14@osu.edu

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