Addressing Math Readiness in Physics: Teaching Geometrical Optics Before Kinematics

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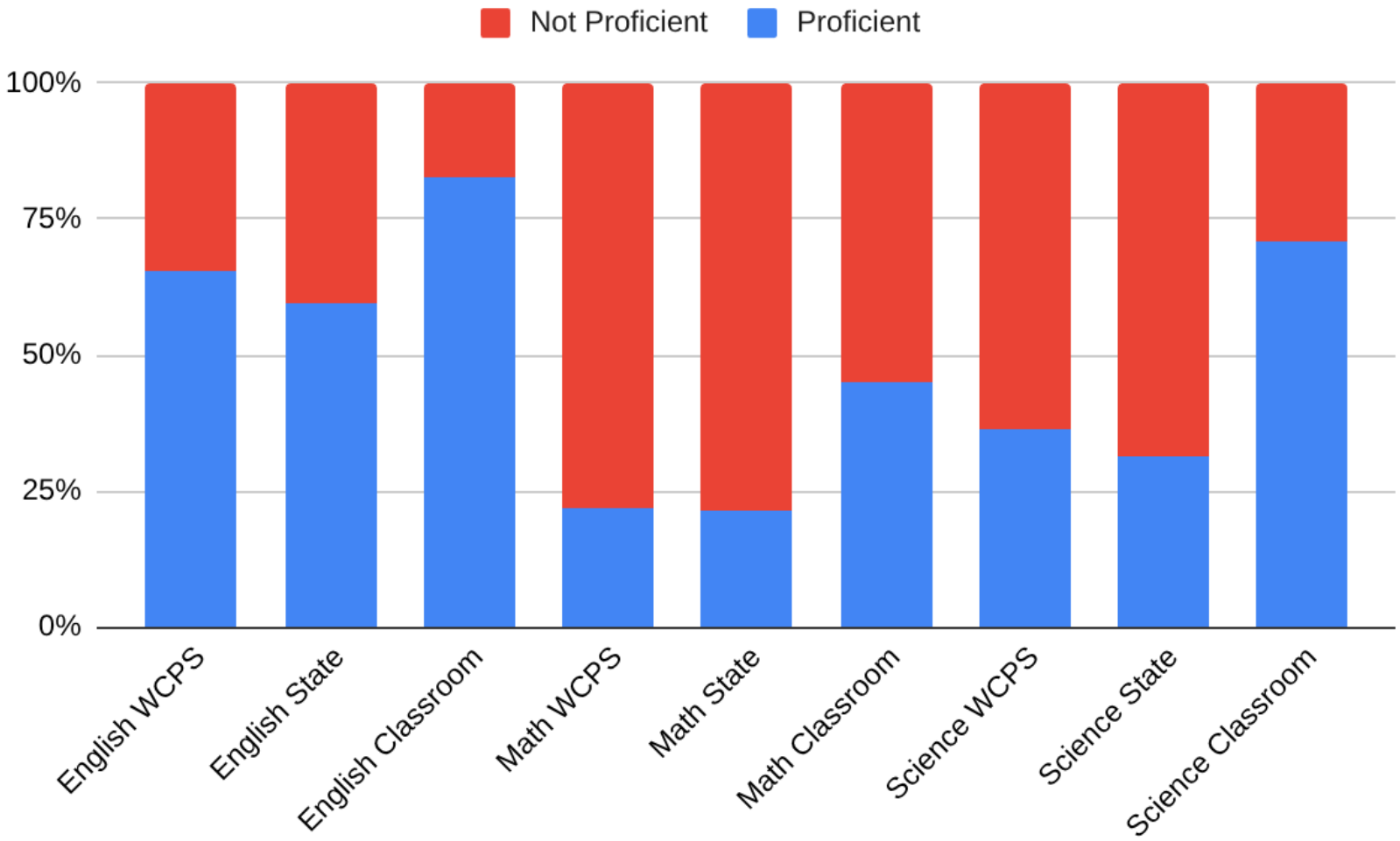
Abstract

Many students enter physics with limited math readiness, yet they must learn scientific concepts while developing the mathematical tools to apply them. This creates a tension: students need science to drive math learning, but math gaps can hinder progress in physics. To address this challenge, a revised instructional sequence was piloted in which geometrical optics were introduced before kinematics. This allowed students to complete the NGSS HS-PS4-2 standards while engaging in conceptually rich investigations that did not immediately require advanced mathematical skills. Using the Active Learning Guide from Chapter 22 of College Physics, students explored wave phenomena, building a foundation in physics while reinforcing Algebra II skills in their concurrent math courses. This sequencing provided time for students to gain confidence in mathematics before encountering more quantitatively demanding physics topics. The presentation will examine the challenges, benefits, and outcomes of this approach, with attention to student readiness, pacing, and rigor.

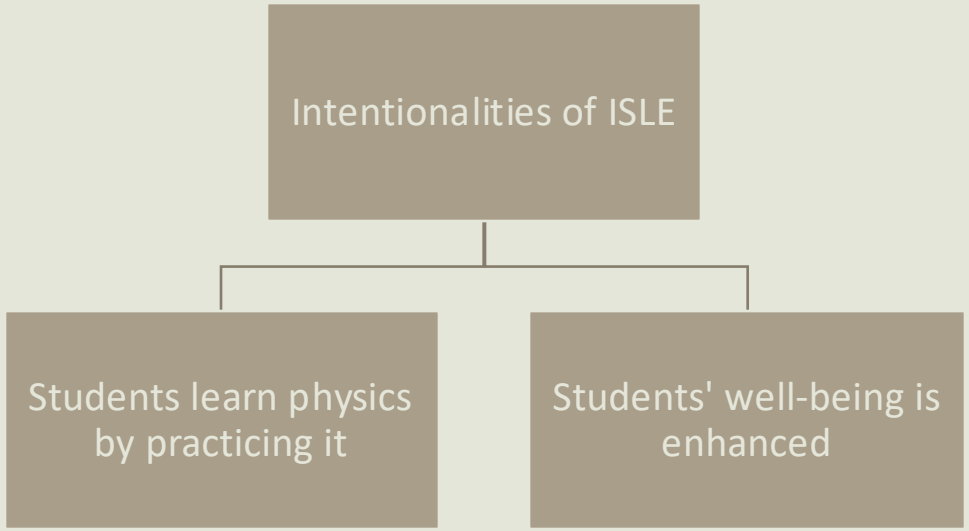
Students struggle with Math more than Science and English

- CTE school has a selection process.
- 54% of students are not proficient in math by 11th grade
- Physics instruction can teach math
- Students need to read in science

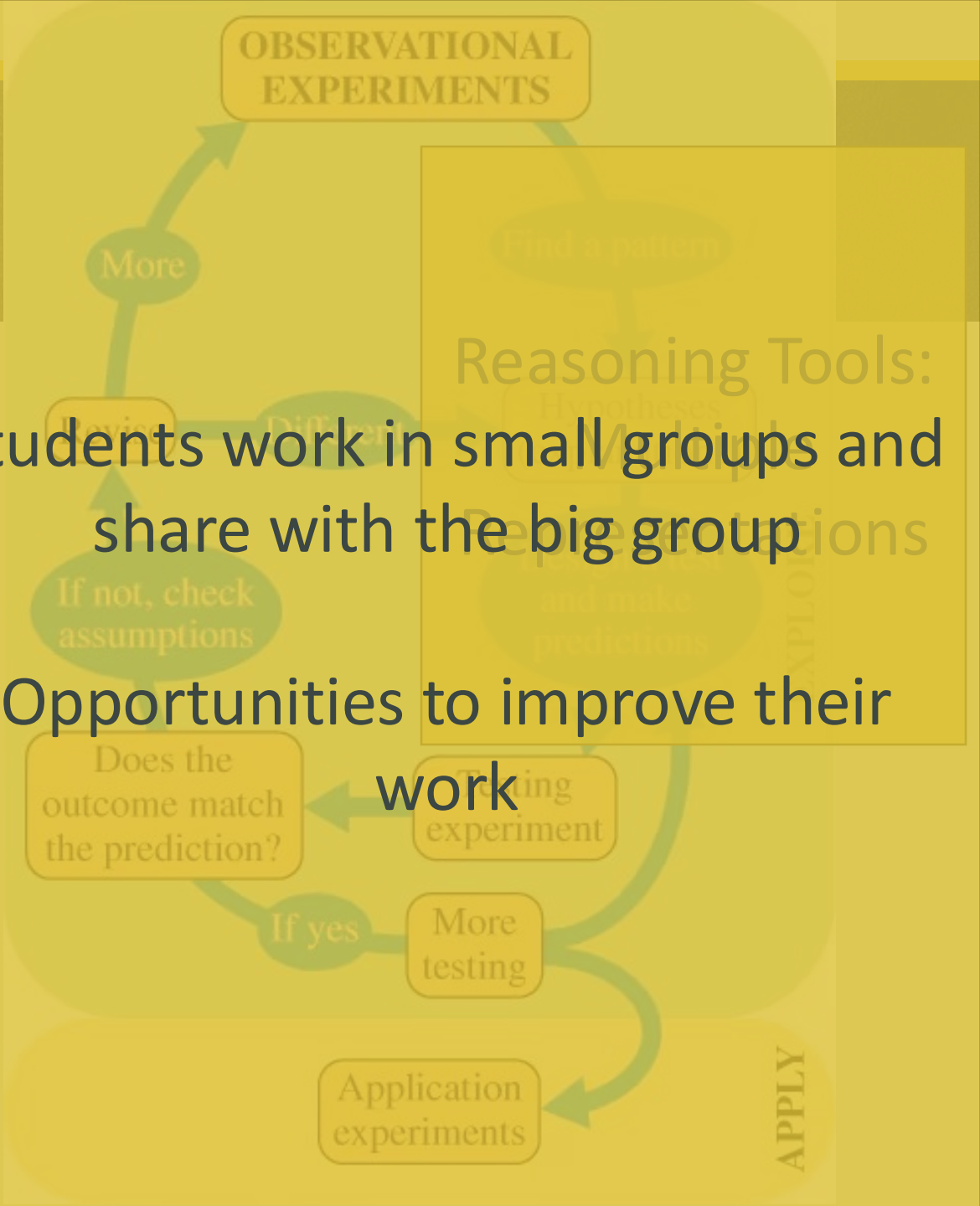


Source: https://reportcard.msde.maryland.gov/Graphs/#/Assessments/SciencePerformance/8/6/3/1/21/XXXX/2025

Investigative Science Learning Environment - ISLE



Source: Etkina, E., Planinsic, G., & Van Heuvelen, A. (2021). College physics: Explore and apply (2nd ed.). Pearson; http://pum.islephysics.net/; https://doi.org/10.1103/PhysRevPhysEducRes.16.020148;



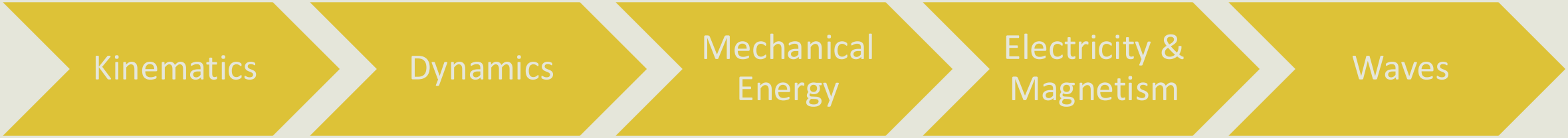
Students work in small groups and share with the big group

Opportunities to improve their work

Honors Physics Curriculum and Implementation

Plan

Traditional



Tested

Waves: Optics Sequence

Plan

- Science Practices Everyday
- Nature of Light
- Reflection
  - Assessment 1: Reflection
- Refraction
  - Critique-Correct-Clarify
  - Assessment 2: Refraction
- The Expert Activity
- Total Internal Reflection
  - Assessment 3: Total Internal Reflection
- Fiber Optics
- Storage and Digital Transmission

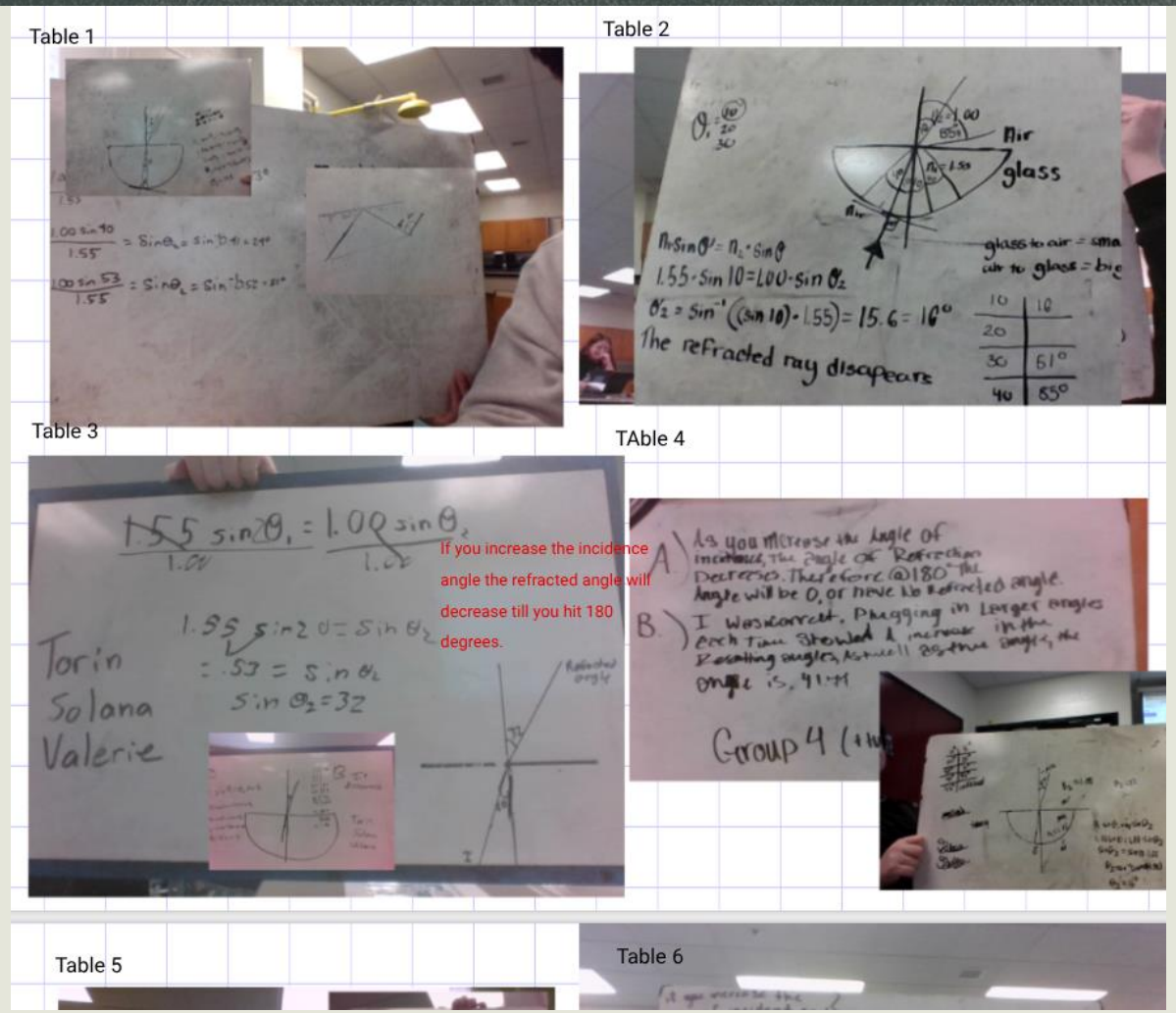
Math Skills Practiced

- Variables & subscripts
- Drawing angles with a protractor
- Constructing perpendicular (normal) lines
- Angle of incidence, reflection, & refraction
- Using Desmos: inverse sine functions
- Algebra: calculating angle of refraction
- Algebra: calculating index of refraction

Source: https://islephysics.net/forum/

Classroom Practices: Work in Whiteboards/Share/Capture

Implement



- Collaborative Learning: Whiteboards & paper practice
- Assessments: On paper
- Retakes: Growth mindset opportunities
- Support: Time and guidance for mastery
- Critique–Correct–Clarify: Peer feedback in groups
- Expert Activity: “You are a great learner” ownership

Source: https://islephysics.net/forum/

What I Would Do Differently Next Year

Evaluate

- Begin the school year with **Geometrical Optics** again.
- Anticipate issues with **nomenclature and subscripts** early on.
- Prepare for **algebra skill gaps** that students may have.
- Address possible **Desmos issues with the inverse function**.
- Keep **assessments shorter** and more focused.
- Plan to run the **expert activity after refraction** for better sequencing.
- Provide **extra practice problems** to support assessment preparation.
- Use more **Active Learning Guide activities** rather than Physics Union Mathematics for Kinematics and Dynamics.
- Have a **support schedule in place before the school year** begins.

3 minutes of Questions & Answers

Plan
Evaluate Implement

Acknowledgements

600students

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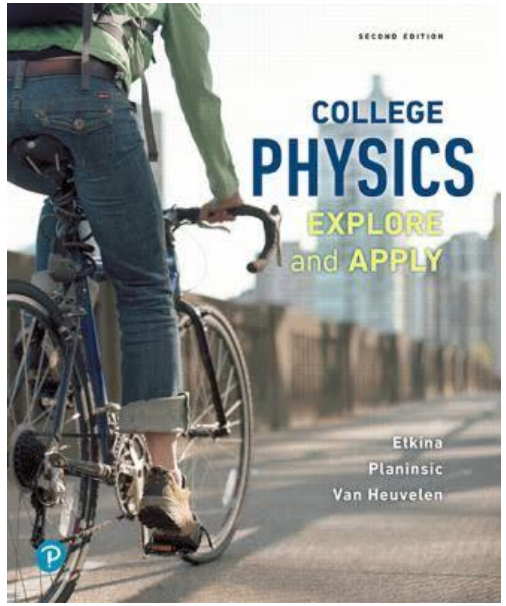
WCPS Washington County Public Schools



CSAAPT

pivot interactives

PUM

Takeaways

- Teach Physics and Math simultaneously
- Geometrical Optics Chapter 22.1-22.6
- Achieved: HS-PS4-2: Digital Transmission-Fiber Optics in 7 weeks
- I expect Kinematics and Dynamics to go smoother

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